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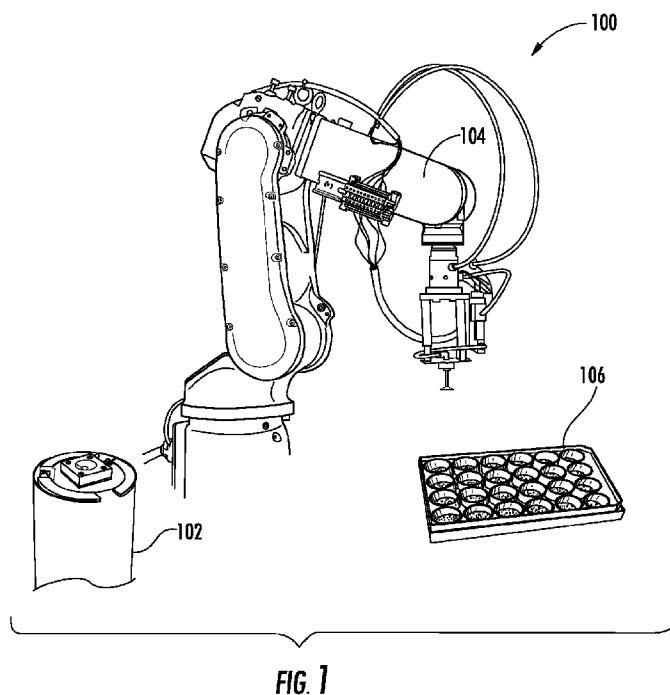
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- (71) Applicant (for all designated States except US): **PIONEER HI-BRED INTERNATIONAL, INC.** [US/US];
7100 N.W. 62nd Avenue, Johnston, Iowa 50131-1014 (US).

- (72) Inventors; and
(75) Inventors/Applicants (for US only): **COPE, Jason** [US/US]; c/o Pioneer Hi-Bred International, Inc., 7250 N.W. 62nd Avenue, Johnston, Iowa 50131-0552 (US). **KURTH, David** [US/US]; c/o Pioneer Hi-Bred International, Inc., 7250 N.W. 62nd Avenue, Johnston, Iowa 50131-0552 (US). **OLDENBURG, Kevin** [US/US]; c/o Pioneer Hi-Bred International, Inc., 7250 N.W. 62nd Avenue, Johnston, Iowa 50131-0552 (US).
- (74) Agent: **VANDER VELDEN, Melinda S.**; Pioneer Hi-Bred International, Inc., 7250 N.W. 62nd Avenue, Johnston, Iowa 50131-0552 (US).
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(54) Title: METHOD, SYSTEM AND APPARATUS FOR REMOVING A SAMPLE PORTION OF A SEED



(57) Abstract: A system configured to remove a sample portion of a seed may include a vibratory device configured to vibrate the seed and orient the seed on an axis, a grasping device configured to grasp the seed, and an apparatus that includes an abrasive material that is configured to abrade the seed. The system may thereby remove the sample portion from the seed without damaging the embryo of the seed. Accordingly, the viability of a remaining portion of the seed may be maintained while producing a sample portion of the seed on which tests may be conducted. In one embodiment the apparatus configured to remove a sample portion of a seed includes a sample removal plate, an abrasive screen, and a funnel plate. The apparatus, system, and method are configured to prevent cross-contamination of sample portions from different seeds.



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METHOD, SYSTEM AND APPARATUS FOR REMOVING A SAMPLE PORTION OF A SEED

FIELD OF THE INVENTION

[0001] The present invention relates generally to methods, systems, and apparatuses for removing a sample portion of a seed. More specifically, the present invention provides methods, systems, and apparatuses for non-destructive sampling of a seed.

BACKGROUND OF THE INVENTION

[0002] It is conventional practice in plant breeding or plant advancement experiments to grow plants from seeds of known parentage. The seeds are planted in experimental plots, growth chambers, greenhouses, or other growing conditions in which they are either cross pollinated with other plants of known parentage or self pollinated. The resulting seeds are the offspring of the two parent plants or the self pollinated plant, and are harvested, processed and planted to continue the plant breeding cycle. Specific laboratory or field-based tests may be performed on the plants, plant tissues, seed or seed tissues, in order to aid in the breeding or advancement selection process.

[0003] Generations of plants based on known crosses or self pollinations are planted and then tested, such as through trait purity tests, to see if these lines or varieties are moving toward characteristics that are desirable in the marketplace. Examples of desirable traits include, but are not limited to, increased yield, increased homozygosity, improved or newly conferred resistance and/or tolerance to specific herbicides and/or pests and pathogens, increased oil content, altered starch content, nutraceutical composition, drought tolerance, and specific morphological based trait enhancements.

[0004] In order to test the genetic composition of the seeds, samples of the individual seeds themselves, or of the plants that develop from the seeds, are gathered. However, when the seeds are going to be planted for research purposes, it is important to retain the viability potential of the seed for when it is planted. Conversely, a useful amount of tissue from the seed must also be obtained in order to conduct certain experimental procedures, such as those described above.

[0005] Accordingly, prior art methods of non-destructive sampling of seeds have typically relied heavily on manual procedures. For example, one prior art procedure for sampling seeds involves a person grasping an individual seed and cutting off a selected portion of the seed using clippers. In this regard, the user must identify the location of the

embryo of the seed so as to avoid damage to the embryo, which could destroy the viability of the seed. Further, the consistency of the sample size which is obtained is determined by the skill of the person removing the sample from the seed. Accordingly, this prior art method of non-destructive sampling involves large amounts of skilled labor and significant amounts of time due to the requirement that the person avoid damaging the embryo. Similar problems exist for manual hand chipping, drilling, sanding, milling, etc.

[0006] Further, the above-mentioned methods of sampling introduce the possibility of cross-contamination of samples. In this regard, the person collecting the samples must be extremely careful to avoid mixing the removed samples. Additionally, particles of the seeds created when collecting samples may still easily transfer and cross-contaminate other samples. Accordingly, present methods of sampling may result in cross-contamination, which can result in incorrect sample results.

[0007] Thus, the above-mentioned methods of obtaining seed samples from seeds and thereafter transferring the samples to testing apparatuses is extremely time consuming and may involve numerous manual processes. In addition, it is difficult to obtain seed samples having repeatable sample sizes. Further, the potential for cross-contamination exists. As a result, there is a need for an improved system and method for obtaining tissue samples from one or more seeds. In various embodiments, the system and method should provide an efficient manner of gathering seed samples for further processing, such as Deoxyribonucleic acid ("DNA") and protein purification and extraction, and it should also provide normalized seed sample sizes while avoiding cross-contamination.

BRIEF SUMMARY OF VARIOUS EMBODIMENTS

[0008] The present invention addresses the above needs and achieves other advantages by providing a method, system and apparatus for removing a sample portion of a seed. In one embodiment, the present invention provides a method for non-destructively sampling a seed. In general, the method comprises orienting a seed on an axis, grasping the seed, positioning the seed in a first compartment, and abrading the seed with an abrasive material in the first compartment to thereby remove a sample portion of the seed. In some embodiments, abrading the seed comprises rotating the seed about the axis relative to the abrasive material. In some embodiments, abrading the seed comprises translating the seed relative to the abrasive material. Some embodiments further comprise pressing the seed against the abrasive material while abrading the seed. In some embodiments, grasping the seed comprises grasping the seed with a vacuum device. Some embodiments further

comprise singulating the seed prior to orienting the seed. In some embodiments, the method further comprises retaining the sample portion of the seed in the first compartment.

[0009] Some embodiments further comprise depositing a remaining portion of the seed in a second compartment. In some embodiments, the second compartment corresponds to the first compartment. In some embodiments, the remaining portion of the seed comprises an embryo. In some embodiments, abrading the seed comprises abrading a cotyledon of the seed adjacent an embryo of the seed. In some embodiments, the seed comprises a soybean. In some embodiments, orienting the seed on the axis comprises vibrating the seed. Some embodiments further comprise directing the sample portion of the seed into a sample plate substantially simultaneously with abrading the seed. Some embodiments further comprise directing the sample portion of the seed through a funnel plate to the sample plate.

[0010] In another embodiment, the present invention provides a system configured to remove a sample portion of a seed. In general, the system comprises an orienting device configured to orient the seed on an axis, a grasping device configured to grasp the seed, and a first container that includes an abrasive material therein that is configured to abrade the seed. In some embodiments, the first container comprises a plurality of compartments. Some embodiments further comprise a second container, wherein the second container comprises a second plurality of compartments which correspond to the first plurality of compartments. Some embodiments further comprise a singulator configured to singulate the seed. In some embodiments, the orienting device comprises a sloped surface configured to center the seed such that the axis is coaxial with a desired axis. In some embodiments, the grasping device comprises a vacuum device configured to contact the seed and rotate the seed about the axis. In some embodiments, the grasping device is configured to press the seed against the abrasive material. In some embodiments, the vacuum device is spring-loaded. In some embodiments, the orienting device comprises a vibratory device configured to vibrate the seed.

[0011] In another embodiment, the present invention provides an apparatus for removing a sample portion from each of one or more seeds. In general the apparatus comprises a sample removal plate comprising one or more compartments configured to receive the seeds, and an abrasive screen accessible through each of the compartments, wherein the abrasive screen is configured to remove the sample portions of the seeds and allow the sample portions to pass therethrough. Some embodiments further comprise a funnel plate comprising one or more funnels configured to respectively receive the sample

portions from the compartments and direct each of the sample portions into a respective one of a plurality of sample compartments in a sample plate. In some embodiments, the sample removal plate is configured to engage the funnel plate with the abrasive screen therebetween.

[0012] In some embodiments, the sample plate defines a first quantity of the sample compartments, and the sample removal plate defines a second quantity of the compartments which is less than the first quantity of the sample compartments. In some embodiments, the funnel plate defines a third quantity of the funnels which is less than the first quantity of the sample compartments. In some embodiments, the second quantity equals the third quantity. In some embodiments the second quantity and the third quantity equal one half of the first quantity. In some embodiments, the compartments of the sample removal plate define a plurality of compartment openings which are configured to be larger in area than a plurality of sample plate openings defined by the sample compartments of the sample plate. In some embodiments, the compartments of the sample removal plate are configured to align with the funnels of the funnel plate so as to prevent cross-contamination of the sample portions.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

[0013] Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

[0014] FIG. 1 illustrates a system configured to remove a sample portion of a seed according to an embodiment of the invention;

[0015] FIG. 2 illustrates a vibratory device and grasping device from the system of FIG. 1 according to an embodiment of the invention;

[0016] FIG. 3 illustrates a soybean which may be non-destructively sampled using the system of FIG. 1 according to an embodiment of the invention;

[0017] FIG. 4 illustrates a first embodiment of an apparatus configured to remove a sample portion of a seed that includes an abrasive material which is added to the compartments according to an embodiment of the invention;

[0018] FIG. 5 illustrates a second embodiment of an apparatus configured to remove a sample portion of a seed that includes an abrasive material which may be integral with the compartments according to an embodiment of the invention;

[0019] FIG. 6 illustrates a third embodiment of an apparatus configured to remove a sample portion of a seed comprising a sample removing plate, an abrasive screen, and a funnel plate according to an embodiment of the invention;

[0020] FIG. 7 illustrates the funnel plate of FIG. 6 according to an embodiment of the invention;

[0021] FIG. 8 illustrates a use of the system of FIG. 1 to remove a sample portion of a seed with one of the apparatuses configured to remove a sample portion of a seed and use of the system to deposit a remaining portion of the seed in a second compartment according to an embodiment of the invention; and

[0022] FIG. 9 illustrates a method of non-destructive sampling of a seed comprising abrading the seed according to an embodiment of the invention.

DETAILED DESCRIPTION

[0023] The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the invention are shown. Indeed, this invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like numbers refer to like elements throughout.

[0024] As will be described below, the present invention is generally directed to a method, system, and apparatus for removing a sample portion of a seed. In this regard, FIG. 1 illustrates a system 100 which is configured to remove a sample portion of a seed. The system 100 may include an orienting device such as a vibratory device 102, which is configured to vibrate a seed and orient the seed on an axis, as will be described below. The system 100 may further include a grasping device configured to grasp a seed, which is herein illustrated as a robotic arm 104. The robotic arm 104 may grasp and transport seeds between various portions of the system 100 such that various operations may be conducted on the seed. For example, the robotic arm 104 may grasp a seed from the vibratory device 102 and transfer the seed to an apparatus 106 configured to remove a sample portion of the seed.

[0025] Turning now to FIG. 2, an enlarged view of the vibratory device 102 and a portion of the robotic arm 104 is illustrated. As described above, the vibratory device 102 is configured to vibrate a seed. The seed in the illustrated embodiment is a soybean seed 108. Soybean seeds generally comprise certain characteristics that will be described

herein. However, it should be understood that variances in the genetic composition of soybean seeds, and the differences in various types of soybean seeds may result in some of the description herein differing from some soybean seeds.

[0026] As illustrated, the soybean seed 108 comprises a shape which is generally ovular as viewed from the perspective in FIG. 3. In this regard, the soybean seed 108 has a length on a major axis 110 which is generally greater than a length on a minor axis 112. The soybean seed 108 comprises a hilum 114, which is an externally visible “scar” on the soybean seed, indicating the point of attachment to the funiculus of a soybean plant. An embryo 116 of the soybean seed 108 is within the soybean seed adjacent to the hilum 114, and thus may or may not be externally visible. Further, the soybean seed 108 includes first 118a and second 118b cotyledons which correspond to the generally flat sections of the soybean seed. The first 118a and second 118b cotyledons are positioned adjacent to the embryo 116, and when the soybean seed 108 is positioned such that the minor axis 112 is directed vertically as illustrated in FIG. 3, first and second cotyledons are positioned generally below and above the embryo, respectively.

[0027] Returning to FIG. 2, the soybean seed 108 may be singulated by a singulator and placed in the vibratory device 102. For example, a singulator as disclosed in U.S. Patent Application Serial Number 11/939,402 filed on November 13, 2007, which is incorporated herein by reference, may be used in some embodiments of the system 100. In other embodiments multiple soybean seeds 108 may be inserted into the vibratory device 102, for example when the vibratory device comprises multiple compartments for soybean seeds. By vibrating the soybean seed 108 using the vibratory device 102, the soybean seed may tend to orient itself such that the hilum 114 and the major axis 110 lie generally horizontally as illustrated in FIG. 3. Thus, in this configuration the soybean seed 108 is oriented on the minor axis 112, such that the minor axis is positioned substantially vertically. This occurs because one of the generally flat cotyledons 118a, 118b of the soybean seed 108 will tend to face downwardly due to the force of gravity. Orientation of the soybean seed 108 within the vibratory device 102 may further be assisted by a sloped surface 120. The sloped surface 120 may be configured to center the soybean seed 108 with respect to the sloped surface 120 such that the minor axis 112 of the soybean seed is coaxial with a desired axis 122, which extends substantially vertically from the vibratory device 102.

[0028] Note that some embodiments of the system 100 and methods disclosed herein may not include the vibratory device 102. In this regard, while the vibratory device 102 is

believed to assist in aligning the minor axis 112 of the soybean seed 108 with the desired axis 122, soybean seeds may tend to naturally orient themselves such that the minor axis is aligned vertically, due to soybean seeds comprising the cotyledons 118a, 118b which are generally flat. Thus, some embodiments of the system 100 may place the soybean seed 108 onto a flat surface or the sloped surface 120 without vibrating the soybean seed in order to orient the seed. In particular, use of the sloped surface 120 may orient seed by aligning the minor axis 112 of the soybean seed 108 with the desired axis 122.

Accordingly, orienting devices which orient the seed may comprise just the sloped surface 120 in some embodiments whereas in other embodiments the orienting devices may comprise vibratory devices which vibrate the seed.

[0029] However, it should also be noted that the method, system, and apparatus disclosed herein may be used to conduct operations on various other types of seeds and objects. In this regard, the vibratory device 102 may additionally or alternatively be used to orient other varieties and types of seeds and objects, for example seeds and other objects which are not perfectly spherical or which are not uniformly weighted. In this regard, corn, canola, sunflower, rice, sorghum, wheat, alfalfa, cotton, millet, and other seeds may be oriented and sampled using the apparatus, system, and methods described herein. Thereby the vibratory device 102 may orient seeds and other objects in a manner similar to that described above with respect to the soybean seed 108. For example, non-spherical seeds or other objects may tend to orient themselves such that they define a minimum height extending vertically. With respect to seeds and objects which are not weighted evenly, the center of mass may be displaced by vibration such that the center of mass tends to orient downwardly. Accordingly, although the embodiments discussed herein generally refer to soybean seeds, this is for example purposes.

[0030] Once the soybean seed 108 has been oriented on the minor axis 112, such as by vibrating the soybean seed 108 with the vibratory device 102, the soybean seed may be ready for sampling. In this regard, the system 100 may use the robotic arm 104 to grasp the soybean seed 108 and transfer the soybean seed to the apparatus 106 configured to remove a sample portion of the seed. Although the robotic arm 104 (or other grasping device) may include various embodiments of features which enable grasping and transfer of the soybean seed 108, the illustrated robotic arm includes a vacuum device 124 which allows the robotic arm to grasp the soybean seed. The vacuum device 124 is spring-loaded in the illustrated embodiment, through use of a spring 126 which allows the robotic arm 104 to securely contact a vacuum tip 128 to the soybean seed 108 when picking the

soybean seed up without placing excessive force on the soybean seed, which could potentially damage the soybean seed. Thereby, the robotic arm 104 may grasp and transfer the soybean seed 108 to the apparatus 106 configured to remove a sample portion of the seed.

[0031] FIGS. 4 and 5 respectively illustrate first 106a and second 106b embodiments of the apparatus 106 configured to remove a sample portion of a seed. FIGS. 1 and 8 illustrate use of the first embodiment 106a of the apparatus 106 configured to remove a sample portion of the seed. However, in other embodiments the system 100 may employ the second embodiment 106b or various other embodiments of the apparatus 106 configured to remove a sample portion of the seed as described below. As illustrated in FIG. 4, the first embodiment 106a of the apparatus 106 configured to remove a sample portion of the seed comprises a plurality of compartments 130a which each include an abrasive material 132a therein. In the first embodiment 106a of the apparatus 106 configured to remove a sample portion of the seed, the abrasive material comprises a material which is added to the apparatus. For example, the abrasive material 132a may comprise sand paper which is coupled, for example by an adhesive, to the bottom of each of the compartments 130a of the first embodiment 106a of the apparatus 106 configured to remove a sample portion of the seed. By way of further example, the abrasive material 132a may comprise a particle and adhesive mixture which is poured into each of the compartments 130a and dries therein. Further, in the first embodiment 106a of the apparatus 106 configured to remove a sample portion of the seed, the compartments 130a are separated from one another by gaps 134a. The gaps 134a between the compartments 130a may decrease the likelihood that cross-contamination occurs between the compartments as will be discussed below.

[0032] FIG. 5 illustrates the second embodiment 106b of the apparatus 106 configured to remove a sample portion of the seed. The second embodiment 106b of the apparatus 106 configured to remove a sample portion of the seed also includes a plurality of compartments 130b which each include an abrasive material 132b therein. In the second embodiment 106b of the apparatus 106 configured to remove a sample portion of the seed, the abrasive material 132b may be integral with the apparatus. In this regard, the abrasive material 132b may comprise a plurality of protrusions 132b' extending from the bottom of the compartments 130b. Thereby, for example, the abrasive material 132b and the remainder of the second embodiment 106b of the apparatus 106 configured to remove a sample portion of the seed may be formed from a single mold in some embodiments.

Although the second embodiment 106b of the apparatus 106 configured to remove a sample portion of the seed does not is not illustrated as comprising gaps between the respective compartments 130b, each compartment is still separated from one another such that cross-contamination may be avoided.

[0033] In other embodiments (not shown) the second embodiment 106b of the apparatus 106 configured to remove a sample portion of the seed may comprise not only the protrusions 132b' extending from the bottom of the compartments 130b, but also an added abrasive material. For example, the above-described particle and adhesive mixture may be poured into each of the compartments 130b and may dry therein. Thereby, for example, the protrusions 132b' may form a structure to which the mixture may more easily adhere. Accordingly, the second embodiment 106b of the apparatus 106 configured to remove a sample portion of the seed may be used with or without the addition of a particle and adhesive mixture.

[0034] FIG. 6 illustrates an exploded view of a third embodiment 106c of the apparatus 106 configured to remove a sample portion from each of one or more seeds. The third embodiment 106c of the apparatus 106 may comprise a sample removal plate 107 including one or more compartments 130c configured to receive the seeds. The third embodiment 106c of the apparatus 106 may further comprise an abrasive screen 109. The abrasive screen 109 may be accessible through each of the compartments 130c. In particular, the compartments 130c may comprise open cylinders with the abrasive screen 109 positioned at one end. For example, in the illustrated embodiment the abrasive screen 109 comprises a single piece of screen material, which may for example comprise drywall sandpaper, which is coupled to the bottom of the sample removal plate 107 such that a different portion of the abrasive screen is respectively accessible through each of the compartments 130c. However, in other embodiments the abrasive screen 109 may comprise separate pieces which are separately accessible through the compartments 130c. For example, each compartment 130c may have a respective abrasive screen attached therein. Regardless of the particular configuration of the abrasive screen 109, seeds may be inserted into the compartments 130c and abraded in the compartment with the abrasive screen.

[0035] Accordingly, the sample portion of the seed may travel through the abrasive screen 109 and thereby fall into a sample plate (not shown) substantially simultaneously with abrading the seed. However, the third embodiment 106c of the apparatus 106 configured to remove a sample portion of the seed may further comprise a funnel plate

111. The sample removal plate 107 may be configured to engage the funnel plate 111 with the abrasive screen 109 positioned therebetween.

[0036] As illustrated in FIG. 7, the funnel plate 111 may comprise a plurality of funnels 113 configured to respectively receive the sample portions from the compartments 130c of the sample removal plate 107 and direct each of the sample portions into respective sample compartments in the sample plate. The compartments 130c of the sample removal plate 107 may align with respective funnels 113 of the funnel plate 111 so as to prevent cross-contamination between the sample portions from different compartments. In some embodiments the sample compartments in the sample plate may be relatively small as compared to the size of the seeds which are being sampled. Accordingly, the sample removal plate 107 and the funnel plate 111 may respectively comprise quantities of compartments 130c and funnels 113 which are less than the quantity of sample compartments in the sample plate. For example, in some embodiments the sample plate may comprise ninety-six (96) sample compartments. Accordingly, as illustrated, the sample removal plate 107 and the funnel plate 111 may respectively comprise forty-eight (48) compartments 130c and funnels 113 in order to direct the sample portions to half of the sample compartments. In this regard, in some embodiments the funnel plate 111 may define a quantity of funnels 113 which is equal to the quantity of compartment 130c in the sample removal plate 107. Thereby, a second one of the third embodiment 106c of the apparatus 106 may be configured to direct additional sample portions to the remaining forty-eight (48) sample compartments in the sample plate at a later time. However, the sample removing plate 107 and the funnel plate 111 may be configured to direct the sample portions of the seeds to various other numbers of sample compartments in the sample plate as may be understood by one having skill in the art. Regardless, the funnel plate 111 of the third embodiment 106c of the apparatus 106 configured to remove a sample portion of the seed may provide benefits in that the sample portions may be directly deposited in the sample plate without requiring transfer from an intermediate plate with less than the number of sample compartments.

[0037] In this regard, the sample compartments of the sample plate may not be large enough to receive the seeds directly to remove the sample portions directly therein. Hence, the sample removal plate 107 may function to remove the sample portions from the seeds and then direct the sample portions of the seeds to the sample plate through the funnel plate 111. Accordingly, the compartments 130c of the sample removal plate 107 may define respective compartment openings which are each sized and otherwise

configured to receive one of the seeds. Thereby, in some embodiments the compartment openings of the compartments 130c of the sample removal plate 107 may be configured to be larger in area than sample plate openings defined by the sample compartments of the sample plate. Accordingly, cross-contamination may be avoided even when directly removing a sample portion in the sample plate may not be possible.

[0038] Note that although the apparatuses configured to remove a sample portion of a seed are illustrated as comprising certain numbers of compartments and certain other physical features, these are provided for example purposes only. In this regards, various different number of compartments may be employed in the apparatuses. For example 24, 48, 96, or other numbers of compartments may be used. Further, the pattern of the compartments may vary. For example, the compartments may be arranged in rows and/or columns, in circular arrangements, in staggered arrangements, etcetera. Thus, many of the shown and described features of the apparatuses may vary in other embodiments of the apparatuses while still functioning as described herein.

[0039] With further regard to cross-contamination, some prior apparatuses which sanded seeds for purposes of obtaining samples used a single planar sheet of sandpaper on which the seeds were abraded at separate locations. The pieces of the sandpaper where the seeds were abraded were then removed from the sandpaper and placed into respective compartments. However, using these methods, the potential existed for particulate matter to cross-contaminate amongst the various sample locations on the sandpaper. However, through use of the first 106a, second 106b, or third 106c embodiments of the apparatus 106 configured to remove a sample portion of the seed, each seed is abraded in a separate compartment 130. Thus, by both abrading each seed in a respective compartment 130 and storing the resulting sample in the same compartment, or directing the sample portion to a separate sample compartment with a funnel 113, the potential for cross-contamination is believed to be significantly reduced.

[0040] Turning now to FIG. 8, operations relating to abrading a seed are shown. In this regard the robotic arm 104 is shown grasping and moving the soybean seed 108 after the soybean seed has oriented such that the minor axis 112 of the seed is oriented vertically along the desired axis 122 by the vibratory device 102 as previously discussed with respect to FIGS. 2 and 3. Thereby, the robotic arm 104 may position the soybean seed 108 in a first compartment 130' of the apparatus 106 configured to remove a sample portion of the seed, which is herein illustrated by way of example as the first embodiment 106a of the apparatus. Accordingly, the soybean seed 108 may be abraded by the abrasive material

132 therein. For example, the vacuum device 124 attached to the robotic arm 104 or other grasping device may be configured to contact the soybean seed 108 and rotate the soybean seed about the minor axis 112 on which the seed was oriented by the vibratory device 102. Thereby, when the soybean seed 108 is pressed against the abrasive material 132 by the robotic arm 104, a sample portion of the soybean seed is removed and retained in the first compartment 130'. Note that when using the third embodiment 106c of the apparatus configured to remove a sample portion of the seed, the sample portion of the seed would be directed into a sample plate.

[0041] Further, various other forms of motion may be used to remove the sample portion from the soybean seed 108. For example, instead of, or in addition to, rotating the soybean seed 108, the robotic arm 104 may translate the soybean seed across the abrasive material 132 or move in other directions or patterns. Additionally, it should also be noted that the soybean seed 108 may remain substantially stationary during removal of the sample portion of the soybean seed in some embodiments. In this regard, the apparatus 106 configured to remove a sample portion of the seed may in some embodiments rotate, translate, or otherwise move. Thus, relative motion between the seed 108 and the abrasive material 132 may be accomplished through various different arrangements in various embodiments of the system 100. Further, in some embodiments of the system 100, vibrating the soybean seed 108 may occur within the first compartment 130' of the apparatus 106 configured to remove a sample portion of the seed. In this regard, in some embodiments the apparatus 106 configured to remove a sample portion of the seed may comprise sloped walls which are configured to respectively center the soybean seeds 108 in each first compartment of the apparatus to thereby orient the soybean seeds on respective desired axes within the respective first compartments.

[0042] By abrading the soybean seed 108 as described above, the system 100 is configured to remove a sample portion 108'' from one of the two cotyledons 118a, 118b of the seed, as illustrated in FIG. 2. This is because the vibratory device 102 is configured to orient the seed on the minor axis 112 of the soybean seed 108. Thus, the soybean seed 108 is oriented such that the hilum 114 and embryo 116 do not come into contact with the abrasive material 132, and thereby the embryo may remain intact and undamaged. Accordingly, the remaining portion 108' of the seed may retain viability and may be planted as will be described below.

[0043] Returning to FIG. 8, after the sample portion 108'' of the soybean seed 108 is removed and deposited in the first compartment 130' of the apparatus 106 configured to

remove a sample portion of the seed, the robotic arm 104 may transport the remaining portion 108' of the soybean seed to a second container 136. The second container 136 may comprise a blister package with a second plurality of compartments, or other container configured for planting seeds. As further illustrated, a funnel 138 may be used to direct the remaining portion 108' of the soybean seed 108 to a second compartment 136' of the second container 136. In some embodiments the second container 136 may be moveable relative to the funnel 138 such that when the remaining portion 108' of the soybean seed 108 falls through the funnel, it lands in the desired compartment therein. However, in other embodiments the robotic arm 104 or other grasping device may directly deposit the remaining portion 108' of the soybean 108 in the second compartment 136' in the second container 136.

[0044] The second compartment 136' in the second container 136 may correspond with the first compartment 130' in the apparatus 106 configured to remove a sample portion of the seed such that it may be possible to know which sample portion 108'' came from which soybean seed 108. Thereby, for example, the remaining portion 108' of the soybean seed 108 may be stored for future planting and the sample portion 108'' of the soybean seed may be tested for various characteristics. Thus, since the soybean seed 108 may still comprise an undamaged embryo 116, the remaining portion 108' of the soybean seed may be planted to determine growth characteristics and/or produce additional seeds. By way of further example, DNA, lipids, or proteins may be extracted from the sample portion 108'' of the soybean seed 108 through various procedures. For instance, a cell lysis solution may be added to the sample portion 108'' of the soybean seed 108 to break down the sample portion and release the DNA, lipids, and proteins. Thereafter, through centrifuge, decanting, or other methods the DNA may be isolated. Thereby analysis of the soybean seed 108 may be conducted without harming viability of the soybean seed.

[0045] In further embodiments a method of non-destructively sampling a seed is provided. For example, one method of non-destructive sampling of a seed, which may comprise a soybean seed, is illustrated in FIG. 9. The method may comprise orienting the seed on an axis at operation 200. The method may further include grasping the seed at operation 202. Further, the method may comprise positioning the seed in a first compartment at operation 204. For example, the soybean seed 108 may be positioned in the first compartment 130' of the first apparatus 106 configured to remove a sample portion of a seed. Thereby, the method may further include abrading the seed with an

abrasive material in the first compartment to thereby remove a sample portion of the seed at operation 206.

[0046] In some embodiments the method may additionally or alternatively comprise other operations including those operations illustrated in dashed lines in FIG. 9. For example, orienting the seed on an axis at operation 200 may comprise vibrating the seed at operation 208 using the vibratory device 102. The method may also include singulating the seed at operation 210 prior to orienting the seed at operation 200. Further, grasping the seed at operation 202 may comprise grasping the seed with a vacuum device at operation 212. For example, the soybean seed 108 may be grasped with the vacuum device 124 of the robotic arm 104 in some embodiments. Additionally, abrading the seed at operation 208 may comprise rotating the seed about the axis relative to the abrasive material at operation 214 and/or translating the seed relative to the abrasive material at operation 216. As discussed above, in some embodiments the vacuum device 124 may be configured to rotate in order to abrade the seed. The method in some embodiments may further comprise pressing the seed against the abrasive material at operation 218 while abrading the seed at operation 206.

[0047] The method may additionally comprise retaining the sample portion of the seed in the first compartment at operation 220. For example, the sample portion of the seed may be retained in the compartment 130a, 130b of the first 106a and second 106b embodiments of the apparatus 106 configured to remove a sample portion of a seed. However, in other embodiments the method may further comprise directing the sample portion of the seed into a sample plate at operation 222, which may occur substantially simultaneously with abrading the seed at operation 206. Further, the method may comprise directing the sample portion of the seed through a funnel plate to the sample plate at operation 224. For example, this may occur when the method is conducted using the third embodiment 106c of the apparatus 106 configured to remove a sample portion of a seed.

[0048] Also, the method may include depositing a remaining portion of the seed in a second compartment at operation 226. In some instances the second compartment corresponds to the first compartment such that the relationship of the sample portion to the remaining portion may be preserved. For example, in some embodiments the apparatus 106 may include a plurality of first compartments 130 which are equal in number to the second compartments 136' of the second container 136 and correspond thereto. Additionally, in some embodiments the remaining portion of the seed comprises an

embryo. Accordingly, in some embodiments the method may further comprise abrading a cotyledon of the seed adjacent an embryo of the seed at operation 228. Thereby, embodiments of the method may obtain a sample portion of a seed which is suitable for testing while also producing a remaining portion of the seed which retains viability.

[0049] While the methods, systems, and apparatuses described and illustrated herein have generally been discussed in terms of sequentially acting on each seed, in other embodiments multiple seeds may be acted upon at the same time. In this regard, for example, the vibratory device or other orienting device may orient multiple seeds at the same time. For example, the vibratory device may comprise multiple sloped surfaces into which seeds are respectively oriented. Further, the robotic arm may comprise multiple vacuum devices which respectively grasp the seeds and then simultaneously abrade the seeds in respective compartments of the first container. Accordingly, in some embodiments the method, system, and the apparatus may allow for increased productivity in non-destructive sampling through simultaneous operation on multiple seeds.

[0050] Many modifications and other embodiments of the invention set forth herein will come to mind to one skilled in the art to which the invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

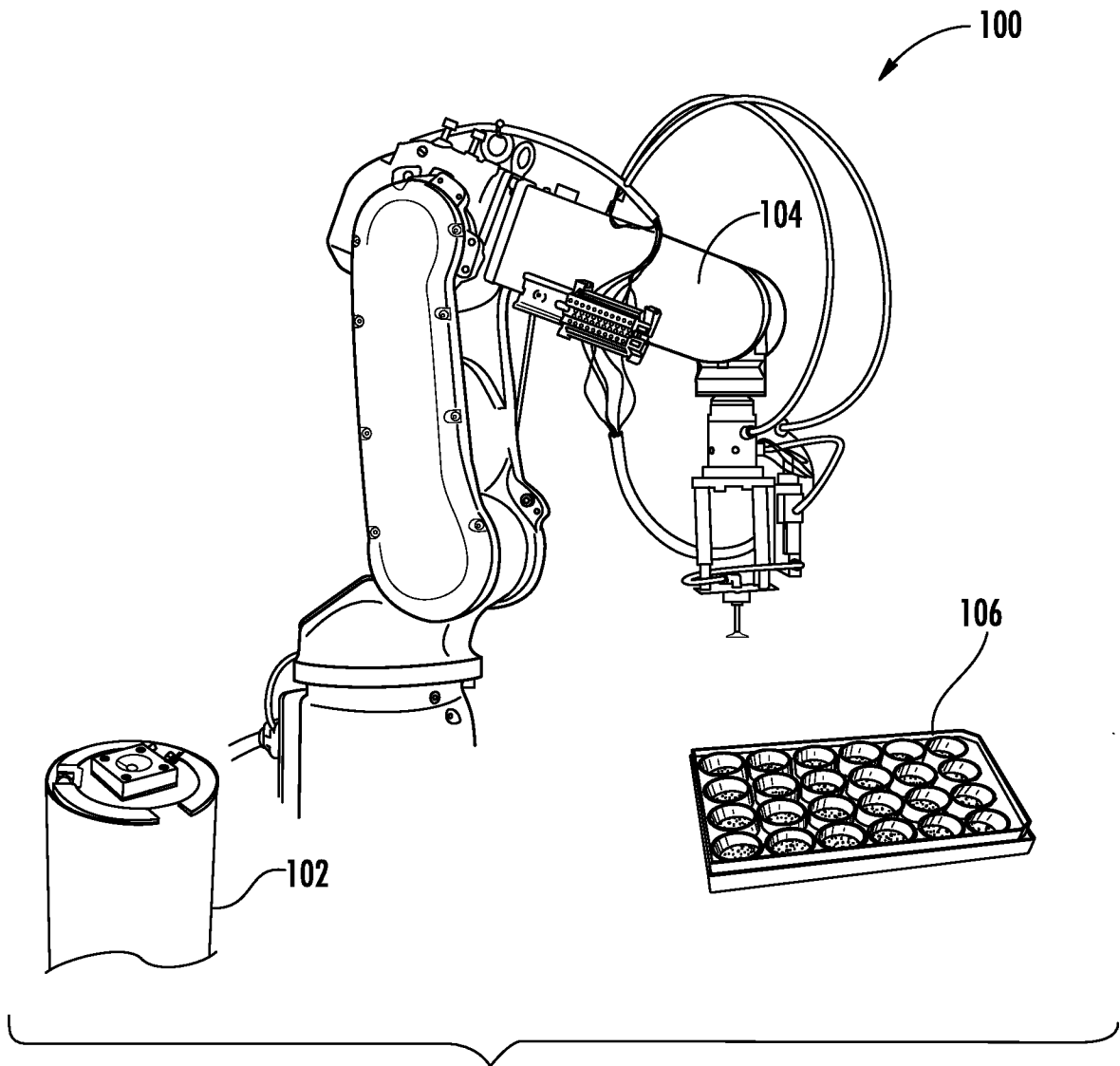
THAT WHICH IS CLAIMED:

1. An apparatus configured to remove a sample portion from each of one or more seeds, comprising:
 - a sample removal plate comprising one or more compartments configured to receive the seeds; and
 - an abrasive screen accessible through each of the compartments, wherein the abrasive screen is configured to remove the sample portions of the seeds and allow the sample portions to pass therethrough.
2. The apparatus of Claim 1, further comprising a funnel plate comprising one or more funnels configured to respectively receive the sample portions from the compartments and direct each of the sample portions into a respective one of a plurality of sample compartments in a sample plate.
3. The apparatus of Claim 2, wherein the sample removal plate is configured to engage the funnel plate with the abrasive screen therebetween.
4. The apparatus of Claim 2, wherein the sample plate defines a first quantity of the sample compartments, and
 - wherein the sample removal plate defines a second quantity of the compartments which is less than the first quantity of the sample compartments.
5. The apparatus of Claim 4, wherein the funnel plate defines a third quantity of the funnels which is less than the first quantity of the sample compartments.
6. The apparatus of Claim 5, wherein the second quantity equals the third quantity.
7. The apparatus of Claim 6, wherein the second quantity and the third quantity equal one half of the first quantity.
8. The apparatus of Claim 2, wherein the compartments of the sample removal plate define a plurality of compartment openings which are configured to be larger in area

than a plurality of sample plate openings defined by the sample compartments of the sample plate.

9. The apparatus of Claim 2, wherein the compartments of the sample removal plate are configured to align with the funnels of the funnel plate so as to prevent cross-contamination of the sample portions.

1/9

**FIG. 1**

2/9

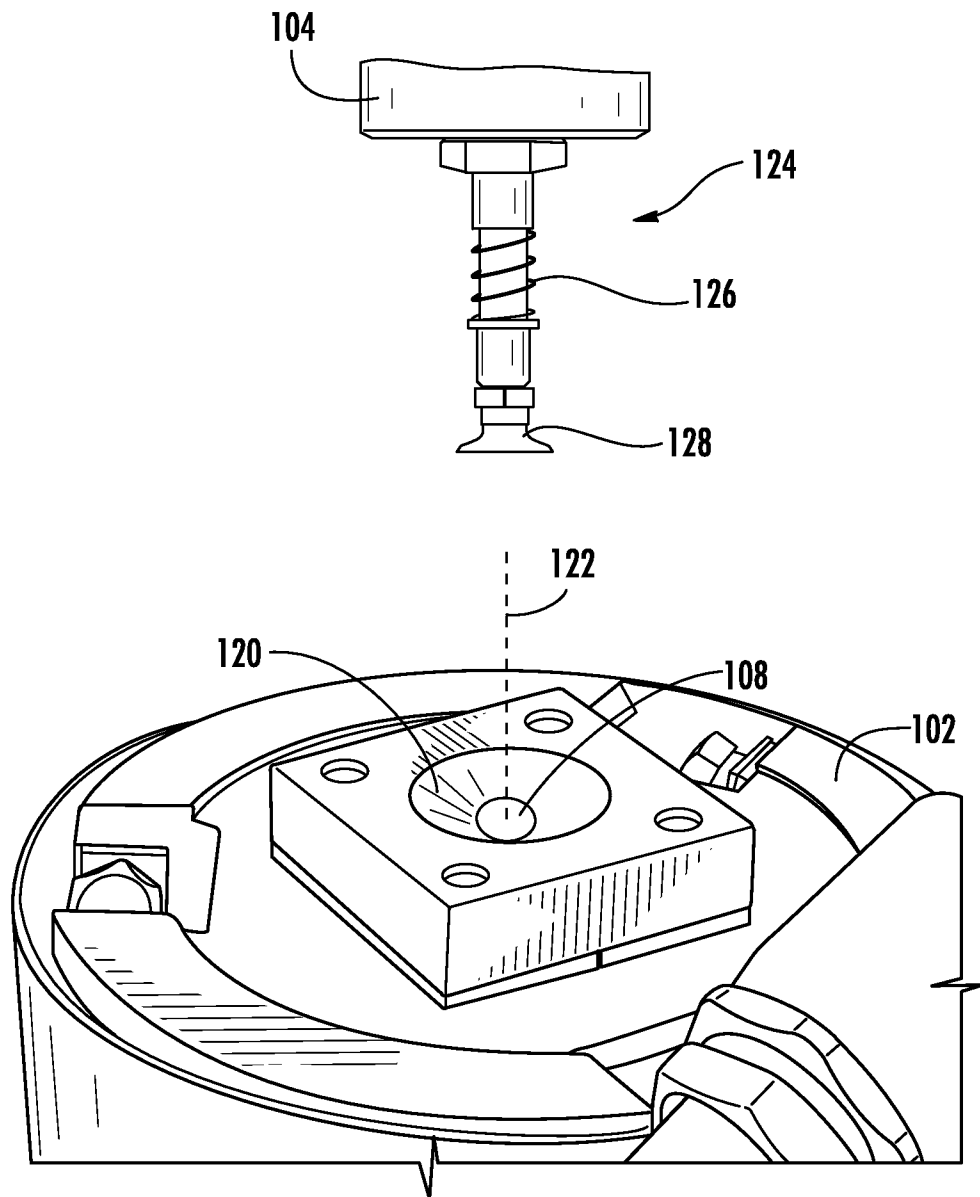


FIG. 2

3/9

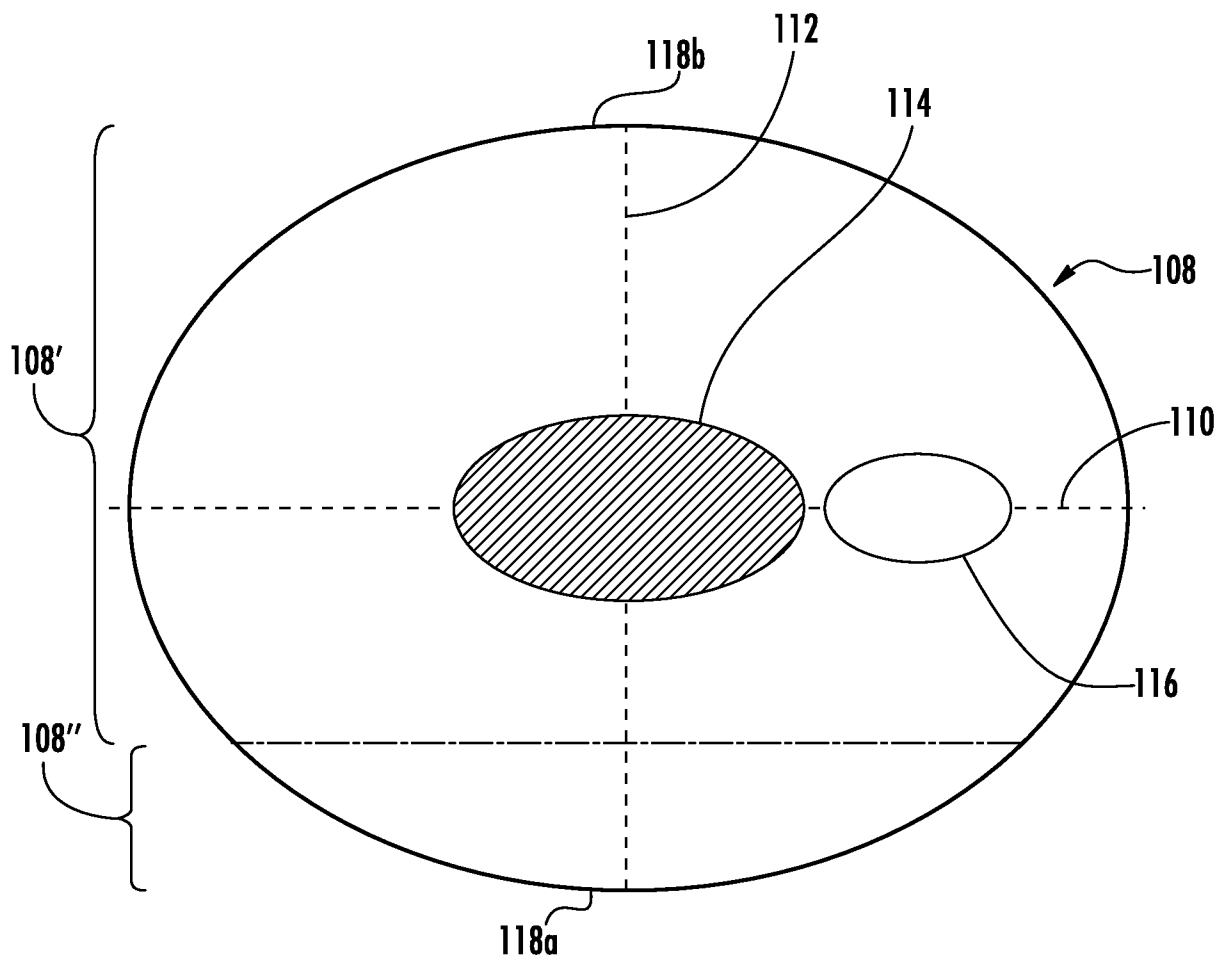


FIG. 3

4/9

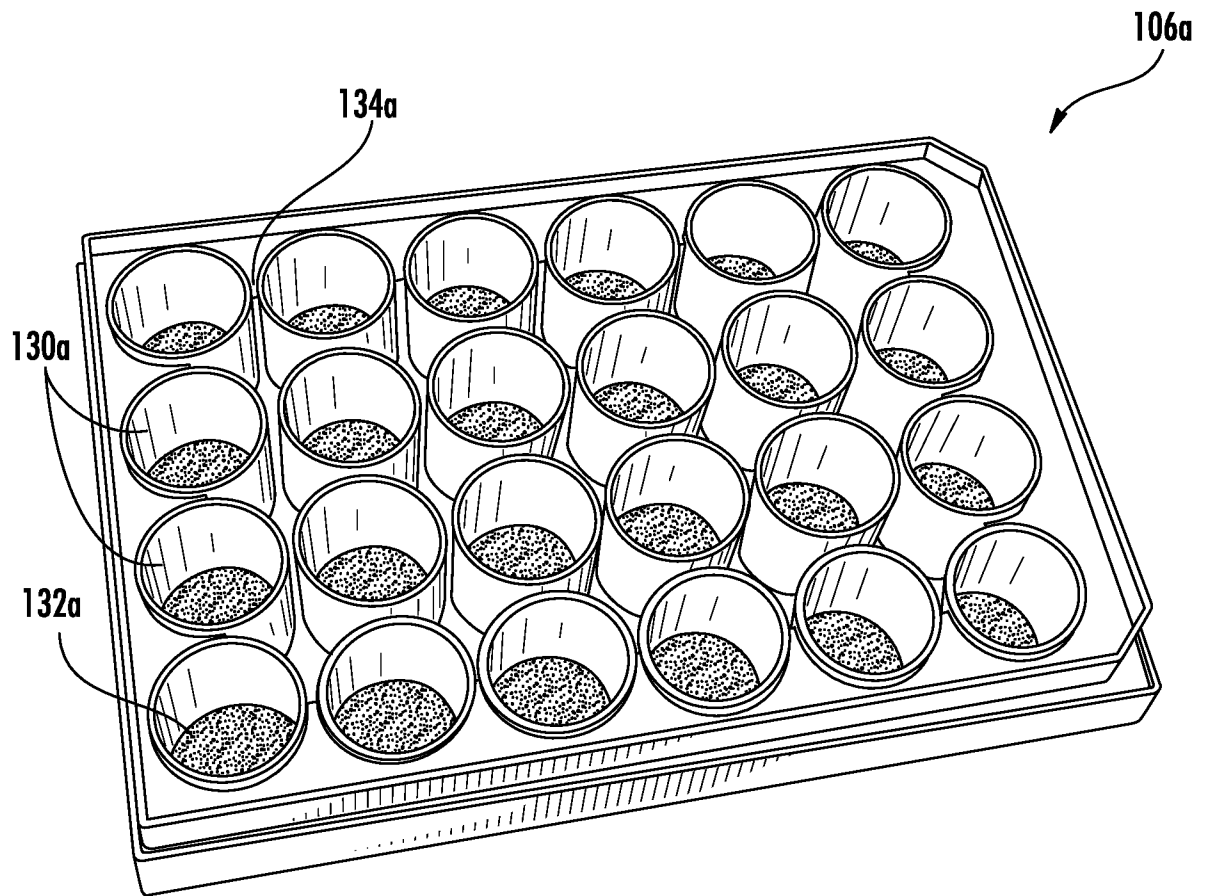


FIG. 4

5/9

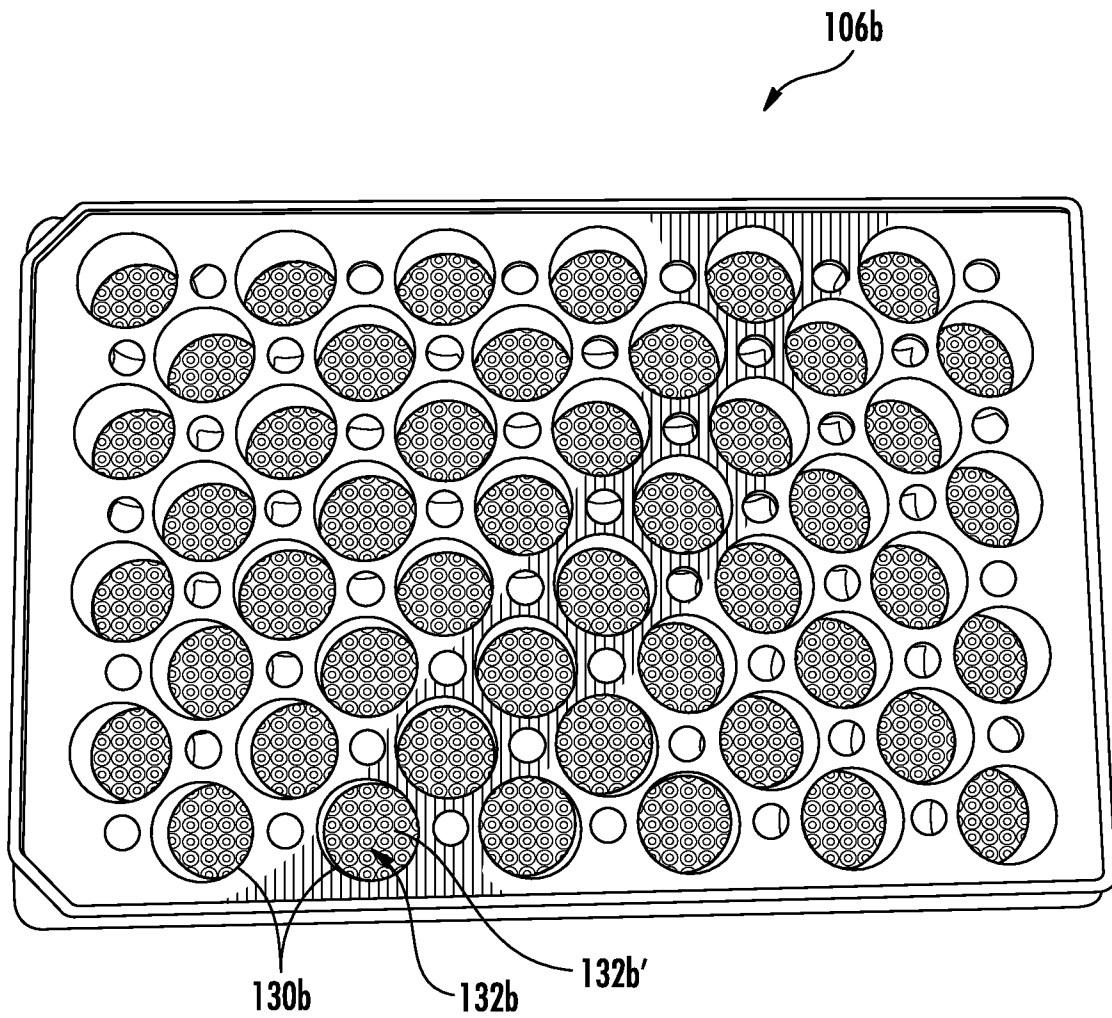


FIG. 5

6/9

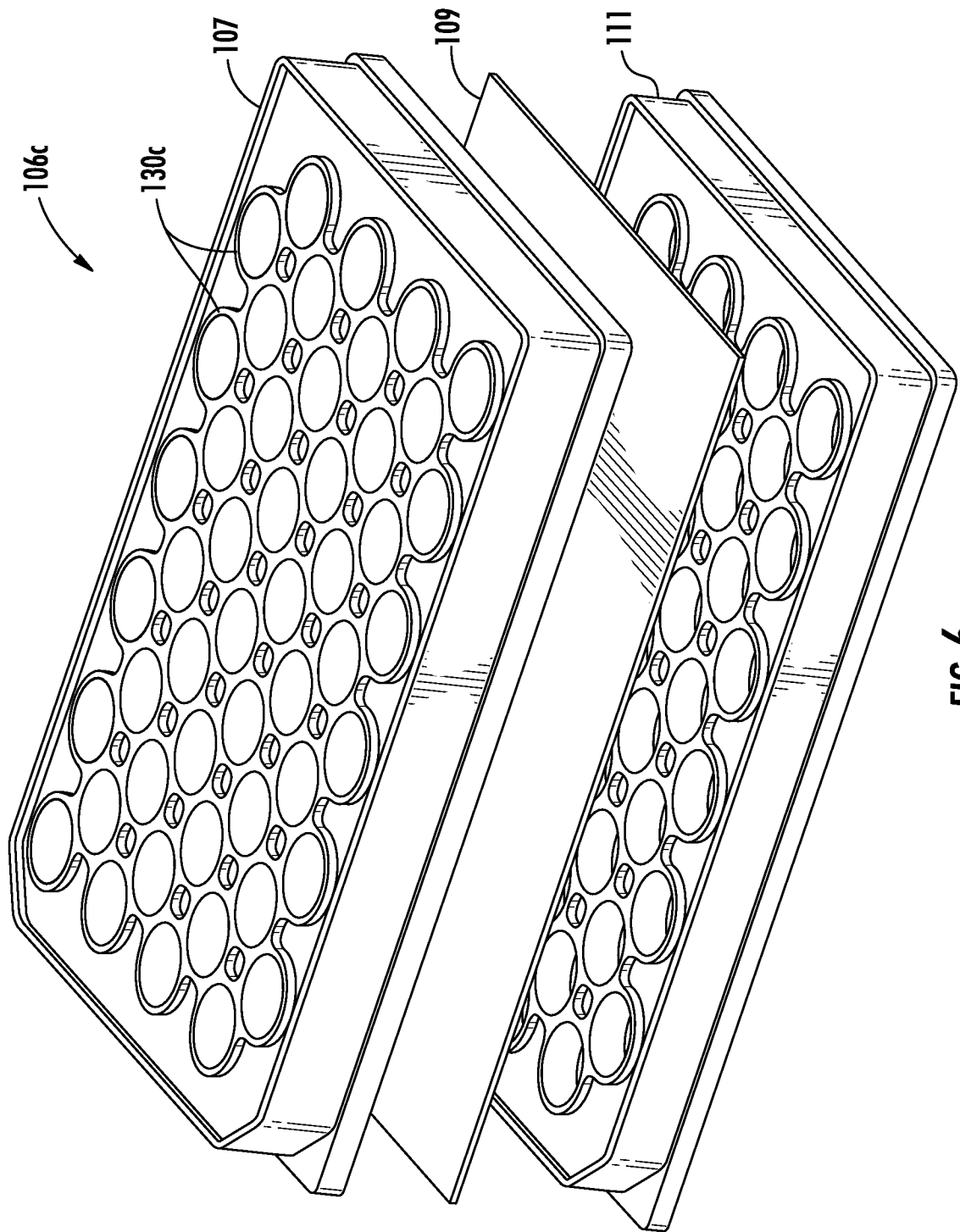


FIG. 6

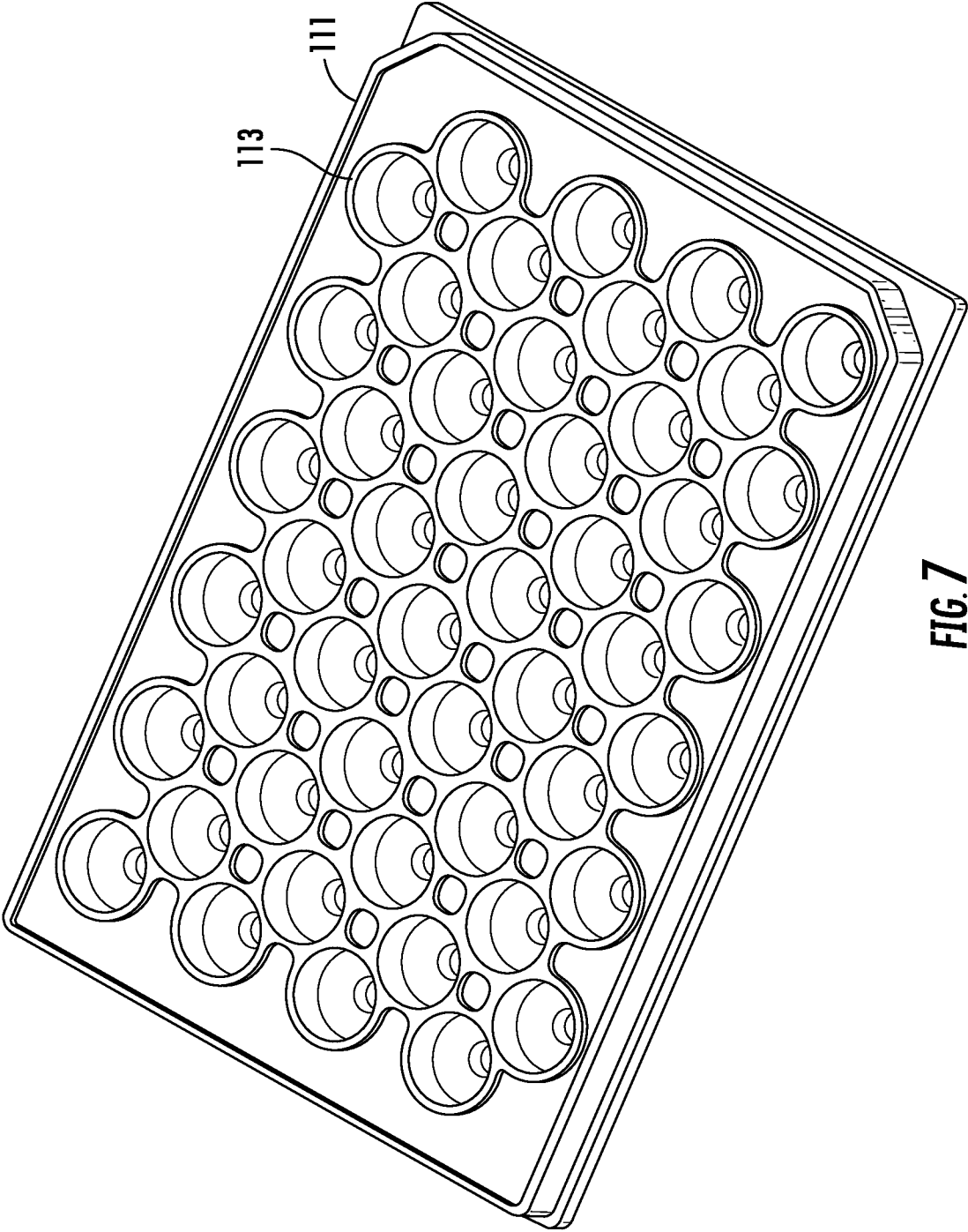


FIG. 7

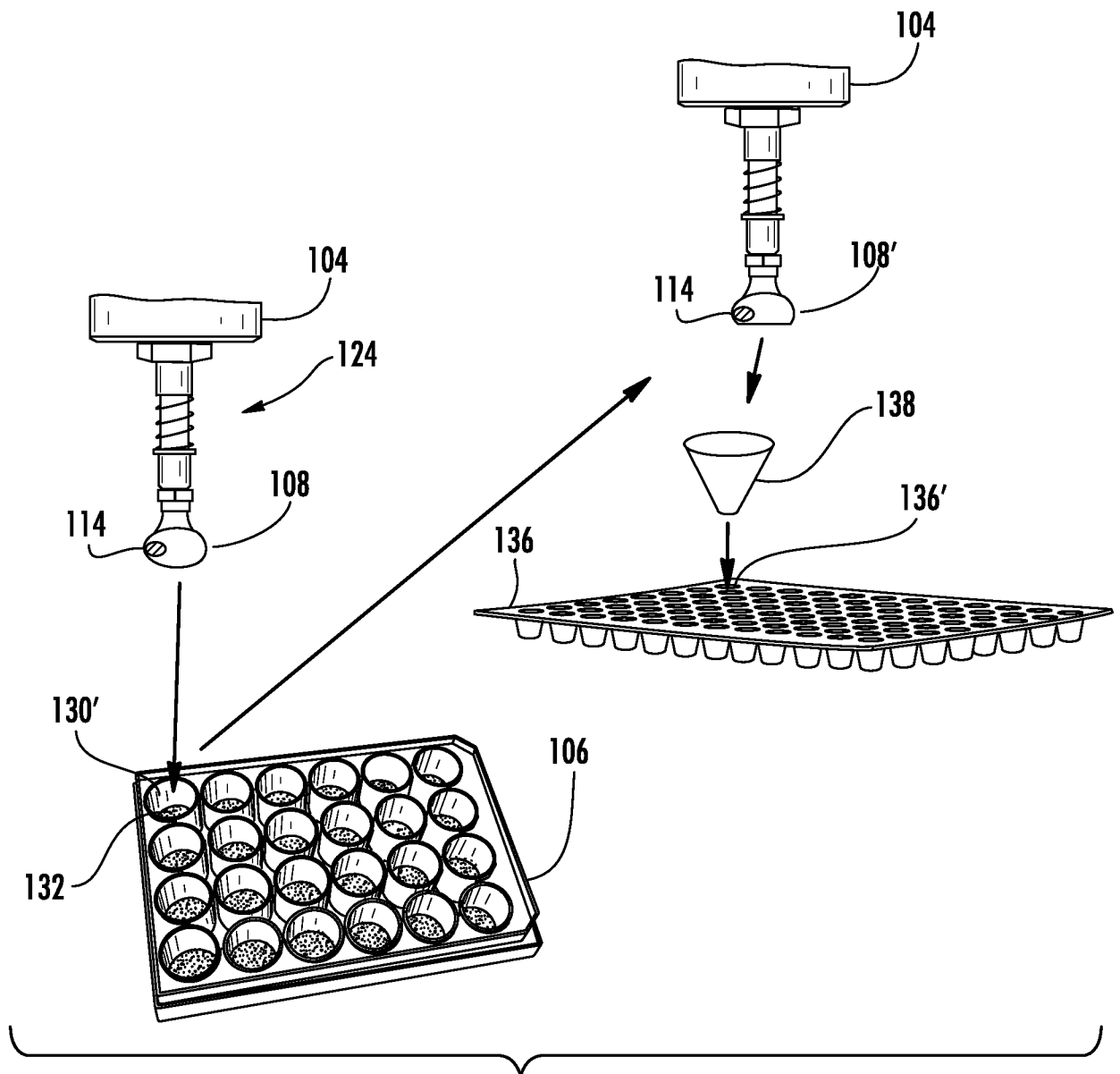


FIG. 8

