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(54) **METHODS AND APPARATUS FOR SAMPLE FRACTURING**

(71) Applicant: **DOW AGROSCIENCES LLC**, Indianapolis, IN (US)

(72) Inventors: **Sandra Grace Toledo**, West Lafayette, IN (US); **Marcelo Julio Sosa**, West Lafayette, IN (US)

(73) Assignee: **DOW AGROSCIENCES LLC**, Indianapolis, IN (US)

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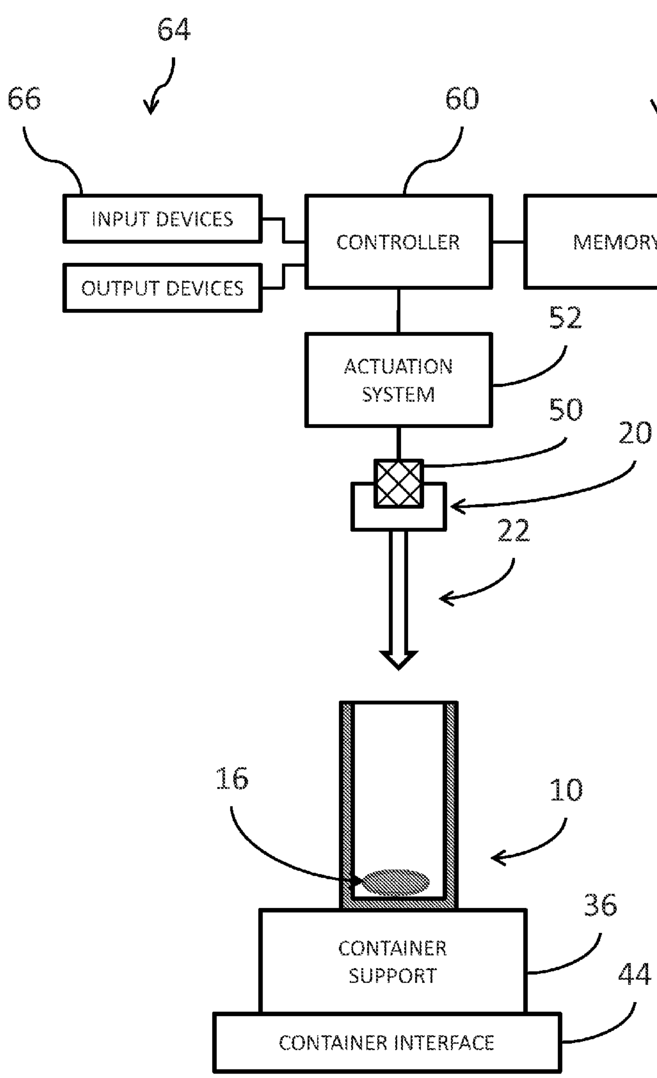
B02C 1/04 (2006.01)

(52) **U.S. Cl.**
USPC **241/6**; 241/199.11; 241/27

(57) **ABSTRACT**

An apparatus is disclosed which may be used to homogenize a sample in a container. In one embodiment, the apparatus includes a container and a cap with a fracturing member rigidly attached to the cap such that the fracturing member engages a sample as the cap is coupled to the container. In an example embodiment, the container is a test tube and the sample is a seed, such as a corn kernel. Methods of fracturing samples in containers with fracturing members rigidly attached to caps are also disclosed.



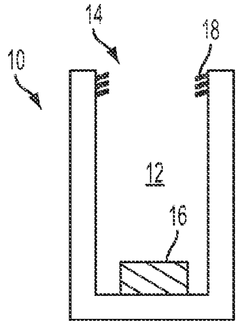


FIG. 1

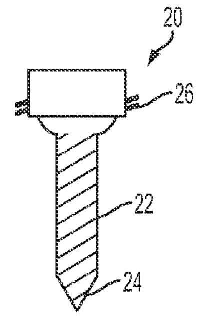


FIG. 2

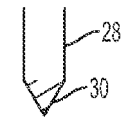


FIG. 3A

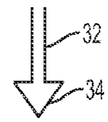


FIG. 3B

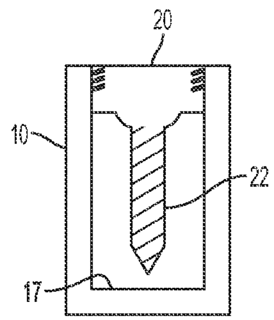


FIG. 4

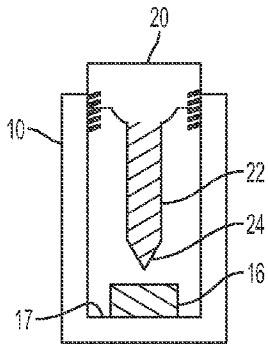


FIG. 5

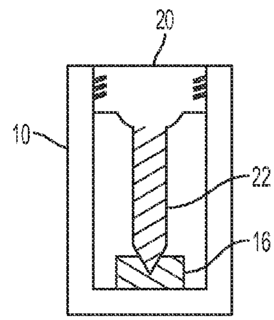


FIG. 6

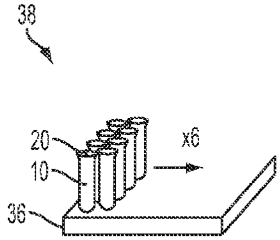


FIG. 7

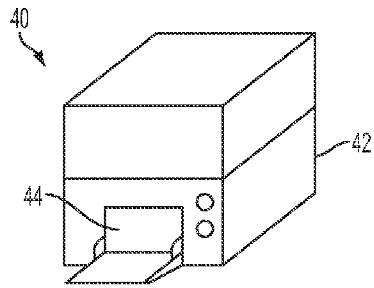


FIG. 8

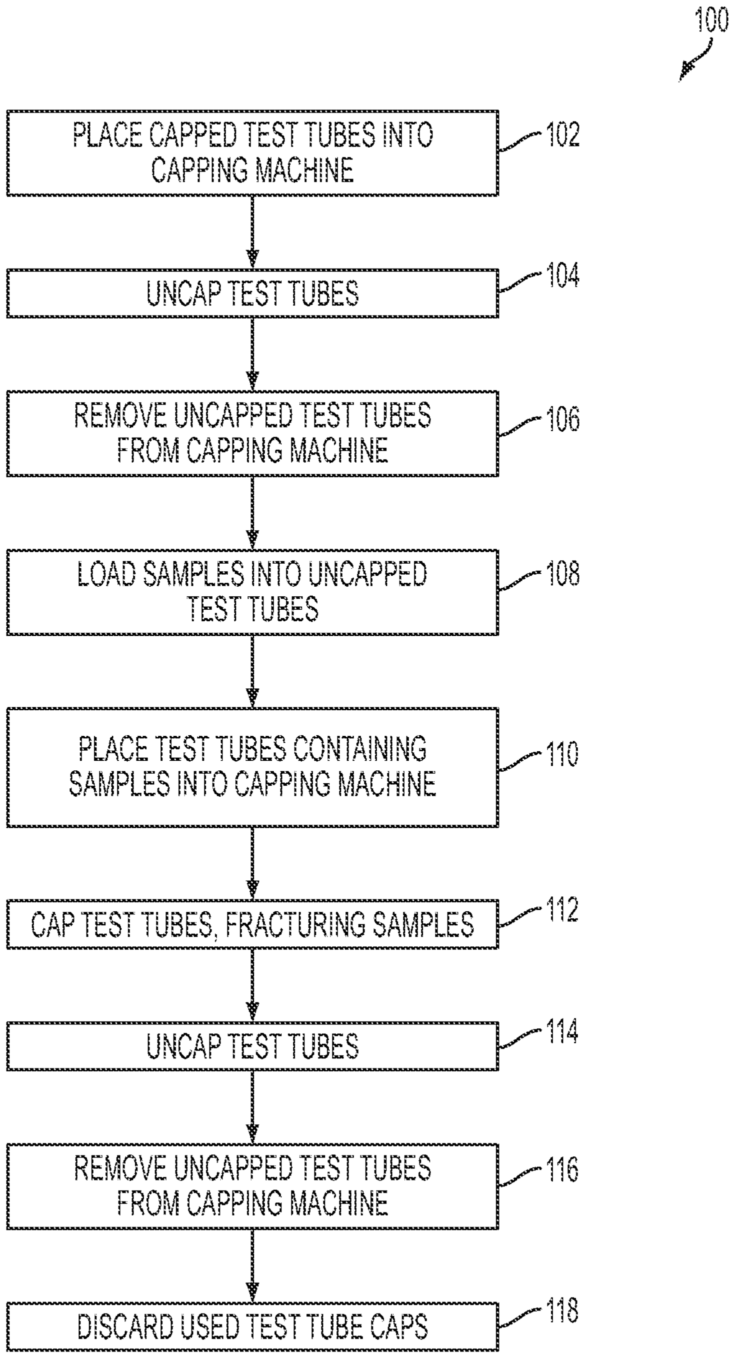

100
PLACE CAPPED TEST TUBES INTO CAPPING MACHINE
102
UNCAP TEST TUBES
104
REMOVE UNCAPPED TEST TUBES FROM CAPPING MACHINE
106
LOAD SAMPLES INTO UNCAPPED TEST TUBES
108
PLACE TEST TUBES CONTAINING SAMPLES INTO CAPPING MACHINE
110
CAP TEST TUBES, FRACTURING SAMPLES
112
UNCAP TEST TUBES
114
REMOVE UNCAPPED TEST TUBES FROM CAPPING MACHINE
116
DISCARD USED TEST TUBE CAPS
118

FIG. 9

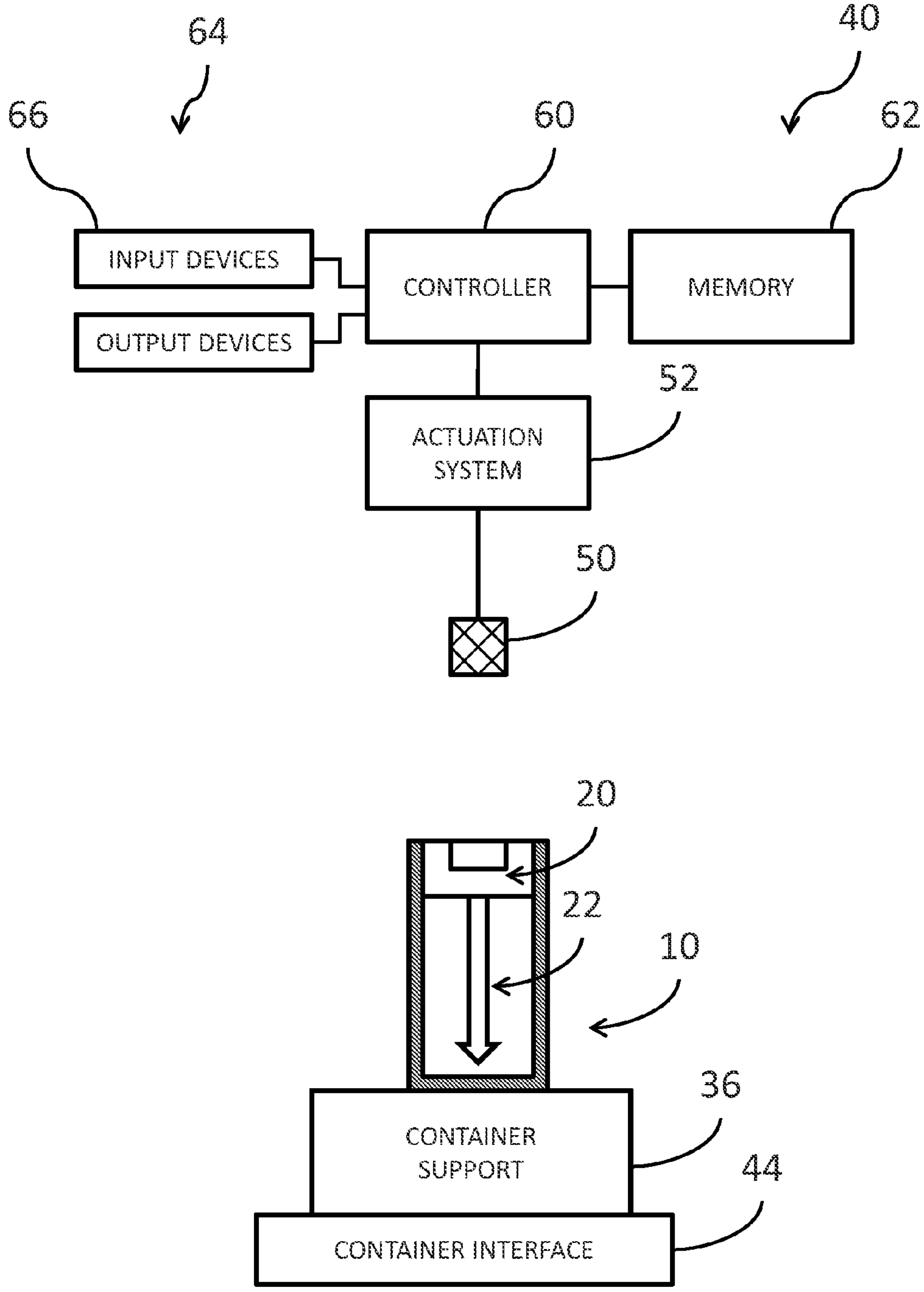
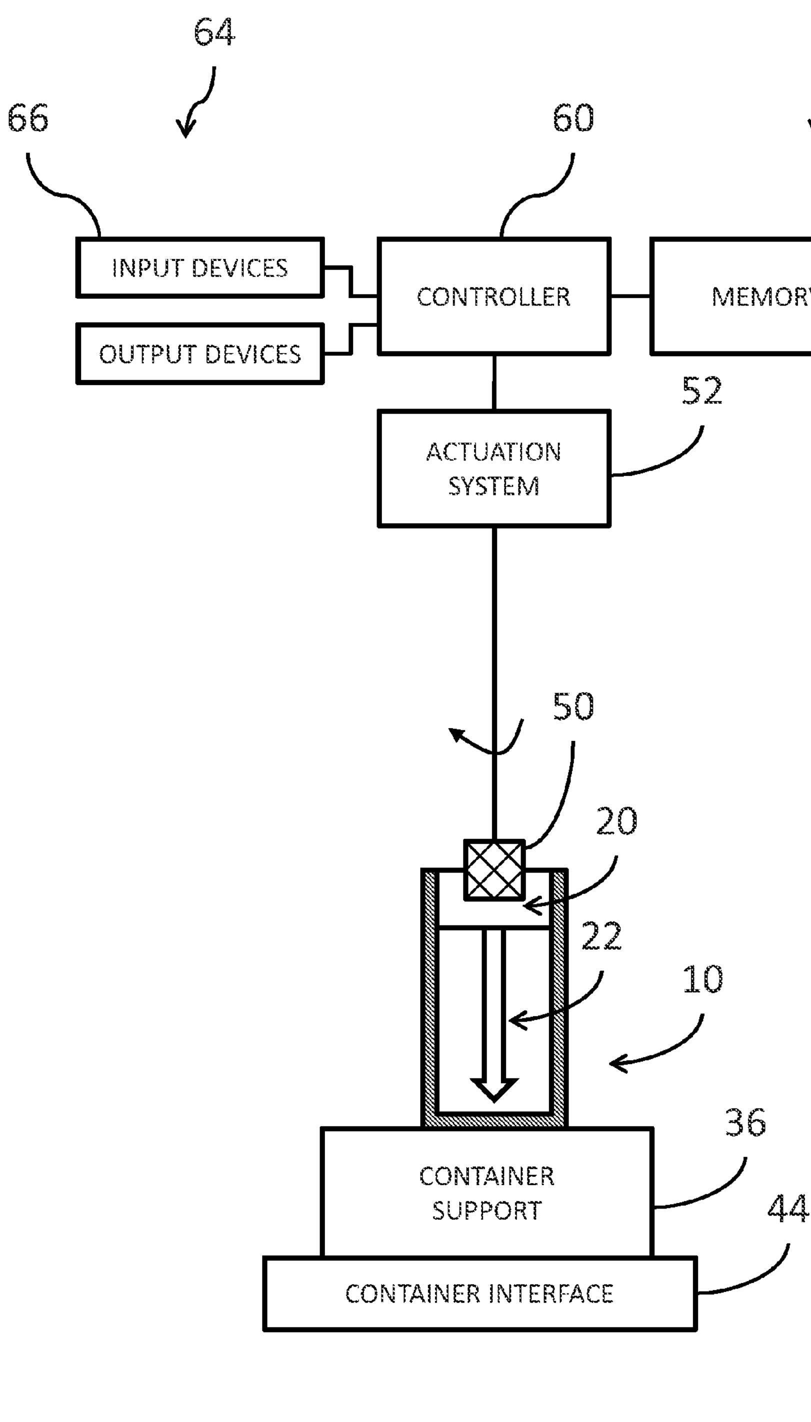

64
40
66
60
62
INPUT DEVICES
CONTROLLER
MEMORY
OUTPUT DEVICES
52
ACTUATION SYSTEM
50
20
22
10
36
CONTAINER SUPPORT
44
CONTAINER INTERFACE

FIG. 10A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62
INPUT DEVICES
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OUTPUT DEVICES
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ACTUATION SYSTEM
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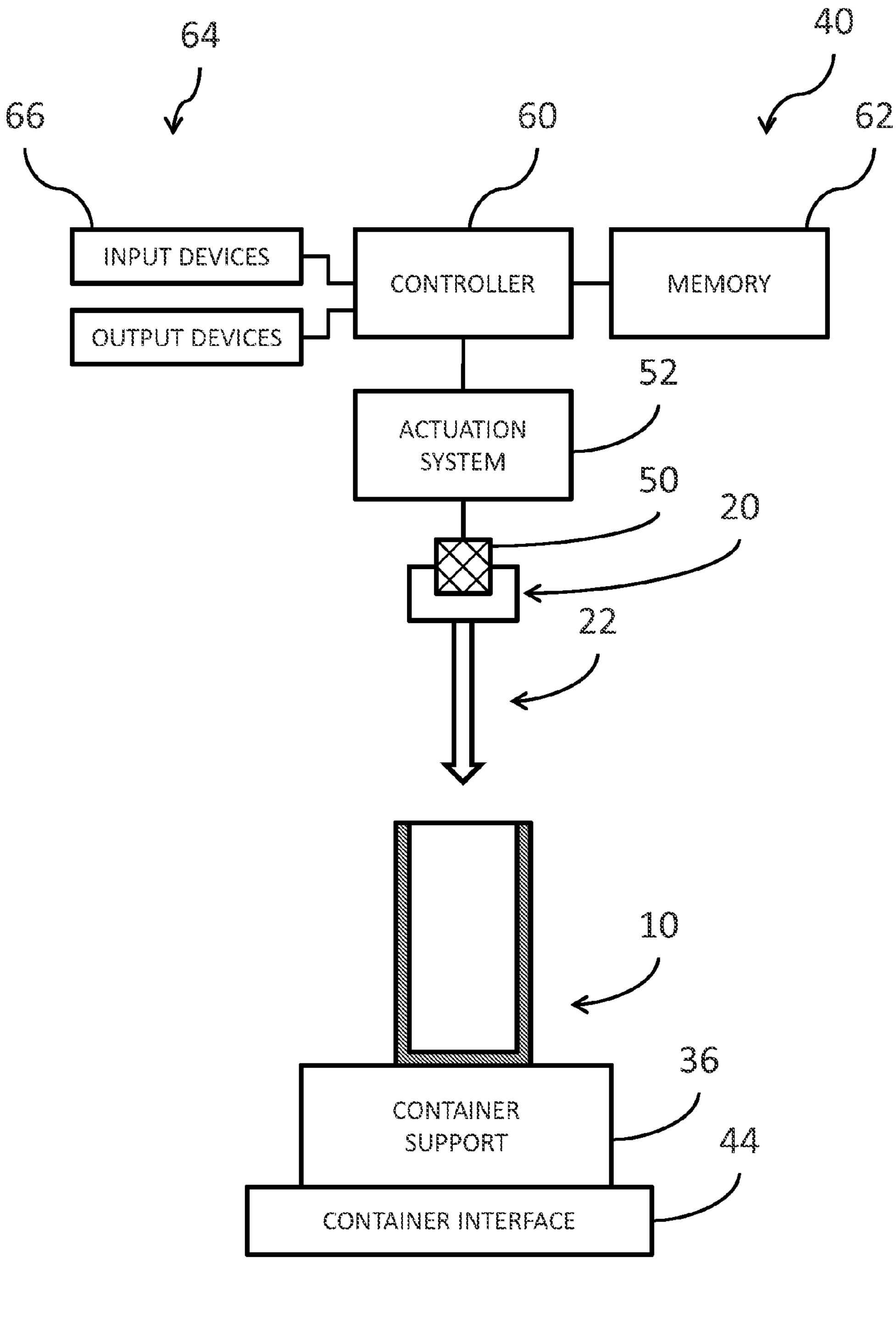
36
CONTAINER SUPPORT
44
CONTAINER INTERFACE

FIG. 10B


64
40
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62
INPUT DEVICES
CONTROLLER
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OUTPUT DEVICES
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ACTUATION SYSTEM
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22
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36
CONTAINER SUPPORT
44
CONTAINER INTERFACE

FIG. 10C

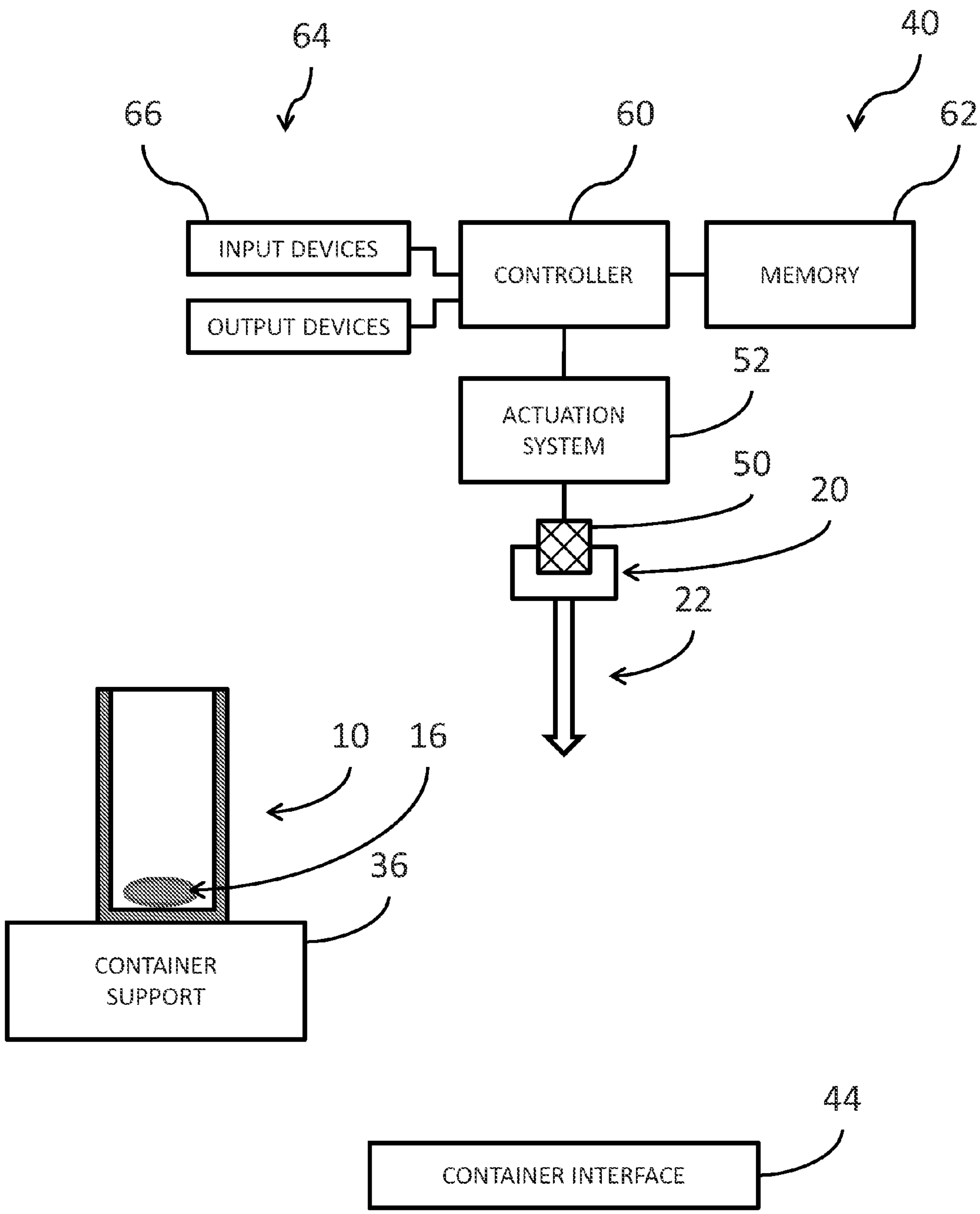

64
40
66
60
62
INPUT DEVICES
CONTROLLER
MEMORY
OUTPUT DEVICES
52
ACTUATION SYSTEM
50
20
22
10
16
36
CONTAINER SUPPORT
44
CONTAINER INTERFACE

FIG. 10D

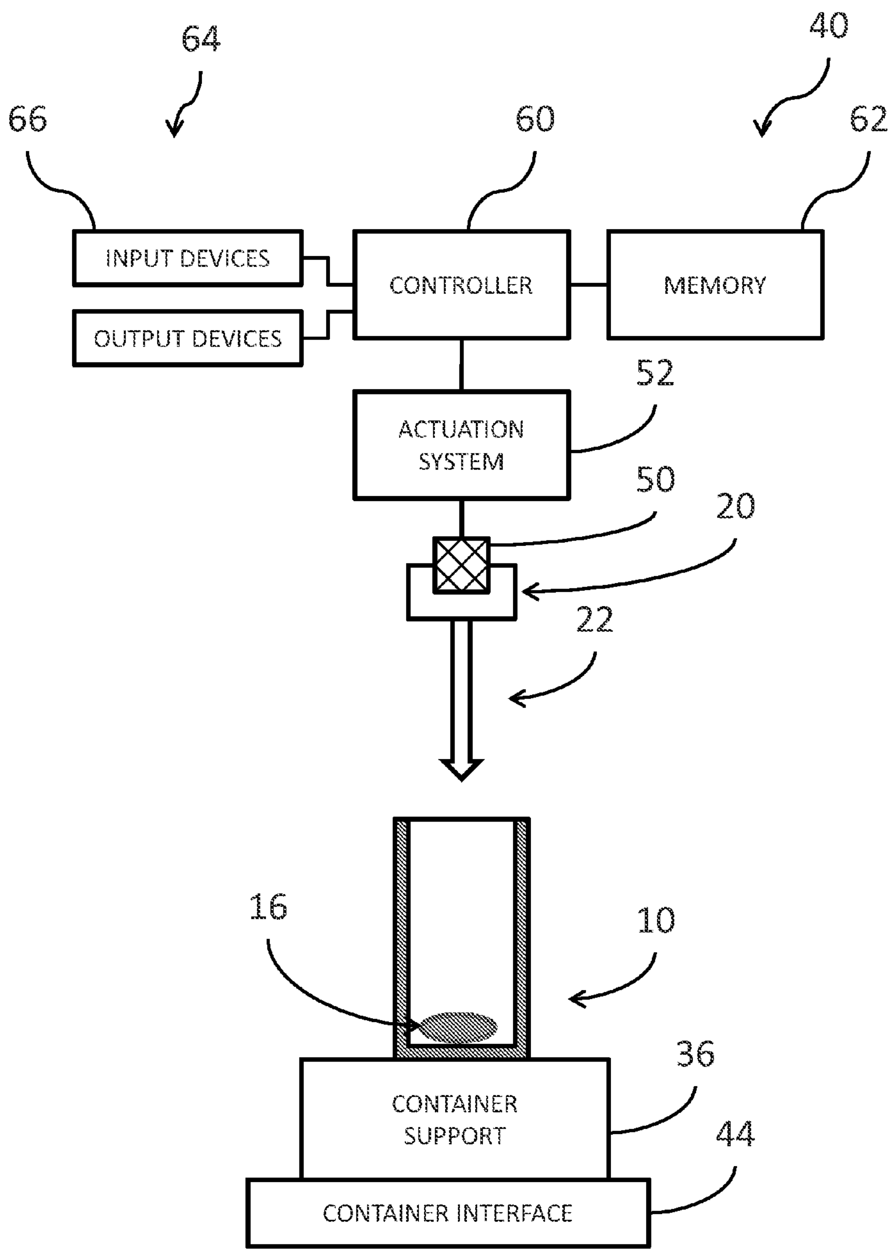

64
40
66
60
62
INPUT DEVICES
OUTPUT DEVICES
CONTROLLER
MEMORY
52
ACTUATION SYSTEM
50
20
22
16
10
36
CONTAINER SUPPORT
44
CONTAINER INTERFACE

FIG. 10E

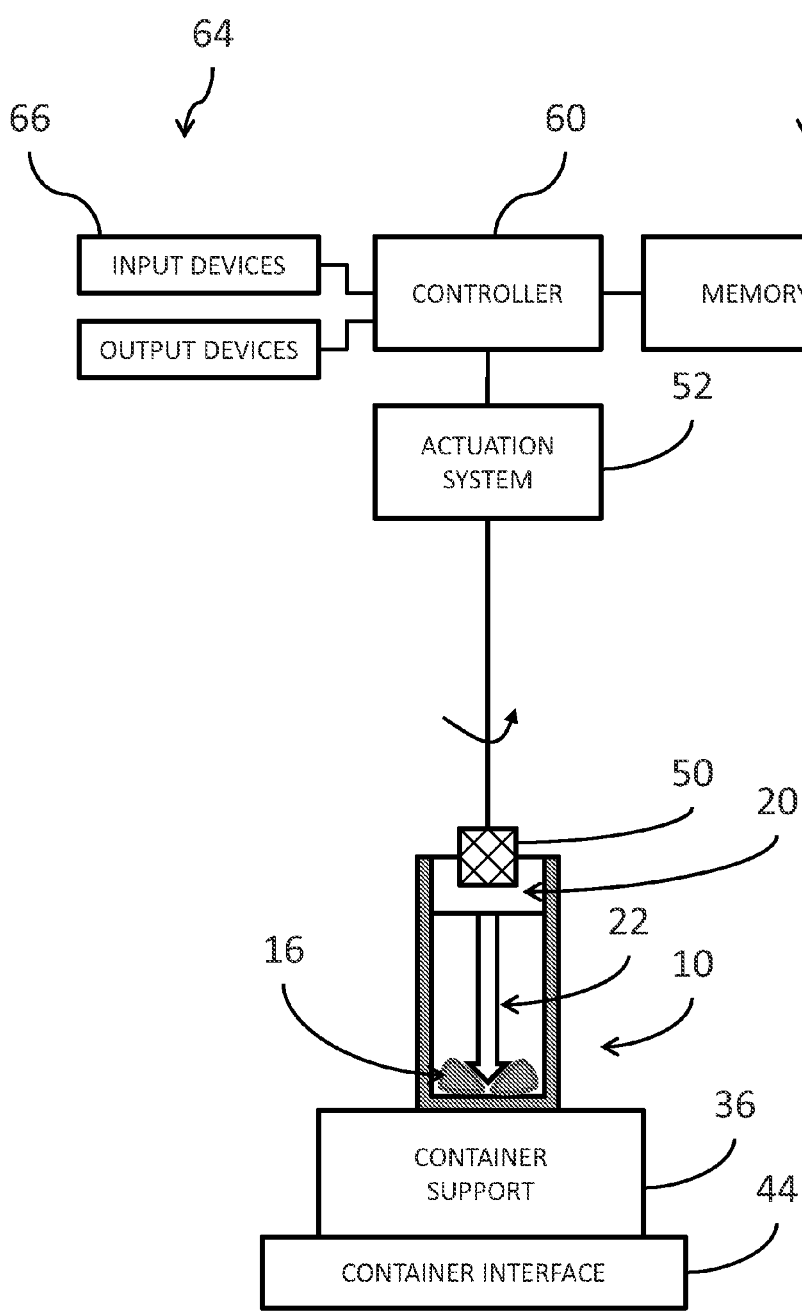
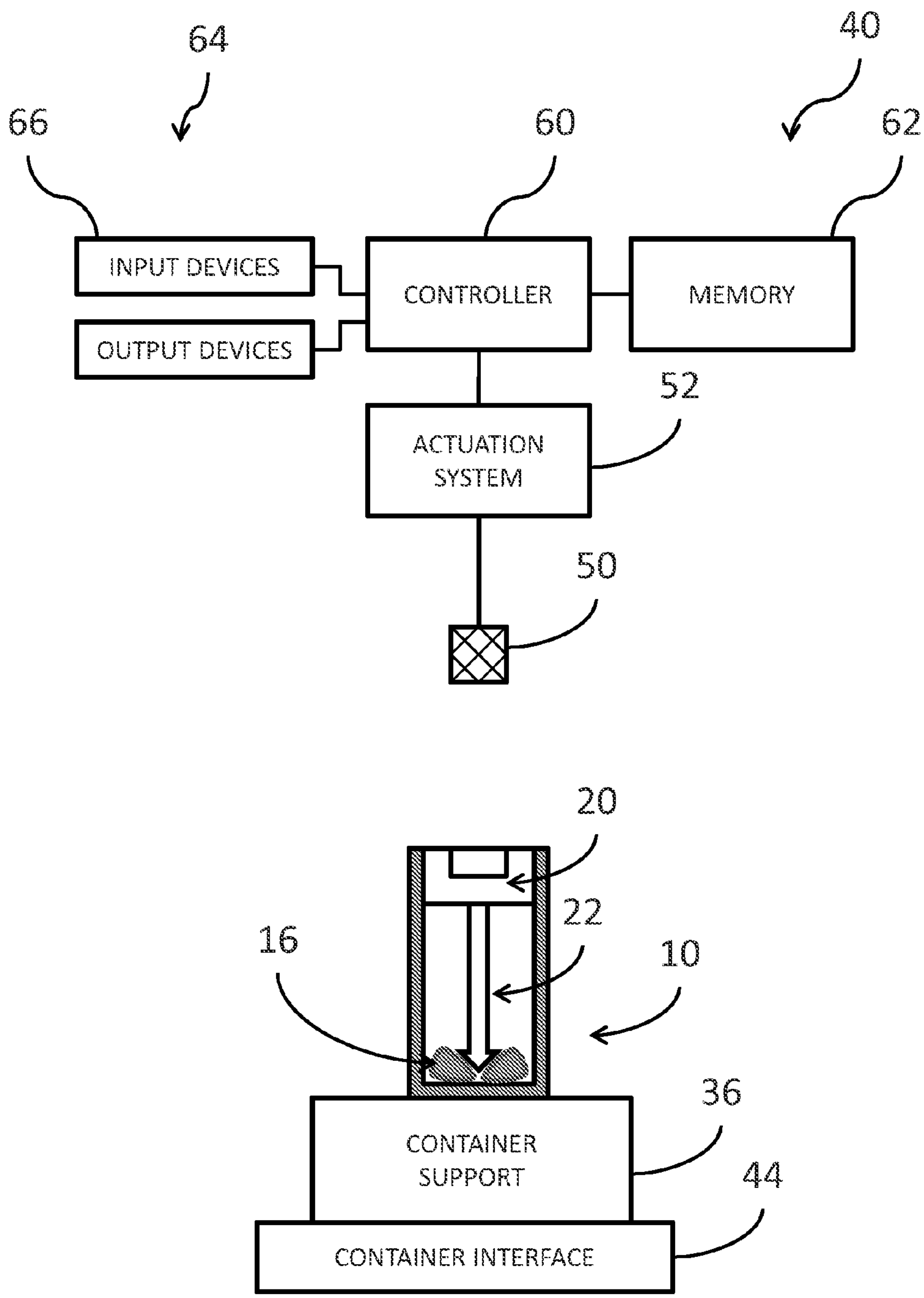

64
40
66
60
62
INPUT DEVICES
CONTROLLER
MEMORY
OUTPUT DEVICES
52
ACTUATION SYSTEM
50
20
22
16
10
36
CONTAINER SUPPORT
44
CONTAINER INTERFACE

FIG. 10F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40
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62
INPUT DEVICES
CONTROLLER
MEMORY
OUTPUT DEVICES
52
ACTUATION SYSTEM
50
20
22
16
10
36
CONTAINER SUPPORT
44
CONTAINER INTERFACE

FIG. 10G

METHODS AND APPARATUS FOR SAMPLE FRACTURING

RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application Ser. No. 61/556,208, filed Nov. 5, 2011, titled METHODS AND APPARATUS FOR SAMPLE FRACTURING, docket DAS-P0216-US, the disclosure of which is expressly incorporated by reference herein.

FIELD

[0002] The present invention relates to methods and apparatus for fracturing samples and in particular to methods and apparatus for fracturing hard exterior samples in an interior of a container.

BACKGROUND

[0003] Homogenization of maize kernels requires the fracturing of the hard exterior of maize kernels. This currently is a labor intensive process that is accomplished manually or through using commercially available homogenizers. Manual grinding is time consuming, ergonomically challenging, and may be a source of cross-contamination if the grinding device is not properly cleaned between samples. The same cross-contamination risk is present when using low-throughput grinding mills.

[0004] Steel beads have also been used to attempt to fracture the hard exterior of the maize kernels. The steel beads are placed within a test tube holding the kernel to be fractured. However, fracturing of the kernels is minimal.

[0005] A device is desired which may quickly and effectively fracture hard exterior samples, such as maize kernels, while minimizing cross-contamination. By providing improved fracturing of the maize kernels, improved differentiation between positive and negative results in later analysis, such as enzyme-linked immunosorbent assay ("ELISA") testing for a given protein may be achieved.

SUMMARY

[0006] In an exemplary embodiment of the present disclosure, a fracturing apparatus is provided. The fracturing apparatus comprising a container including a bottom and an open top and a cap including a first portion removably coupled to the container and a second portion including a fracturing member extending downward from the first portion. An interior of the container being accessible through the open top. When the cap is coupled to the container the fracturing member extends through the interior of the container and a lower end of the fracturing member is proximate to the bottom of the container. The lower end of the fracturing member being in a fixed position relative to the first portion of the cap.

[0007] In another exemplary embodiment of the present disclosure, a fracturing apparatus is provided, The fracturing apparatus comprising a container including a bottom and an open top, an interior of the container being accessible through the open top; a container support which positions the container in a first orientation; a cap including a first portion removably coupled to the container and a second portion including a fracturing member extending downward from the first portion; a cap support which supports the cap in a second orientation, wherein in the second orientation the fracturing member is positioned directly over the bottom of the container; and an actuator which changes the orientation of at least one of the container and the cap relative to the other, decreasing the distance between the bottom of the container and the lower end of the fracturing member and coupling the first portion of the cap to the container.

[0008] In yet another exemplary embodiment of the present disclosure, a method of fracturing samples in a container is provided, The method comprising the steps of positioning a cap relative to the container; and coupling the cap to the open end of the container, the cap including a first portion and a second portion, wherein when the cap is coupled to the open top of the container, the first portion extends over the open end of the container and the second portion extends through the interior of the container and includes a fracturing member, a lower end of the fracturing member being proximate to the bottom of the container, the lower end of the fracturing member being in a fixed position relative to the first portion of the cap.

[0009] The above mentioned and other features of the invention, and the manner of attaining them, will become more apparent and the invention itself will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** illustrates an exemplary embodiment of a container in which a sample has been placed;

[0011] FIG. **2** illustrates an exemplary cap including an exemplary embodiment of a fracturing member;

[0012] FIGS. **3**A and **3**B illustrate other exemplary embodiments of fracturing members;

[0013] FIG. **4** illustrates an empty exemplary container coupled to the exemplary cap of FIG. **2**;

[0014] FIG. **5** illustrates the exemplary cap of FIG. **2** positioned above the exemplary container of FIG. **1** with the fracturing member extending into the interior of the container;

[0015] FIG. **6** illustrates the exemplary assembly shown in FIG. **5** after the exemplary cap has been coupled to the exemplary container, fracturing the sample placed inside;

[0016] FIG. **7** illustrates an exemplary arrangement of containers on a container support;

[0017] FIG. **8** illustrates an exemplary capping machine for a plurality of test tubs on a rack;

[0018] FIG. **9** illustrates an exemplary processing sequence using a capping machine; and

[0019] FIGS. **10**A-**10**G illustrate a representative view of an exemplary capping machine for fracturing samples.

DETAILED DESCRIPTION OF THE DRAWINGS

[0020] The embodiments disclosed below are not intended to be exhaustive or to limit the invention to the precise forms disclosed in the following detailed description. Rather, the embodiments are chosen and described so that others skilled in the art may utilize their teachings. While the present disclosure is primarily directed to the preparation of seed samples within a sterile environment, it should be understood that the features disclosed herein may have application to the preparation of other types of samples.

[0021] Referring to FIG. **1**, a container **10** is shown. In the illustrated exemplary embodiment, container **10** is a test tube. However, other container types and shapes may also be used. In one exemplary embodiment, container **10** is approximately

3 inches in height, shown as D**1** in FIG. **4**, although other sizes are also contemplated. The container **10** defines an interior **12** accessible through an open end **14**. Although a container with a flat bottom is shown, other configurations such as a rounded or a pointed bottom are also contemplated. A sample **16** is shown placed in the interior **12** of the container **10** through open top **14**. In one example embodiment, the sample **16** has a hard exterior. An exemplary hard exterior sample is a seed, such as a corn kernel.

[0022] Also shown in the illustrated embodiment of FIG. **1**, threads **18** are provided on the interior **12** of container **10**. In another example embodiment, threads **18** are provided on the exterior of the container **10**. In yet another embodiment, no threads are on the container **10**.

[0023] Referring to FIG. **2**, a cap **20** for the container **10** is shown. In one example embodiment, the cap **20** includes a first portion for removably coupling the cap **20** to the container **10** and a second portion including a fracturing member **22** extending downward from the first portion **21**. An engaging portion **24** is located at a lower end of the fracturing member **22**.

[0024] In one embodiment, the second portion **23** of the cap **20**, including the fracturing member **22**, is in a fixed position relative to the first portion **21** of the cap **20**. In another embodiment, the lower end of the fracturing member **22** is in a fixed position relative to the first portion of the cap **20**. In still another embodiment, the engaging portion **24** is in a fixed position relative to the first portion **21** of the cap **20**.

[0025] In the illustrated embodiment, the second portion **21** of the cap **20** including the fracturing member **22** is rigidly attached to the cap **20**. In one example embodiment, the fracturing member **22** is attached using a press fit. Other attachments are contemplated, some examples including glue or molding the cap **20** around the fracturing member **22**. In one embodiment, the fracturing member **22** is removably coupled to the first portion **21**. In one example, fracturing member **22** and the first portion **21** have threaded portions which cooperate to couple the fracturing member to the first portion **21**. In one embodiment, the first portion **21** and second portion **23** of the cap **20** including the fracturing member **22** are a unitary device.

[0026] In the illustrated embodiment shown in FIG. **2**, cap **20** includes threads **26** on the outside of the cap **20**. Threads **26** cooperate with thread **18** of container **10** to couple cap **20** to container **10**. In the illustrated embodiment, threads **26** are on the exterior of the cap **20** to engage with threads **18** on the interior of the container **10**. In one embodiment, threads **26** are on the interior of the cap **20** to engage with threads **18** on the exterior of the container **10**.

[0027] Other methods of coupling the container **10** to a cap **20** besides using threads, such as press-fit, friction fit, and tongue and groove are also contemplated. Further, cap **20** may engage portions of container **10** not proximate to open end **14** to couple cap **20** to container **10**. In one embodiment, an additional component positions cap **20** relative to container **10** such that fracturing member **22** engages a sample within the interior **12** of container **10**.

[0028] In one example embodiment, the fracturing member **22** is a screw attached to the first portion **21** of the cap **20**. In one example embodiment, the screw is a flat-head wood screw, such as a number 6, ½ inch wood screw attached to the first portion **21** of the cap **20**. Other sizes and types of screws may also be used. In another example embodiment, the fracturing member **22** is not a screw, but is unitary with the first portion **21** of the cap **20**.

[0029] In other example embodiments, the fracturing member **22** is of the type shown in either FIGS. **3**A and **3**B. FIG. **3**A shows an example alternative fracturing member **28** in which only the bottom engaging portion **30** is threaded. FIG. **3**B shows a second example alternative fracturing member **32** in which the engaging portion **34** is spear shaped. Other designs for a fracturing member that include an engaging portion at one end are also contemplated and may be used depending on the size and material of the sample.

[0030] In one embodiment, fracturing member **22** is shaped to press against the hard exterior of a sample **16** and to penetrate or otherwise crack the hard exterior of the sample. In one embodiment, container **10** includes a protrusion which engages sample **16** and sample **16** is pressed against the protrusion to crack the hard exterior of the sample.

[0031] Referring next to FIG. **4**, an assembly of an empty container **10** and cap **20** with the cap **20** coupled to the container **10** is shown. Fracturing member **22** extends downward into the interior **12** of the container **10**.

[0032] Referring next to FIG. **5**, an assembly of an empty container **10** and cap **20** with the cap **20** positioned above a container **10** in which a sample **16** has been placed. In this position, the fracturing member **22** has not yet engaged the sample **16** to fracture the sample **16**. In one embodiment, the container **10** is shaped to generally position the sample **16** under the fracturing member **22**. In the illustrated embodiment, the diameter of the interior of container **10** is selected to generally position the sample **16** under the fracturing member **22**.

[0033] Referring next to FIG. **6**, the container **10** is shown with the cap **20** coupled to container **10** in which sample **16** has been placed. The coupling of cap **20** and container **10** engages the engaging tip **24** of fracturing member **22** into the sample **16**, fracturing the sample **16**. Although FIGS. **5** and **6** illustrate one embodiment of coupling the container **10** with the cap **20** with threads **18** and **26**, other methods are also contemplated.

[0034] In the illustrated embodiment shown in FIGS. **5** and **6**, a length of the fracturing member **22** is selected to engage and fracture the sample when the cap and container are assembled. As shown in FIG. **6**, the engaging portion **24** of fracturing device **22** is spaced apart from a bottom, interior surface **17** of container **10**. In one example embodiment, the distance between the lower end of the fracturing member **22** and the bottom surface **17** of the container **10**, shown as D2 on FIG. **4**, is up to about 0.5 inches when cap **20** is coupled to container **10**. In another example embodiment, the distance between the lower end of the fracturing member **22** and the bottom surface **17** of the container **10**, shown as D2 on FIG. **4**, is up to about 0.1 inches. In still another example embodiment, the distance between the lower end of the fracturing member **22** and the bottom surface **17** of the container **10**, shown as D2 on FIG. **4**, is up to about 25% of the height of the container, shown as D1 on FIG. **4**. In yet another example embodiment, the distance between the lower end of the fracturing member **22** and the bottom surface **17** of the container **10**, shown as D2 on FIG. **4**, is up to about 10% of the height of the container, shown as D1 on FIG. **4**. In still yet another example embodiment, the distance between the lower end of the fracturing member **22** and the bottom surface **17** of the container **10**, shown as D**2** on FIG. **4**, is up to about 5% of the height of the container, shown as D**1** on FIG. **4**.

[0035] Referring now to FIG. **7**, one example embodiment of a container support **36** holding a plurality of containers **38** is shown. In some embodiments, each of the containers **10** in the plurality of containers **38** includes a cap **20**. In one example embodiment, the plurality of containers **38** is a plurality of test tubes. Other container types, shapes, and sizes of containers **10** are also contemplated. FIG. **7** shows a pattern of 48 containers **10** on a container support **38**, but other quantities and arrangements of containers **10** are also contemplated. In the illustrated embodiment, container support **36** is a test tube rack which includes a plurality of recesses, each sized to receive and support a respective test tube such that the respective test tube is spaced apart from adjacent test tubes and is generally vertically oriented.

[0036] FIG. **8** illustrates an exemplary capping machine **40**. Capping machine **40** includes a housing **42** and a container interface **44** which receives a container support **36**. In one embodiment, container interface **44** is a rotatable platform onto which container support **36** is placed. In one embodiment, container interface **44** is a conveyor system which transports the container support **36**. An exemplary automatic capping machine is the Capit-All brand screw cap tube capper/decapper available from Thermo Fisher Scientific Inc. in Waltham, Mass. Other methods for coupling and/or decoupling the containers **10** and caps **20** are also contemplated. Other example methods of coupling the containers **10** and caps **20** include pressing the caps **20** onto the containers **10**, rotating the caps **20** by hand, or using a power drill or other handheld instrument.

[0037] Referring to FIG. **10**A, a representative view of an exemplary capping machine **40** is shown. Capping machine **40** includes a container interface **44**, which is shown supporting container support **36**. Capping machine **40** further includes a cap support **50** which engages cap **10**. Exemplary cap supports include systems to support a cap **20** including a mechanical system, a vacuum system, and other suitable system for supporting cap **20**. In one embodiment, cap support **50** supports a cap **20** over a container **10** in a spaced apart relationship, the cap **20** being oriented so that fracturing member **22** may be received in the interior of container **10**. An exemplary mechanical system interfaces with grooves on cap **20** to grip or hold cap **20**. An exemplary cap support **50** is provided as part of the Capit-All brand screw cap tube capper/decapper available from Thermo Fisher Scientific Inc. in Waltham, Mass. In one embodiment, capping machine **40** includes a plurality of tools **50** which engage respective caps **10** of a plurality of containers **10**.

[0038] Capping machine **40** further includes an actuation system **52** which moves cap support **50**. In one embodiment, actuation system **52** moves cap support **50** relative to cap **20** and moves cap support **50** and actuation system **52** together. In one embodiment, actuation system **52** moves cap **20** to cause cap **20** to become coupled to container **10** or uncoupled from container **10**. In an example wherein container **10** and cap **20** include cooperating threads, actuation system **52** rotates cap support **50** and hence cap **20** in a first direction such that the threads on cap **20** engage the threads on container **10** and in a second direction such that the threads on cap **20** disengage from the threads on container **10**. An exemplary actuation system **52** is provided as part of the Capit-All brand screw cap tube capper/decapper available from Thermo Fisher Scientific Inc. in Waltham, Mass. In one embodiment, container interface **44** moves container **10** to cause container **10** to become coupled to cap **20** or uncoupled from cap **20**.

[0039] In the illustrated embodiment, capping machine **40** further includes a controller **60** which controls the operation of the actuation system **52**. In one embodiment, controller **60** is an electronic controller. An exemplary processing sequence **100** of controller **60** is provided in FIG. **9**. Controller **60** may execute software stored on a memory **62** which is accessible by controller **60** to perform one or more portions of processing sequence **100**. Controller **60** may include a hardware implementation to perform one or more portions of processing sequence **100**. In one embodiment, controller **60** includes one or more processors which execute software stored on one or more memories **62**.

[0040] Memory **62** is a computer readable medium and may be a single storage device or may include multiple storage devices, located either locally with controller **60** or accessible across a network. Computer-readable media may be any available media that may be accessed by controller **60** and includes both volatile and non-volatile media. Further, computer readable-media may be one or both of removable and non-removable media. By way of example, computer-readable media may include, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, Digital Versatile Disk (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which may be used to store the desired information and which may be accessed by controller **60**. In one embodiment, controller **60** communicates data, status information, or a combination thereof to a remote device for analysis.

[0041] Capping machine **40** further includes one or more I/O modules **64** which provide an interface between an operator and capping machine **40**. Exemplary I/O modules **64** include input members **66** and output members **68**. Exemplary input members **66** include buttons, switches, keys, a touch display, a keyboard, a mouse, and other suitable devices for providing information to controller **60**. Exemplary output devices **68** include lights, a display (such as a touch screen), printer, speaker, visual devices, audio devices, tactile devices, and other suitable devices for presenting information to an operator.

[0042] Referring to FIG. **9**, an exemplary processing sequence **100** is shown. In the exemplary processing sequence, containers **10** are provided with caps **20** already coupled thereto. In other embodiments, caps **20** are spaced apart from the containers.

[0043] The capped containers **10** are loaded into a container support **36**, if not already so situated. The capped containers are loaded into the container interface **44** of capping machine **40**, as represented by block **102**. Referring to FIG. **10**A, capping machine **40** positions the capped containers **10** generally under cap support **50**. This may be performed by the movement of container support **36** by container interface **44**, the movement of cap support **50** by actuation system **52**, or a combination thereof.

[0044] Capping machine **40** removes the cap **20** from container **10**, as represented by block **104**. Referring to FIG. **10**B, cap support **50** engages cap **20**. Actuation system **52** rotates cap **20** relative to container **10** to uncouple cap **20** from container **10**. Once uncoupled, cap **20** is raised relative to container **10** by cap support **50** and actuation system **52**. At this point, the uncapped container **10** may be removed from capping machine **40**, as represented by block **106**.

[0045] Sample **16** is loaded into the respective containers **10** as illustrated in FIG. **10**D and as represented by block **108**. In one embodiment, the sample **16** has a hard exterior. Exemplary samples include seeds such as maize kernels, soybeans, cotton seeds, wheat seeds, canola seeds, sunflower seeds, sorghum seeds, rice, and grass seeds.

[0046] The container **10** and container support are loaded again into capping machine **40**, as represented by block **110**. Referring to FIG. **10**E, the container **10** is positioned below the respective cap **20**. Actuation system **52** moves cap **20** downward relative to container **10** and couples cap **20** to container **10**, as illustrated in FIG. **10**F and as represented by block **112**. The downward movement of cap **20** causes fracturing member **22** to engage and fracture sample **16**. Actuation system **52** may rotate the cap **20** a predetermined number of rotations, or may rotate the cap **20** until a predetermined torque is reached for each cap.

[0047] In one embodiment, the caps **20** remain in place after fracturing until removed by an operator. In one embodiment, capping machine **40** removes caps **20** after sample **16** have been fractured, as illustrated in FIG. **10**G and as represented by block **114**. The uncapped containers are removed from capping machine **40**, as represented by block **116**.

[0048] In one embodiment, caps **20** are disposable and are discarded by capping machine **40**, as represented by block **118**. In one embodiment, cap **20** are reusable and are cleaned by capping machine **40** or otherwise stored by capping machine **40** for later cleaning.

[0049] In one embodiment, once sample **16** is fractured, sample **16** may be further ground to homogenize the sample **16**. Exemplary further grinding may be performed with a geno-grinder or similar bead-mill type of equipment. In one embodiment, the fracturing member **22** is made of a material that may be ground with a geno-grinder or similar bead-mill type of equipment. As such, if the fracturing member **22** inadvertently breaks during the fracturing process of the sample **16**, the fracturing member **22** may be ground with the sample.

[0050] In one embodiment, an empty container **10** and cap **20**, such as shown in FIG. **4** is provided. In one example embodiment, the container **10** is positioned in a container support **36** which positions the container in a first orientation. In another example embodiment, the cap is supported by a cap support **39**. The cap **20** is removed from the container **10** and supported by a cap support **39**. In one example embodiment, an actuator is used to remove the cap from the container. In another example embodiment, the actuator is part of capping machine **40**.

[0051] In one embodiment, a sample **16** is placed in the interior **12** of an empty container **10**. In one example embodiment, the sample **16** is placed in the interior **12** of the container **10** manually. In another example embodiment, the sample **16** is placed in the interior **12** of the container **10** by capping machine **40**. Once a sample **16** has been placed in the interior **12** of the container **10**, the container **10** is coupled to the cap **20**, fracturing the sample **16** with the fracturing member **22**. In still another example embodiment, a lower end of the fracturing member **22** is in a fixed position relative to a first portion **21** of the cap **20**. In yet still another example embodiment, an actuator changes the orientation of one of the container and the cap relative to the other and decreases the distance between the bottom of the container and the lower end of the fracturing member on the cap, fracturing the sample **16** inside the container **10**. Example coupling methods include using an automatic capping machine, rotating the cap **20** by hand or using a power drill.

[0052] In still another example embodiment, the cap **20** is removed from the container **10** after the sample **16** has been fractured, leaving the sample **16** in the interior **12** of the container **10**. In yet still another example embodiment, the cap **20** is disposed of after removal, reducing the chance of contamination between samples.

[0053] In another example embodiment, a plurality of empty containers **10** and caps **20**, such as shown in FIG. **4** are provided in a container support **36**. The automatic capping machine **40** is used to remove the caps **20** from the containers **10**.

[0054] In one example embodiment, a sample **16** is placed in the interior **12** of each of the empty containers **10**, as shown in FIG. **1**. In one example embodiment, the samples are placed in the interior **12** of each of the empty containers **10**. In another example embodiment, a capping machine **40** places the samples in the interior **12** of each of the empty containers **10**. In still another example embodiment, the samples **16** may be placed in the interior **12** of each of the containers **10** substantially simultaneously through the use of a multiple sample tool. In yet still another example embodiment, the samples **16** may be placed in the interior **12** of each of the containers **10** substantially serially by placing the samples **16** into the containers **10** one at a time.

[0055] In another example embodiment, once the samples **16** have been placed in the interior **12** of the containers **10**, the rack **36** is placed back in the capping machine **40**. The capping machine **40** then couples the container **10** and cap **20**, fracturing the sample **16** with the fracturing member **22** rigidly attached to the cap **20**.

[0056] In still another example embodiment, the capping machine **40** is then used to remove the cap **20** from the container **10** after the sample **16** has been fractured. In yet still another example embodiment, the cap **20** is disposed of, reducing the chance of contamination between samples.

[0057] In one example embodiment, multiple samples, such as corn kernels, are fractured simultaneously, increasing efficiency and productivity.

[0058] While this invention has been described as relative to exemplary designs, the present invention may be further modified within the spirit and scope of this disclosure. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains.

1. A fracturing apparatus comprising:

a container including a bottom and an open top, an interior of the container being accessible through the open top; and

a cap including a first portion removably coupled to the container and a second portion including a fracturing member extending downward from the first portion, wherein when the cap is coupled to the container the fracturing member extends through the interior of the container and a lower end of the fracturing member is proximate to the bottom of the container, the lower end of the fracturing member being in a fixed position relative to the first portion of the cap.

2. The apparatus of claim **1**, wherein the lower end of the fracturing member engages a sample having a hard exterior, the sample being supported by the bottom of the container, to fracture the sample as the cap and container are coupled together.

3. The apparatus of claim **2**, wherein the sample is at least one seed.

4. The apparatus of claim **3**, wherein the sample is at least one kernel of corn.

5. The apparatus of claim **1** wherein the cap and container are coupled together by rotating at least one of the cap and the container relative to the other.

6. The apparatus of claim **1** wherein the cap is coupled to the open top of the container by threads.

7. The apparatus of claim **1** wherein the cap is coupled to the open top of the container by press-fit.

8. The apparatus of claim **1** wherein the container is a test tube.

9. The apparatus of claim **1** wherein the distance between the lower end of the fracturing member and the bottom of the container is up to about 10% of the height of the container.

10. The apparatus of claim **1** wherein the distance between the lower end of the fracturing member and the bottom of the container is up to about 5% of the height of the container.

11. The apparatus of claim **1** wherein the lower end of the fracturing member is threaded.

12. The apparatus of claim **1** wherein the fracturing member is a screw.

13. The apparatus of claim **1** wherein the lower end of the fracturing member is a spear.

14. A fracturing apparatus comprising:

a container including a bottom and an open top, an interior of the container being accessible through the open top;

a container support which positions the container in a first orientation;

a cap including a first portion removably coupled to the container and a second portion including a fracturing member extending downward from the first portion;

a cap support which supports the cap in a second orientation, wherein in the second orientation the fracturing member is positioned directly over the bottom of the container; and

an actuator which changes the orientation of at least one of the container and the cap relative to the other, decreasing the distance between the bottom of the container and the lower end of the fracturing member and coupling the first portion of the cap to the container.

15. The apparatus of claim **14** further comprising a controller that controls the movement of the actuator.

16. The apparatus of claim **14**, wherein when the first portion of the cap is coupled to the container the fracturing member extends through the interior of the container and a lower end of the fracturing member is proximate to the bottom of the container, the lower end of the fracturing member being in a fixed position relative to the first portion of the cap.

17. The apparatus of claim **16**, wherein the lower end of the fracturing member engages a sample having a hard exterior, the sample supported by the bottom of the container, to fracture the sample as the cap and container are coupled together.

18. The apparatus of claim **16** wherein the sample is at least one seed.

19. The apparatus of claim **16** wherein the sample is at least one kernel of corn.

20. The apparatus of claim **16** wherein the cap and container are coupled together by rotating one of the cap and the container in relation to the other.

21. The apparatus of claim **16** wherein the cap is coupled to the open top of the container by threads.

22. The apparatus of claim **16** wherein the cap is coupled to the open top of the container by press-fit.

23. The apparatus of claim **16** wherein the container is a test tube.

24. The apparatus of claim **23** wherein the distance between the lower end of the fracturing member and the bottom of the container is up to about 10% of the height of the container.

25. The apparatus of claim **23** wherein the distance between the lower end of the fracturing member and the bottom of the container is up to about 5% of the height of the container.

26. The apparatus of claim **16** wherein the lower end of the fracturing member is threaded.

27. The apparatus of claim **16** wherein the fracturing member is a screw.

28. The apparatus of claim **16** wherein the lower end of the fracturing member is a spear.

29. The apparatus of claim **16** wherein the actuator is an automatic capping machine.

30. A method of fracturing samples in a container, the container including a bottom, an open top, and an interior accessible through the open top, the method comprising the steps of:

positioning a cap relative to the container; and

coupling the cap to the open end of the container, the cap including a first portion and a second portion, wherein when the cap is coupled to the open top of the container, the first portion extends over the open end of the container and the second portion extends through the interior of the container and includes a fracturing member, a lower end of the fracturing member being proximate to the bottom of the container, the lower end of the fracturing member being in a fixed position relative to the first portion of the cap.

31. The method of claim **30** further comprising:

placing a sample in the interior of the container;

wherein, the lower end of the fracturing member engages the sample to fracture the sample as the cap is coupled to the open end of the container.

32. The method of claim **31** further comprising removing the cap from the container.

33. The method of claim **32** further comprising disposing the cap.

34. The method of claim **32** wherein an actuation system controlled by an electronic controller removes the cap from the container.

35. The method of claim **34** wherein the actuation system couples the cap to the open end of the container.

36. The method of claim **31** wherein the sample is at least one seed.

37. The method of claim **31** wherein the sample is at least one kernel of corn.

38. The method of claim **31** wherein the placing step is done automatically.

39. The method of claim **31** further comprising:

placing a second sample in a interior of a second container, the second container including a bottom, and an open top, the interior of the second container accessible through the open top of the second container;

coupling a second cap to the open end of the second container, the second cap including a first portion and a second portion, wherein when the second cap is coupled to the open top of the container, the first portion extends over the open end of the container and the second portion extends through the interior of the container and includes a fracturing member, a lower end of the fracturing member being proximate to the bottom of the container, the lower end of the fracturing member being in a fixed position relative to the first portion of the cap, and the lower end of the fracturing member engages the sample to fracture as the second cap is coupled to the open end of the second container.

40. The method of claim **30** wherein the coupling step includes rotating at least one of the cap and container in relation to the other.

41. The method of claim **30** wherein the container is a test tube.

42. The method of claim **30** wherein the distance between the lower end of the fracturing member and the bottom of the container is up to about 10% of the height of the container.

43. The method of claim **30** wherein the distance between the lower end of the fracturing member and the bottom of the container is up to about 5% of the height of the container.

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