



(51) International Patent Classification:

A47J 31/06 (2006.01) A23N 12/00 (2006.01)
A47J 31/36 (2006.01) A47J 31/00 (2006.01)
A47J 31/42 (2006.01) B65D 85/804 (2006.01)
A23F 5/08 (2006.01)

(21) International Application Number:

PCT/GB2017/050845

(22) International Filing Date:

24 March 2017 (24.03.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1604992.6 24 March 2016 (24.03.2016) GB

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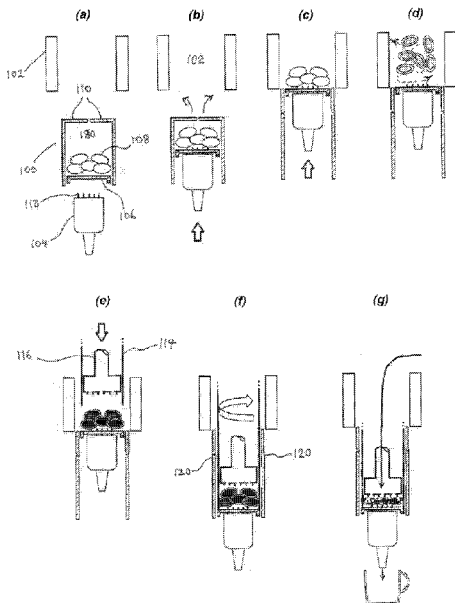
(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,

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(54) Title: COFFEE BREWING SYSTEM

FIGURE 3



(57) Abstract: A system for grinding, brewing and dispensing coffee comprises (a) a coffee cartridge (10, 100) containing unground coffee beans (108), said cartridge (10, 100) having walls defining a chamber (18) in which the beans (108) are confined, wherein part or all of at least one wall (16) of the cartridge (10, 100) is openable, and the openable wall (16) is opposed to a bottom wall (14) supporting the beans (108); wherein said cartridge (10, 100) is secured in a cartridge holder of: (b) apparatus comprising: a brewing spike (104) for perforating the bottom wall (14) of the cartridge thereby permitting a flow of water through said wall; a grinding head (116) adapted to enter the chamber (18) via the openable wall (16) thereof and to compress the beans (108) contained therein against the bottom wall (14); a source of pressurized hot water; feed means for delivering pressurized hot water to the beans whereby coffee is thereby extracted to yield a coffee brew; a brew spout (104) for delivering said coffee brew to a drinking vessel for consumption; and a controller for controlling the operations of one or more of the brewing spike, grinding head, source of pressurized hot water, feed means and/or brew spout; wherein the grinding head is disposed within an extraction sleeve and adapted to reciprocate and/or rotate therein.



LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

— before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments (Rule 48.2(h))

Published:

— with international search report (Art. 21(3))

COFFEE BREWING SYSTEM

Field of the Invention

5 This invention relates to systems and processes for producing and dispensing brewed coffee by roasting, grinding and extraction of coffee from a prepacked coffee cartridge.

Background to the Invention

10 Coffee making apparatus for brewing coffee powder contained in a cartridge, comprising a brewing chamber adapted to receive a coffee powder cartridge, means for perforating the coffee powder cartridge, and a pump for feeding hot brewing water into the brewing chamber to extract the coffee are now ubiquitous.

15 These devices are used predominantly in homes, being designed for use by untrained operators. They offer a relatively quick and convenient method for producing higher quality coffee brews than can be obtained using instant coffee granules, whilst avoiding the need for costly roasting, grinding and brewing paraphernalia, the use of which requires considerable expertise. Indeed, the system commercialized under the trademark
20 “Nespresso®” has sold in the millions and is currently used in homes, restaurants and hotels throughout the world.

A variety of different cartridges (or capsules) for use with such apparatus have been described (see for example: US4895308; US5402707; WO93/17932; US5656316;
25 WO2014/128658; WO2014/091439; US2005/0150391 and EP1554958). Such cartridges contain ground and roasted coffee powder which is automatically or semi-automatically extracted under pressure, providing convenience in operation as well as reproducible extraction conditions. They therefore permit any user to quickly and effortlessly prepare a cup of freshly extracted coffee.

30

For extracting the coffee powder contained in the cartridge, manually operated, semi-automatic as well as fully automatic devices have been described. Usually, in a manually operated coffee maker, the cartridge is inserted into a cartridge holder that in turn is inserted into the coffee making apparatus. In semi-automatic coffee makers, the cartridge
35 is inserted into a cartridge retainer or directly into the brewing chamber of the machine,

which is then closed manually (typically by means of a lever mechanism). In a fully automatic coffee maker, the cartridge is removed from a cartridge magazine and automatically inserted into the brewing chamber. In both automatic and semi-automatic apparatus, the used or spent cartridge is ejected from the brewing chamber and discarded
5 into a waste container after brewing is complete without any operator intervention.

Common to all of the above-described coffee makers is the provision of one or more "brewing spikes" provided with one or more openings for injecting brewing water into the cartridge and also adapted to punch the bottom and/or the top of the cartridge. During
10 operation, the brewing water is injected into the cartridge by means of the brewing spike, with the result that it flows under pressure through the coffee powder contained in the cartridge and escapes as brewed coffee from the cartridge through perforations created in the bottom.

15 However, the quality of the brewed coffee dispensed by the cartridge systems described above is limited by the fact that the coffee contained in the cartridges is in a pre-roasted, pre-ground and powdered form. This greatly compromises the organoleptic qualities of the resultant coffee extract, since many soluble and volatile aromatic components which contribute to the quality (and freshness) of brewed coffee are produced transiently during
20 roasting and/or grinding and are rapidly lost during subsequent storage.

There is also a growing recognition of the adverse environmental impact of the spent coffee cartridges, which are typically manufactured of heat-resistant polymer/metal composites which cannot be economically recycled.

25

There is therefore a need for a convenient, cartridge-based coffee making system which provides superior coffee beverages by permitting the user to grind (and optionally roast) the coffee prior to brewing, as well as for cartridge-based coffee making systems which use more environmentally friendly consumables.

30

Summary of the Invention

In a first aspect there is provided a system for grinding, brewing and dispensing coffee comprising:

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(a) a coffee cartridge containing unground coffee beans, said cartridge having walls defining a chamber in which the beans are confined, wherein part or all of at least one wall of the cartridge is openable, and the openable wall is opposed to a bottom wall supporting the beans;

5

wherein said cartridge is secured in a cartridge holder of:

(b) apparatus comprising:

10

i. a brewing spike for perforating the bottom wall of the cartridge thereby permitting a flow of water through said wall;

ii. a grinding head adapted to enter the chamber *via* the openable wall thereof and to compress the beans contained therein against the bottom wall;

iii. a source of pressurized hot water;

15

iv. feed means for delivering pressurized hot water to the beans whereby coffee is thereby extracted to yield a coffee brew;

v. a brew spout for delivering said coffee brew to a drinking vessel for consumption; and

20

vi. a controller for controlling the operations of one or more of the brewing spike, grinding head, source of pressurized hot water, feed means and/or brew spout;

wherein the grinding head is disposed within an extraction sleeve and adapted to reciprocate and/or rotate therein.

25

The use of an extraction sleeve permits great flexibility in the materials used to form the cartridge, since it can be configured to act in conjunction with the slidable wall of the cartridge to isolate the beans from the rest of the cartridge during the grinding and extraction steps, thereby permitting the use of compostable/biodegradable materials and avoiding the need for pressure jackets and/or non-recyclable metals/hard plastic composites.

30

The unground coffee beans are preferably whole coffee beans. However, the grinding operation may be facilitated by the use of cracked coffee beans. In such embodiments, unground beans having an average particle size of at least 2 mm, for example at least 3mm, at least 4mm, at least 5mm or about 6mm may be used.

35

The unground coffee beans may be roasted or part-roasted, but in preferred embodiments the cartridge comprises unground and unroasted coffee beans.

5 In embodiments where the cartridge comprises unroasted coffee beans, the roasting process may be facilitated by the use of dried or pre-heated coffee beans (or mixtures thereof). Such beans may be pre-ground prior to roasting, since dried and pre-heated beans require less force to grind, and readily form fragments which increase the surface area of the beans exposed to heat in a subsequent roasting step.

10

In embodiments where the cartridge comprises roasted coffee beans, the degree of roasting of the roasted beans may be: (a) light; (b) medium-light; (c) medium; (d) medium-dark; (e) dark; (f) very dark; (g) extremely dark; or (h) a mixture of two or more of the foregoing.

15

Typically, the beans contained in the chamber consist, or consist essentially of, beans of a single type as defined above (e.g. being all unroasted or all roasted). However, it will be appreciated that the use of mixtures of bean types (such as a mixture of two or more of whole, cracked, dried, pre-heated, lightly roasted and unroasted beans) may be used to balance the quality of the brew with the stringency of the demands for roasting and grinding, while producing highly desirable flavour profiles.

20

In another aspect there is provided a system for roasting, grinding, brewing and dispensing coffee comprising:

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(a) a coffee cartridge containing: (i) unground and (ii) unroasted or part-roasted coffee beans, said cartridge having walls defining a chamber in which the beans are confined, wherein part or all of at least one wall of the cartridge is openable, and the openable wall of the cartridge is opposed to a slidable bottom wall thereof;

30

wherein said cartridge is secured in a cartridge holder of:

(b) apparatus comprising:

35

i. a roasting chamber comprising means for roasting the coffee beans;

- 5
- ii. a brewing spike for perforating the slidable wall of the cartridge thereby permitting a flow of water through said wall, wherein the brewing spike is integrated with a plunger and is adapted to drive the slidable wall of the chamber towards the openable wall thereof thereby displacing said beans from the chamber;
 - iii. means for conveying the beans to said roasting chamber;
 - iv. a grinding head adapted to enter the chamber *via* the openable wall thereof and to compress the beans contained therein against the slidable wall;
 - v. a source of pressurized hot water;
 - 10 vi. feed means for delivering pressurized hot water to the beans whereby coffee is thereby extracted to yield a coffee brew;
 - vii. a brew spout for delivering said coffee brew to a drinking vessel for consumption; and
 - viii. a controller for controlling the operations of one or more of the roasting
 - 15 means, brewing spike, conveying means, grinding head, source of pressurized hot water, feed means and/or brew spout;

wherein the grinding head is disposed within an extraction sleeve and adapted to reciprocate and/or rotate therein.

20

In another aspect, there is provided a process for producing and dispensing brewed coffee comprising the steps of grinding and extracting unground coffee beans, comprising the steps of:

25

(a) providing a coffee cartridge as defined in any one of the preceding claims;

(b) securing the cartridge in a cartridge holder of apparatus as defined in any one of the preceding claims; and then

30

(c) grinding and extracting the roasted beans within an extraction sleeve as defined in any one of the preceding claims.

Other aspects and preferred embodiments and features of the invention are as defined in the claims appended hereto, which is hereby incorporated into this section by reference.

35

Detailed description

Definitions and general preferences

5 The coffee beans used according to the invention are seeds of plants of the genus *Coffea*. The beans may be of any variety, but are preferably from the species *C. robusta* ("*robusta*" coffee beans) or *C. Arabica* ("*arabica*" coffee beans).

10 Preferably the coffee beans are derived from *C. arabica* (for example, being South American or East African arabicas).

The coffee beans used according to the invention may also comprise blends containing mixtures of coffee bean-derived material derived from both *C. robusta* and *C. arabica* (for example, South American, East African or blends thereof). In preferred embodiments, the
15 coffee beans are blend of arabica and robusta which are predominantly arabica with minor quantities of robusta.

The term *coffee cartridge* (sometimes abbreviated herein to *cartridge*, where context permits) is a term of art defining a single-use container comprising a chamber containing
20 coffee which is adapted to be inserted into an automatic or semi-automatic coffee dispensing apparatus whereat hot water is introduced into the chamber and the coffee extracted and dispensed, after which the cartridge is discarded. Coffee cartridges are sometimes referred to as "coffee capsules" in the art.

25 Coffee cartridges can both reduce the time needed to brew coffee and simplify the brewing process by eliminating the need to measure out portions from large bulk containers, while permitting the user to select from a wide range of different coffee types. They can also help to keep the unused product fresher by individually packaging portions separately without exposing the entire supply batch to air and light.

30 A *single-serve coffee cartridge* is a term of art for a coffee cartridge containing a single portion of coffee in the chamber, i.e. containing a quantity of coffee sufficient for a single beverage.

As used herein, the term *roasted* as applied to coffee beans (including the whole, cracked and/or ground coffee beans as herein defined) defines material that has been roasted to some degree. The term *roasting* is to be interpreted accordingly.

5 The term *fluidized bed roasting* in the context of coffee beans is a term of art defining a roasting process whereby coffee beans are at least partially levitated by a stream of heated air in which the degree of roasting is controlled by variation of the temperature of the air and the duration of heating.

10 Fluidized bed roasting may be applied according to the invention to unground coffee beans (as defined herein), and in particular to whole beans as well as beans which have been cracked or fragmented to a limited degree. Its use in relation to cracked beans may permit lower air velocities, smaller air ducts and/or reduced roasting temperatures and/or times.

15 Fluidized bed roasting may also be advantageously applied to dried and/or pre-heated coffee beans (as herein defined), since its use in relation to such materials may permit lower air velocities, smaller air ducts and/or reduced roasting temperatures and/or times.

20 The term *fast fluidized bed roasting* as used herein defined fluidized bed roasting (as defined above) in which the temperature of the heated air exceeds 250°C (for example, about 300°C) , so permitting roasting to proceed at an accelerated rate. Fast fluidized bed roasting may also be advantageously applied to dried and/or pre-heated coffee beans (as herein defined), since its use in relation to such materials may permit lower air velocities, smaller air ducts and/or reduced roasting temperatures and/or times.

25 The degree of roasting depends *inter alia* on factors such as temperature and duration of roasting, but may be characterized by the colour change of the coffee as a result of the roasting process.

30 This colour change can be measured using an Agtron® spectrophotometer and expressed as values on a scale as follows:

Roast	Agtron value	Characteristics

Light	>70	Light brown to cinnamon colour. Light body, muted aroma, tea-like flavour. No oil on surface of bean.
Medium-light	61-70	Moderately light brown colour. Bright, sweet acidity. Surface of bean remains dry
Medium	51-60	Medium brown color. Balanced acidity, fuller body. Generally dry bean surface
Medium-dark	41-50	Rich brown color. Droplets of oil appear on bean surface. Muted acidity, sometimes heavier body.
Dark	35-40	Deep brownish/black color. Spots of oil to shiny surface Bittersweet, scorched-wood roast notes. Acidity muted.
Very dark	25 – 34	Black surface covered brightly with oil. Bitter/bittersweet tones dominate. Body thin.
Extremely dark	< 25	Black, shiny surface. Burned bitter tones.

Thus, the terms *light*, *medium-light*, *medium*, *medium-dark*, *dark*, *very dark* and *extremely dark* are applied herein in relation to the roasted coffee bean material for use according to the invention in accordance with the above scale.

As explained above, whilst the degree of roasting depends in part on the duration of roasting, in general it will be appreciated that temperatures of 196°C - 200°C yield a light roast, about 205°C a medium-light roast, about 210°C a medium ("American") roast, about 219°C a medium-dark ("City") roast, about 225°C a dark ("Full City") roast, 230°C to 240°C very dark ("Vienna" or "French") roasts and about 245°C an extremely dark ("Italian") roast.

Roasting therefore typically involves a process of heating coffee beans to a point beyond the *first crack*. The *first crack* is a term of art which describes a stage of roasting at which the beans first emit a cracking sound as the temperature nears 200°C (usually about 196°C). Since the roasting of pre-ground or cracked beans may not be characterized by a "first crack", the term "roasting" as used herein may also define a process whereby cracked

or ground coffee beans are heated to temperature of 196°C or higher, or subjected to heating such that an Agtron value of >70 is achieved.

5 As used herein, the term "unroasted coffee beans" defines coffee beans that are unroasted (as defined above), but which may have been subject to certain heat treatments to yield the dried or pre-heated beans defined below. The term therefore includes "green" coffee beans.

10 In this context, the term "green" is a term of art defining beans which are unroasted but which have been dried to reduce the water content below that of beans fresh from demucilaging (which have a moisture content of 45 to 55% by weight). Thus, the term includes green coffee beans which have been dried (e.g. by sun drying or artificial oven heating) to a water content of 10%-14% by weight, and usually about 12% by weight.

15 However, it should be noted that the term "unroasted coffee bean" encompasses not only green coffee beans (as described above), but also a class of beans which includes "dried" and "pre-heated" coffee beans.

20 In this regard, the term "dried coffee bean" defines an unroasted bean which, while being unroasted (as defined above), has been dried to a moisture content of less than 10% (for example within the range of 0.5% to 9.0% or 1.0 to 5.0% by weight). Such dried beans are relatively brittle and shrunken relative to green coffee beans, and are therefore easier to grind in the unroasted state. They may also exhibit favourable roasting and extraction properties.

25 Furthermore, it should be noted that the term "unroasted coffee bean" encompasses not only green and dried coffee beans (as explained above), but also "pre-heated" coffee beans.

30 In this regard, the term "pre-heated coffee bean" defines an unroasted bean which, while being unroasted (as defined above), has nevertheless been heated to a point beyond being merely *dried* (as defined above), but which has not yet been *lightly roasted* (as also defined above). This is typically achieved by heating to a point before the first crack. Pre-heating green or dried coffee beans before grinding greatly facilitates subsequent heating and
35 grinding operations and so may be useful in some embodiments of the invention.

As used herein, the term "part-roasted coffee bean" defines a bean which has been heated to a point beyond being merely dried or pre-heated (as defined above), such some (but not all) of the beans (or some but not all of any individual bean) has been at least lightly
5 roasted. Thus, part-roasted coffee beans include beans which have been heated to a point at which some (but not all) have passed beyond the first crack. Such beans may be useful in embodiments where particularly rapid roasting is required and/or the roasting temperatures employed are relatively low and/or of short duration. Part-roasted coffee beans also include beans which comprise a mixture (i.e. a blend) of unroasted and roasted
10 coffee beans.

As used herein, the term "whole coffee bean" is used herein to define whole coffee beans which have not been cracked, broken up into fragments or ground. The terms unroasted, dried unroasted, roasted and pre-heated as defined above and used in relation to whole
15 coffee beans are to be interpreted to mean that the various operations are performed on whole coffee beans as starting material, irrespective of the effects of such operations on the physical characteristics of the beans.

The term "cracked coffee bean" is used herein to define unground coffee beans which
20 have been fragmented and/or cracked to some degree, but are not ground (i.e. have not been subject to course (or finer) grinding, as herein defined). Such beans have an average diameter of at least 2 mm, for example at least 3mm, at least 4mm, at least 5mm or about 6mm. Again, the terms unroasted, dried unroasted, roasted and pre-heated as defined above and used in relation to cracked coffee beans are to be interpreted to mean that the
25 various operations are performed on cracked coffee beans as starting material, irrespective of the effects of such operations on the physical characteristics of the beans.

The term "ground coffee bean" is used herein to define coffee beans which are in a fragmented form, for example having an average particle diameter of about 1.5mm
30 ("course ground"), about 1.0mm (regular ground), about 0.75mm (drip ground), about 0.4mm (fine ground) or about 0.2mm (espresso ground). Since coffee beans are typically ground after roasting, ground beans are typically also roasted to some degree. However, ground unroasted, ground dried and ground pre-heated coffee beans are also contemplated for use according to the invention.

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Thus, as used herein, the term "unground coffee bean" defines a class of coffee bean which includes whole coffee beans (as define above) and cracked coffee beans (as defined above). Thus, references herein to unground coffee beans include whole beans as well as beans which have been cracked or fragmented to a limited degree (e.g. such that they
5 have an average diameter of at least 2 mm, for example at least 3mm, at least 4mm, at least 5mm or about 6mm), but which have not been ground to an average particle diameter of less than about 1.5mm.

As used herein, the term "brewing spike" defines a component of the apparatus of the
10 invention which comprises means for perforating a wall of the cartridge thereby permitting the flow of water through said wall.

The brewing spike may also comprise channels for delivering water through the perforations in the wall and/or for conducting brewed coffee out of the chamber *via* the
15 perforations.

The means for perforating a wall of the cartridge may take the form of one or more spikes, preferably a plurality of spikes. In cases where the brewing spike also comprise channels for delivering water through the perforations in the wall and/or for conducting brewed coffee
20 out of the chamber, the perforating means may advantageously take the form of one or more hollow spike(s), needle injector(s) or cannula(e).

In cases where the brewing spike comprise channels for conducting brewed coffee out of the chamber *via* the perforations introduced into the chamber wall, the brewing spike may
25 advantageously be integrated with a brew spout for dispensing the brewed coffee.

In cases where the brewing spike comprise channels for delivering hot water through the perforations in the wall and into the cartridge chamber, the brewing spike may
30 advantageously be integrated with a plunger adapted to exert force on a wall of the chamber (or directly on the beans contained therein).

The brewing spike may comprise milling means.

As used herein, the term "grinding head" defines a component of the apparatus of the invention which comprises means for exerting a crushing and/or grinding force on the trapped and isolated beans within the extraction sleeve.

- 5 The grinding head is a component of the apparatus, adapted to enter the cartridge *via* the openable wall and directly contact the beans. The grinding head is disposed within an extraction sleeve and adapted to reciprocate and/or rotate therein.

As used herein, the term "extraction sleeve" defines a hollow tube member within which the grinding head is located and within which the grinding head may reciprocate and/or rotate.
10 The extraction sleeve is preferably adapted to withstand the forces associated with grinding and extraction, and so may be rigid, for example being formed of hard, heat-resistant materials (such as stainless steel). It is adapted to enter the cartridge *via* the openable wall and directly contact the peripheral portion of the slidable wall, whereat it acts in
15 conjunction with the slidable wall to isolate the beans from the rest of the cartridge during grinding and extraction. Thus, the grinding head and extraction sleeve may form a unitary assembly, for example being arranged in a piston-cylinder configuration.

The grinding head may comprise feed means for delivering pressurized hot water to the beans whereby coffee is thereby extracted to yield a coffee brew, and so may be adapted
20 to deliver pressurized hot water to beans isolated by the extraction sleeve as described above. This process may be facilitated by lifting the grinding head away from the beans after grinding in order to create an extraction chamber defined by: (a) the slidable wall of the cartridge; (b) the walls of the extraction sleeve; and (c) the grinding head itself.

25 The means for exerting said crushing and/or grinding force may comprise milling means located on the brewing spike and/or grinding head.

In this context, the milling means are substantially rigid features of the grinding head and/or
30 brewing spike which contact a coffee bean and transmit a concentrated force thereto, facilitating its fragmentation. The milling means may comprise the perforating means of the brewing spike.

Grinding

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In embodiments where the coffee beans in the cartridge are unroasted coffee beans, grinding is typically executed after roasting. However, in some embodiments, a pre-grinding step is carried out in order to facilitate a later roasting step (by increasing the surface area of the coffee material exposed to heat). In such embodiments, the coffee
5 beans are preferably dried or pre-heated (particularly when the coffee beans in the cartridge are green coffee beans, which have a relatively high water content and which are liable to form undesirable pastes when subject to grinding).

As explained above, the ground coffee beans of the invention are in a fragmented form, for
10 example having an average particle diameter of about 1.5mm ("course ground"), about 1.0mm ("regular ground"), about 0.75mm ("drip ground"), about 0.4mm ("fine ground") or about 0.2mm ("espresso ground"). Thus, the term "grinding" as used herein is to be interpreted broadly, to cover any form of processing which results in fragmentation of the coffee bean (for example to the particle sized listed above).

15 It will therefore be appreciated that the ground coffee beans may be prepared by simple crushing - roast coffee beans are friable and the application of a crushing force with no rotational grinding may be sufficient to fragment the roasted beans into fragments sufficiently small as to constitute ground coffee beans as herein defined. In such cases, the
20 grinding means may take the form of a moveable (preferably rigid) portion of the cartridge wall, such that a crushing force may be transmitted to the beans confined in the chamber.

However, grinding is typically more effective if a crushing force is coupled with rotational grinding. Here, the cartridge may be provided with a movable wall or part thereof which is
25 rotatable relative to the chamber such that a rotational grinding force may be exerted on the beans confined in the chamber. Rotational grinding is particularly advantageous in circumstances where drip ground, fine ground or espresso ground coffee beans are required.

30 Crushing/grinding (as described above) may be executed with or without the use of milling means. Milling means are substantially rigid features (of the cartridge and/or apparatus) which contact a coffee bean and transmit a concentrated force thereto, facilitating its fragmentation. In preferred embodiments, the milling means may comprise one or more ribs, recesses, channels, teeth, ridges, spikes, blades or protrusions. The milling means

may for part of the cartridge (e.g. taking the form of elements disposed on the chamber-proximal surface of at least one wall).

5 It will be appreciated that the nature of the milling means will depend on the physical condition of the unground coffee beans contained in the cartridge (and in particular, whether they are: (a) whole or cracked; and (b) unroasted, dried, pre-heated or roasted). It will also be appreciated that whole coffee beans may require coarser, harder and/or sharper milling means than cracked beans, while roasted or dried beans are relatively friable and so may be effectively ground by the application of a crushing force without any
10 such milling means being necessary. In contrast, green coffee beans (which have a relatively high water content and are difficult to grind while avoiding the formation of a paste) are typically (though not necessarily) pre-heated or roasted prior to grinding.

Extraction

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The term "extraction" in this context defines a process whereby hot water is brought into contact with ground coffee beans thereby dissolving certain components of the coffee to form a coffee brew. This process is sometimes referred to in the art as brewing or percolation.

20

The temperature of the water, the pressure at which it is introduced into the chamber and the flow rate through the chamber all affect the quality of the coffee brew. However, those skilled in the art will be able to readily select appropriate values for these parameters by reference *inter alia* to the teachings of US4895308, US5402707, WO93/17932,
25 US5656316, WO2014/128658, WO2014/091439, US2005/0150391 and EP1554958, all of which describe extraction of coffee contained in coffee cartridges.

30

The temperature of the hot water is typically between 91 and 94°C (though this will depend on whether the extraction chamber is under vacuum, when lower temperatures may be effective).

35

The water pressure selected affects the flow rate of the water through the coffee grounds, but many other factors also contribute including *inter alia* the particle size distribution of the coffee grounds, their density, the strength of brew required and the desired extraction yield.

Typically, the target extraction yield will be 18% to 22%. Such yields are obtainable at pressures of between 1 bar and 20 bar, yielding a mean flow rate of from 80 to 250 ml/min, for example from 120 to 200 ml/min.

- 5 The flow rate can be controlled, e.g. by varying the pressure of the hot water, to control the coffee intensity and avoid coffee under-extraction (associated with loss of flavour) or over-extraction (associated with bitterness).

10 The target total dissolved solids (TDS) in the dispensed brew will depend on the style of brew required, but will usually be between 1% (Americano style "long" coffees) and 20% ("short" coffees, such as espresso). This can be readily controlled by *inter alia* varying the total volume of hot water passed through the cartridge chamber and the dose of coffee in the chamber.

- 15 The apparatus of the invention is advantageously adapted to deliver pressurized hot water to trapped and isolated beans within the extraction sleeve. In such embodiments, the contact between the extraction sleeve and bottom wall of the chamber may form a seal sufficient to confine the coffee beans and/or coffee grounds and optionally also the hot water used for extraction. In such embodiments, the extraction sleeve may serve as a
20 pressure jacket ensuring that the hot water pumped into the chamber passes through the grounds and bottom wall of the cartridge chamber without substantially leaking onto the other components of the cartridge.

25 Thus, the extraction sleeve is preferably adapted to serve as a pressure jacket to contain the pressurized hot water during injection into the chamber of the cartridge and through the coffee grounds

30 Various different means for achieving such a seal are described in the art, for example in US4895308, US5402707, WO93/17932, US5656316, WO2014/128658, WO2014/091439, US2005/0150391 and EP1554958.

Roasting

35 The present invention contemplates the use of roasted coffee beans, and in such embodiments a roasting step is not required.

However, even in cases where the cartridge of the invention contains roasted coffee beans, it may still be advantageous to include a heating step (for example, to generate and/or liberate volatile oils which may enhance the flavour and aroma of the brew). In such cases, the apparatus or system may comprise heating means. Suitable heating means may be the roasting oven/roasting process as herein described, but adapted for lower temperature heating (e.g. in the form of a fluidized bed heating chamber). Such heating chambers may be vented, to enhance the aroma during brewing.

10 In embodiments where the cartridge of the invention contains unroasted coffee beans (as herein defined), the beans must be roasted prior to extraction.

As explained above, roasting may be achieved by heating the coffee to temperatures of at least 196°C - 200°C. Lower temperatures may be employed in circumstances where the beans are dried, pre-heated or part-roasted.

Preferably, the duration of roasting is below 5 minutes, and preferably below 3 minutes, more preferably below 2 minutes, and most preferably below 1 minute.

20 Any means of heating may be employed, including microwave heating, radiant heating, conductive heating, convection heating (e.g. by a flow of hot air) or any combination thereof.

The heating means (and heating parameters, including duration and temperature) will also be selected according to the bean to be roasted. For example, whole coffee beans may require exposure to higher temperatures and/or longer heating cycles, whereas cracked coffee beans may require lower temperatures and/or heating durations (since they typically offer a greater surface area to the heat source).

30 The roasting process may include a preliminary heating stage in which moisture is driven out of the beans. In embodiments where green coffee beans are employed, this moisture content can be as much as 12% by weight. The bean cannot actually be roasted until the moisture is removed: until it is removed, prolonged exposure to heat results in "cooking" rather than "roasting" of the bean. Cooking results in the formation of acids (such as acetic

acid), and various off-flavours. Thus, in some embodiments, dried or pre-heated beans (as defined herein) are used.

5 The roasting process may also include a pre-grinding or crushing step, for example to increase the surface area of the beans exposed to heat (and so accelerate roasting).

Roasting may be conveniently achieved by oven roasting or fluidized bed roasting, as described in more detail below. In either case, the roasting may be preceded by an initial microwave heating step (e.g. to dry or pre-heat the beans and/or drive off moisture).

10

Roasting may be accompanied or followed by a degassing/venting step, since roasting is associated with the release of hot gases (mainly carbon dioxide) from the coffee material.

Oven roasting

15

The beans may be roasted by radiant heat, for example in a drum heated in an oven. Such embodiments employ remote roasting configurations (described in more detail herein). However, care must be taken not to scorch and so ruin the beans, and smoke and oils generated in the process remain in contact with the beans and can confer a disagreeable taste.

20

Fluidized bed roasting

In certain embodiments of the invention, the coffee is subjected to fluidized bed roasting (as herein defined). Fluidized bed roasting (for example as described in US5394623) avoids the problems associated with smoke and oils generated during oven roasting.

25

However, care must be taken to avoid scorching the beans. Thus, in embodiments where fluidized bed roasting is employed according to the invention, provision for quenching the beans after roasting is completed may be provided. This may be achieved by the introduction of a stream of ambient air or by spraying with water. Such techniques are described, for example, in US4484064, US5185171, US3964175 and US5394623.

30

Fluidized bed roasting may be readily implemented in remote roasting systems (as described above), since: (a) the stream of hot air may be used to drive the coffee material

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from the chamber of the cartridge and transport it to a separate roasting chamber (so obviating the need for a mechanical transfer ram, shuttle hopper or caddy); and (b) the use of a separate roasting chamber permits the use of larger airflow ducts (and hence higher volumetric flow rates) than could be achieved when using the cartridge itself as a roasting chamber.

However, fluidized bed roasting may also be implemented *in situ*. For example, in embodiments where part or all of at least one wall of the cartridge is reversibly openable or removable, sufficiently high volumetric flow rates into and out of the cartridge may be achieved to fluidize the beans *in situ* without the need for additional ducting in the cartridge.

Fluidized bed roasting may be applied according to the invention to unground coffee beans (as defined herein), and in particular to whole beans as well as beans which have been cracked or fragmented to a limited degree. Its use in relation to cracked beans may permit lower air velocities, smaller air ducts and/or reduced roasting temperatures and/or times.

Fluidized bed roasting may also be advantageously applied to dried and/or pre-heated coffee beans (as herein defined), since its use in relation to such materials may permit lower air velocities, smaller air ducts and/or reduced roasting temperatures and/or times.

Fast fluidized bed roasting (as used herein defined) may be advantageously used in circumstances where accelerated roasting is required. Fast fluidized bed roasting may be applied to dried and/or pre-heated coffee beans (as herein defined), since its use in relation to such materials may permit lower air velocities, smaller air ducts and/or reduced roasting temperatures and/or times.

Fluidized bed roasting may also be employed to remove chaff expelled from the bean as it expands during roasting, so reducing contamination from smoke and oils generated in the roasting process. This may conveniently be achieved by filtering the hot air to remove chaff produced during roasting.

In situ roasting

As explained above, the present invention contemplates cartridges containing roasted coffee beans, and in such embodiments a roasting step is not required.

However, in embodiments where the cartridge of the invention contains unroasted coffee beans (as herein defined), the beans must be roasted prior to extraction.

5

It will be appreciated that the use of dried, pre-heated or part-roasted beans may be advantageously used in circumstances where *in situ* roasting is employed, since their use may permit reduced roasting temperatures and/or times. Similarly, the use of cracked beans may also permit reduced roasting temperatures and/or times. A pre-grinding or
10 crushing step (to increase the surface area of the beans exposed to heat) may also be advantageously employed where *in situ* roasting is used.

15

Thus, any limitations imposed by heat sensitivity of the cartridge may be at least partially mitigated by the extraction sleeve, which serves to at least partially thermally isolate the beans from the cartridge walls. Alternatively, or in addition, dried, pre-heated, part-roasted, cracked, pre-ground and/or crushed coffee beans may be selected.

20

Any means of heating may be employed for *in situ* roasting, including microwave heating, radiant heating, conductive heating, convection heating (e.g. by a flow of hot air) or any combination thereof. *In situ* roasting may also include a microwave heating step for rapid heating and/or drying of the beans (which may be followed by radiant, conductive or convective heating to complete the roasting process).

25

However, preferred according to the invention is *in situ* fluidized bed roasting (as described above).

Remote roasting

30

As an alternative to *in situ* roasting, the beans may be removed from the coffee cartridge, roasted in a separate roasting chamber, and then returned to the cartridge chamber for grinding and extraction.

35

Any suitable means for removing the beans from the cartridge may be employed, including gravity, inertial force (e.g. centrifugal or linear), rams (including air rams), pushers, shunts, conveyors, shuttle hoppers, suction or any combination thereof.

Remote roasting permits greater latitude in the election of cartridge materials: any limitations imposed by heat sensitivity of the cartridge may be circumvented by remote roasting configurations. It is therefore particularly suited to applications where
5 compostable/biodegradable materials are to be used to manufacture the cartridge (see below).

However, it will be appreciated that remote roasting need not necessarily imply complete thermal insulation of the cartridge/cartridge holder from the roasting chamber: in many
10 cases the roasting chamber and cartridge chamber/cartridge holder are in close physical proximity (for example, to facilitate transfer of beans therebetween), so that the coffee cartridge itself may be indirectly heated during roasting by heat from the roasting chamber.

Remote roasting also facilitates fluidized bed roasting (as described above), and in such
15 cases the hot air flow required for fluidizing the beans may also be used to move the beans from the cartridge chamber to the roasting oven and/or from the roasting oven to the cartridge chamber.

Systems according to the invention configured for remote roasting comprise a roasting
20 chamber. This may take the form of a roasting oven (as described above), or may comprise a roasting chamber including an air-permeable member configured to support the coffee beans thereupon; a hot air inlet disposed so as to introduce a stream of hot air into said chamber, through said permeable member, so as to pass through and fluidize said coffee beans; and an air outlet disposed so as to direct said stream of air out of the
25 chamber after it has passed through the beans.

Remote roasting is particularly advantageous when high and/or rapid roasting is required (for example when dark roasts (such as Italian) and/or when transient very high temperatures (up to 300°C or higher) are employed to accelerate roasting.
30

Additives

The coffee cartridge of the invention contains unground coffee beans, but in some embodiments the cartridge may also contain additives confined in the cartridge chamber

together with the coffee beans. In such embodiments, the cartridge is adapted to serve as an extraction chamber for the additives as well as the coffee beans.

5 These optional additives may be selected from flavouring agents, preservatives, foaming agents (as described in e.g. WO2013034520), anti-foaming agents (e.g. surfactants), foam stabilizers (e.g. as described in US2010310746), colouring agents and mixtures thereof.

10 Suitable flavouring agents include those selected from: cocoa, caramel, vanilla, tea, chicory, fruit/berry extracts (e.g. raspberry, cherry, apricot, banana or citrus, such as lemon), herbs (for example mint), spices (for example, chilli and cinnamon, nutmeg), liqueurs (for example brandy and Amaretto), spirits (e.g. rum and brandy), salt, sugar, scorched sugar, honey, nuts (e.g. almond, hazelnut, walnut, peanut, pecan, macadamia and pistachio), coconut and mixtures of the foregoing.

15 The additives may be in powdered or granular form (for example, having been spray-dried). In some cases (such as fruit/berry extracts, honey and liqueurs) they may be provided as a syrup or as a glaze or coating on the coffee beans and/or the walls of the cartridge chamber.

20 Particularly preferred according to the invention is a cartridge containing unground coffee beans and cocoa (optionally further comprising one or more of the other additives listed above), said cartridge having walls defining a chamber in which the beans and cocoa are confined, the cartridge being adapted to serve as a grinding chamber for the coffee beans and as an extraction chamber for the coffee beans and additive(s). In such embodiments,
25 the cocoa is preferably in powdered form.

Cartridge geometry

30 The internal volume of the cartridge chamber is a function of the amount of coffee present and of the volume of water to be introduced into the chamber for extraction. The volume of water will vary according to the style of coffee to be brewed (e.g. long or short), but is typically 0.5 to 3 times the volume of the coffee.

35 In embodiments where remote roasting is employed, the cartridge of the invention is configured such that the beans can be removed from the cartridge chamber, and then

returned after roasting. This requirement may be reflected in the provision of one or more slidable and/or openable walls (or portions thereof).

Cartridge materials

5

It will be appreciated that any single cartridge may be constructed from a variety of different materials, and may for example employ different materials for the slidable and reversibly openable walls.

10

The cartridge may be constructed from materials that are heat resistant to at least 80°C, and preferably to at least 100°C. Those skilled in the art will be able to select an appropriate material from a wide variety of suitable materials described in, for example, US4895308, US5402707, WO93/17932, US5656316, WO2014/128658, WO2014/091439, US2005/0150391 and EP1554958.

15

Other suitable materials include: metals (such as aluminium, usually having a thickness of between 20µm and 100µm); plastics (such as polypropylene, polyethylene terephthalate (PET) and metallized PET); metal-plastic composites (such as plastic-coated aluminium); cardboard, polymer-coated cardboard and cardboard-metal or cardboard-plastic

20

composites.

Suitable composite/laminate materials include those provided with an oxygen barrier layer (such as ethylene vinyl alcohol, polyvinylidene chloride and/or SiO₂), including barrier-layer coated cardboard/aluminium/plastic or cardboard/plastic laminates.

25

In certain embodiments, the cartridge cap or plugs are formed of polypropylene (PP), while the walls are formed of polyethylene terephthalate (PET). In such embodiments, the cap is advantageously injection moulded, while the cartridge itself is blow-moulded.

30

The cartridge may advantageously comprise a filter for retaining coffee grounds and other particulates released during extraction within the cartridge chamber. In such embodiments, the filter is preferably located the bottom (optionally slidable) wall and may comprise a layer of filter paper or woven or non-woven fibres based on PET or PP. Such filters may be bonded or welded to the chamber-proximal surface of the bottom wall of the

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chamber.

Biodegradability

5 The cartridge according to the invention may be advantageously manufactured from a compostable/biodegradable material. Such materials are described in detail in WO2014/128658, and in particular at pages 4-6 thereof (the content of which is incorporated herein by reference).

10 Such cartridges preferably meet European standard EN 13432.

Exemplification

15 Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 shows plan and section views of a coffee cartridge for use in the system of the invention in closed configuration.

20 Figure 2 shows top and bottom perspective views of the coffee cartridge shown in Figure 1.

Figure 3 illustrates schematically a process for roasting, grinding, brewing and dispensing coffee using the coffee cartridge shown in Figures 1 and 2 in a coffee making apparatus adapted for use therewith.

25 It will be appreciated that part-roasted beans may be used in place of the unroasted coffee beans referenced in the Example described below when practising the invention.

Example 1

30 Referring now to Figures 1 and 2, the coffee cartridge (10) is substantially cylindrical with substantially cylindrical side walls (12), a bottom wall (14) slidable against the side walls (12) and a reversibly openable top wall (16). The walls define a chamber (18) containing unground (whole) and unroasted (green) coffee beans (not shown). Part-roasted beans may also be used. The cartridge is formed of cardboard.

35

The reversibly openable top wall (16) is formed by a number of sequentially overlapping hinged flaps (20).

5 Referring now to Figure 3, the cartridge (100) is loaded into a cartridge tray (not shown) by the user, and the tray then moved into position beneath a roasting chamber (102) (Figure 3(a)).

10 The brewing spike/spout (104) then rises to pierce and slide the bottom wall (106) towards the roasting chamber, driving the beans (108) against the folded leaves forming the top wall (110), thereby hinging the sequentially overlapped flaps away from the chamber and so opening the top wall while displacing the beans (108) into the roasting chamber (102) (Figures 3(b) and (c)). The brewing spike/spout (104) comprises milling means (113) in the form of spikes which pierce the slidable bottom wall (106) and protrude into the cartridge chamber (180) and contact the beans therein, thereby anchoring them during subsequent grinding operations.

15 Hot air at about 300°C is then circulated through the roasting chamber by a fan (not shown), fluidizing the beans and rapidly roasting them (Figure 3(d)).

20 After roasting, a stainless steel extraction sleeve (114), within which is disposed, in piston and cylinder configuration, a grinding head (116), descends and contacts the outer periphery of the slidable wall (14), so trapping and isolating the roasted beans (108) (Figure 3(f)).

25 Continued descent of the extraction sleeve (114) pushes the slidable wall (106) together with the isolated roasted beans (108) back into the cartridge (100) (Figure 3(f)).

30 At this stage, the roasted beans are back within the cartridge chamber (180), but separated from the side walls (120) by the steel walls of the extraction sleeve (114). The grinding head (116), in a piston-cylinder configuration with the extraction sleeve (114), then descends and rotates, crushing and grinding the roasted beans against the protruding milling means (113) of the brewing spike/spout.

This process yields fresh roasted coffee grounds confined within the chamber of the cartridge, but separated from the side walls (120) by the steel walls of the extraction sleeve (114).

- 5 Hot water is then fed through the grinding head (116) from a high pressure pump *via* channels therein (not shown), forcing the hot water through the ground beans and extracting a coffee brew which is delivered to the user *via* the brew spike/spout (104) (Figure 3(g), where the arrows show the flow of hot water).
- 10 A reclosing plunger (not shown) refolds the flaps into the closed position, so that the spent grounds and cartridge can be ejected into a waste compartment (not shown) without user intervention. It should be noted that the hinged flaps need not be refolded into a sequentially overlapping configuration at this stage of the process: all that is required is that the spent coffee grounds be substantially retained by the refolded flaps within the
- 15 cartridge chamber prior to ejection into the waste compartment.

The foregoing description details presently preferred embodiments of the present invention which are therefore to be considered in all respects as illustrative and not restrictive.

- 20 Those skilled in the art will recognize, or be able to ascertain, using no more than routine experimentation, many equivalents, modifications and variations to the specific embodiments of the invention described specifically herein. Such equivalents, modifications and variations are intended to be (or are) encompassed in the scope of the following claims.

CLAIMS:

1. A system for grinding, brewing and dispensing coffee comprising:

5 (a) a coffee cartridge containing unground coffee beans, said cartridge having walls defining a chamber in which the beans are confined, wherein part or all of at least one wall of the cartridge is openable, and the openable wall is opposed to a bottom wall supporting the beans;

10 wherein said cartridge is secured in a cartridge holder of:

(b) apparatus comprising:

- 15 i. a brewing spike for perforating the bottom wall of the cartridge thereby permitting a flow of water through said wall;
- ii. a grinding head adapted to enter the chamber *via* the openable wall thereof and to compress the beans contained therein against the bottom wall;
- iii. a source of pressurized hot water;
- iv. feed means for delivering pressurized hot water to the beans whereby
20 coffee is thereby extracted to yield a coffee brew;
- v. a brew spout for delivering said coffee brew to a drinking vessel for consumption; and
- vi. a controller for controlling the operations of one or more of the brewing
25 spike, grinding head, source of pressurized hot water, feed means and/or brew spout;

wherein the grinding head is disposed within an extraction sleeve and adapted to reciprocate and/or rotate therein.

30 2. The system of claim 1 for roasting, grinding, brewing and dispensing coffee, wherein the unground coffee beans are unroasted or part-roasted coffee beans and said bottom wall is a slidable wall, being adapted to slide within the cartridge chamber;

35 3. The system of claim 2 wherein said cartridge is secured in a cartridge holder of apparatus comprising:

- 5
- i. a roasting chamber comprising means for roasting the coffee beans;
 - ii. a brewing spike for perforating the slidable wall of the cartridge thereby permitting a flow of water through said wall, wherein the brewing spike is integrated with a plunger and is adapted to drive the slidable wall of the chamber towards the openable wall thereof thereby displacing said beans from the chamber;
 - iii. means for conveying the beans to said roasting chamber;
 - iv. a grinding head adapted to enter the chamber *via* the openable wall thereof and to compress the beans contained therein against the slidable wall;
 - 10 v. a source of pressurized hot water;
 - vi. feed means for delivering pressurized hot water to the beans whereby coffee is thereby extracted to yield a coffee brew;
 - vii. a brew spout for delivering said coffee brew to a drinking vessel for consumption; and
 - 15 viii. a controller for controlling the operations of one or more of the roasting means, brewing spike, conveying means, grinding head, source of pressurized hot water, feed means and/or brew spout;
- 20 wherein the grinding head is disposed within an extraction sleeve and adapted to reciprocate and/or rotate therein.

4. A system for roasting, grinding, brewing and dispensing coffee comprising:

- 25 (a) a coffee cartridge containing: (i) unground and (ii) unroasted or part-roasted coffee beans, said cartridge having walls defining a chamber in which the beans are confined, wherein part or all of at least one wall of the cartridge is openable, and the openable wall of the cartridge is opposed to a slidable bottom wall thereof;

30 wherein said cartridge is secured in a cartridge holder of:

(b) apparatus comprising:

- i. a roasting chamber comprising means for roasting the coffee beans;

- 5
- ii. a brewing spike for perforating the slidable wall of the cartridge thereby permitting a flow of water through said wall, wherein the brewing spike is integrated with a plunger and is adapted to drive the slidable wall of the chamber towards the openable wall thereof thereby displacing said beans from the chamber;
 - iii. means for conveying the beans to said roasting chamber;
 - iv. a grinding head adapted to enter the chamber *via* the openable wall thereof and to compress the beans contained therein against the slidable wall;
 - v. a source of pressurized hot water;
 - 10 vi. feed means for delivering pressurized hot water to the beans whereby coffee is thereby extracted to yield a coffee brew;
 - vii. a brew spout for delivering said coffee brew to a drinking vessel for consumption; and
 - viii. a controller for controlling the operations of one or more of the roasting
 - 15 means, brewing spike, conveying means, grinding head, source of pressurized hot water, feed means and/or brew spout;

wherein the grinding head is disposed within an extraction sleeve and adapted to reciprocate and/or rotate therein.

20

5. The system of any one of the preceding claims wherein the openable wall is reversibly openable.

25 6. The system of any one of the preceding claims wherein the grinding head is adapted to enter the chamber *via* the openable wall thereof when disposed within the extraction sleeve.

30 7. The system of any one of the preceding claims wherein the grinding head and extraction sleeve are in a piston-cylinder configuration.

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8. The system of any one of the preceding claims wherein the extraction sleeve is adapted to enter the cartridge chamber *via* the openable wall thereof and to contact the periphery of the inner surface of the bottom wall, thereby trapping the beans within the sleeve and isolating them from the cartridge chamber.

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9. The system of claim 8 wherein the grinding head is adapted to crush and/or grind the trapped and isolated beans within the extraction sleeve.

5 10. The system of any one of the preceding claims wherein the grinding head comprises said feed means and is adapted to deliver pressurized hot water to trapped and isolated beans within the extraction sleeve.

10 11. The system of any one of the preceding claims further comprising a motor for: (a) reciprocating the grinding head within the extraction sleeve; and/or (b) rotating the grinding head within the extraction sleeve, optionally bidirectionally; and/or (c) pumping hot water to trapped and isolated beans within the extraction sleeve.

12. The system of any one of claims 3-11 wherein said means for conveying the beans into said roasting chamber comprises said brewing spike.

15

13. The system of any one of claims 3-12 wherein said means for conveying the beans into said roasting chamber comprises a source of a stream of air for levitating the beans.

20 14. The system of claim 13 wherein said means for conveying the beans into said roasting chamber comprises a source of a stream of heated air for levitating and roasting the beans.

15. The system of any one of the preceding claims wherein said brewing spike is adapted to physically support the bottom wall after perforation and/or is integrated with said brew spout.

25

16. The system of any one of the preceding claims wherein said brewing spike comprises a first milling means.

30 17. The system of claim 16 wherein said first milling means comprises one or more optionally retractable needles, cannulae, teeth, spikes, blades or protrusions adapted to pierce the slidable wall and contact the beans within the chamber, whereat they optionally anchor the beans during subsequent grinding operations.

35 18. The system of claim 16 or 17 wherein said first milling means comprises the perforating means of the brewing spike.

19. The system of claim 18 wherein the perforating means of the brewing spike comprises one or more optionally retractable needles, cannulae, teeth, spikes, blades or protrusions adapted to pierce the slidable wall and contact the beans within the chamber.

5

20. The system of any one of the preceding claims wherein the grinding head comprises second milling means.

10

21. The system of claim 20 wherein said second milling means comprises one or more ribs, recesses, channels, teeth, ridges, spikes, blades or protrusions.

22. The system of claim 20 or 21 wherein the second milling means is adapted for crushing and rotational grinding of beans against the bottom wall of the cartridge.

15

23. The system of any one of claims 20-22 as dependent on any one of claims 16-18 wherein the second milling means is adapted for crushing and rotational grinding of the beans in conjunction with the first milling means.

20

24. The system of any one of the preceding claims wherein the extraction sleeve is adapted to serve as a pressure jacket to contain the pressurized hot water during delivery to the beans.

25

25. The system of any one of the preceding claims wherein the apparatus further comprises means for opening the openable wall.

30

26. The system of claim 25 as dependent on any one of claims 2-24, wherein said opening means comprises the brewing spike, and wherein the brewing spike is adapted to drive the slidable wall of the cartridge towards the openable wall thereof thereby exerting a force of the openable wall such that it opens, so allowing the beans to be displaced from the chamber.

27. The system of any one of the preceding claims wherein the apparatus further comprises means for closing the openable wall.

28. The system of claim 27 wherein the closing means is adapted to permit substantial retention of spent coffee grounds within the cartridge chamber after extraction.

5 29. The system of claim 27 or 28 wherein the closing means is adapted to fold a portion of the cartridge walls into contact with spent coffee grounds within the cartridge chamber after extraction.

30. The system of any one of the preceding claims wherein the openable wall comprises a releasably crimped, welded or folded closure.

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31. The system of any one of the preceding claims wherein the openable wall comprises a flap.

32. The system of claim 31 wherein said flap is adapted to fold at a hinge portion.

15

33. The system of claim 32 wherein said hinge portion comprises: (a) a fold in a cartridge wall; and/or (b) a weakened fold-line joining the flap to the cartridge wall, optionally wherein the fold-line is weakened by perforations or scorings.

20 34. The system of any one of claims 31-33 wherein said flap is adapted to open and close the reversibly openable wall by movement about the hinge portion.

35. The system of any one of claims 31-34 wherein the flap is connected to a cartridge wall by said hinge portion.

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36. The system of claim 34 or 35 wherein the flap is also releasably connected to said cartridge wall by: (a) a perforated tear-line; and/or (b) a rupturable welded connection; and/or (c) a rupturable crimped connection.

30 37. The system of any one of claims 30-36 wherein the folded closure is in the form of a single flap.

38. The system of claim 37 wherein said flap is configured as a single-leaf door.

39. The system of any one of claims 30-36 wherein the folded closure is in the form of two opposed flaps.

40. The system of claim 39 wherein said opposed flaps are configured as a two-leaf door.

5

41. The system of claim 39 or 40 wherein the opposed flaps are mutually overlapping when folded into a closed configuration.

42. The system of any one of claims 30-36 wherein the folded closure comprises:

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(a) at least three flaps; or

(b) at least four flaps; or

(c) at least five flaps; or

(d) at least six flaps; or

15

(e) at least seven flaps; or

(f) at least eight flaps; or

(g) at least nine flaps; or

(h) at least ten flaps; or

(i) at least eleven flaps; or

20

(j) at least twelve flaps; or

(k) more than twelve flaps.

43. The system of claim 42 wherein two or more of the flaps are mutually overlapping when folded into a closed configuration.

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44. The system of claims 41 or 43 wherein at least one of the mutually overlapping flaps comprises a slit to permit mutual overlap.

45. The system of claim 42 wherein the flaps are sequentially overlapping when folded into a closed configuration.

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46. The system of any one of claims 39-45 wherein said flaps are of uniform shape and/or are substantially rectangular or wedge-shaped.

47. The system of any one of claims 2-46 wherein said slidable wall is in the form of a plug slidably fitted within the chamber.

5 48. The system of claim 46 wherein the slidable plug comprises a peripheral sealing portion adapted to contact the inner surface of the side walls of the cartridge thereby forming a seal, optionally wherein the plug is friction-fitted within the side walls of the chamber.

10 49. The system of any one of claims 47-48 wherein the slidable plug comprise an annular co-axial rim which increases the surface area of the plug in contact with the inner side walls of the chamber.

15 50. The system of any one of the preceding claims which comprises a cylindrical or substantially cylindrical portion wherein the slidable wall is adapted to reciprocate and/or rotate within the cartridge chamber so that a crushing and/or rotational grinding force may be exerted on the beans confined in the chamber.

20 51. The system of any one of the preceding claims wherein said cartridge is cylindrical, substantially cylindrical or frustoconical, having top and bottom walls defining the ends of the cylinder or bases of the frustum, respectively, and wherein the top wall is the reversibly openable wall and the bottom wall is the slidable wall.

25 52. The system of claim 51 wherein the cartridge is frustoconical, and wherein the top wall has a larger surface area than the slidable wall.

53. The system of any one of the preceding claims wherein the unground coffee beans are selected from:

- 30 (a) whole and/or cracked coffee beans;
- (b) unroasted coffee beans, for example selected from: (i) green coffee beans; (ii) dried coffee beans; (iii) pre-heated coffee beans; and (iv) mixtures of two or more of the foregoing;
- (c) roasted coffee beans;
- (d) part-roasted coffee beans; and
- 35 (e) mixtures of the foregoing.

54. The system of claim 53, wherein the unground coffee beans are unroasted coffee beans, for example selected from: (i) green coffee beans; (ii) dried coffee beans; (iii) pre-heated coffee beans; and (iv) mixtures of two or more of the foregoing.

5

55. The system of any one of the preceding claims wherein part or all of the cartridge is formed of materials selected from: paper, cardboard, coated paper or cardboard, and metal-, polytetrafluoroethylene- (PTFE-) or nitrocellulose-coated paper or cardboard.

10 56. The system of claim 55 wherein the metal is aluminium.

57. The system of any one of the preceding claims, which is a disposable, single-serve cartridge.

15 58. The system of any one of the preceding claims wherein one or more additives selected from flavouring agents, preservatives, foaming agents, anti-foaming agents, foam stabilizers, colouring agents and mixtures thereof are confined in the chamber of the cartridge together with the coffee beans.

20 59. The system of claim 58 wherein said one or more additives are selected from cocoa, caramel, vanilla, tea, chicory, fruit/berry extracts (e.g. raspberry, cherry, apricot, banana or citrus, such as lemon), herbs (for example mint), spices (for example, chilli and cinnamon, nutmeg), liqueurs (for example brandy and Amaretto), spirits (e.g. rum and brandy), salt, sugar, scorched sugar, honey, nuts (e.g. almond, hazelnut, walnut, peanut, pecan,
25 macadamia and pistachio), coconut and mixtures of the foregoing.

60. The system of any one of the preceding claims, wherein at least one component of the cartridge is: (a) biodegradable; (b) non-biodegradable; (c) compostable; (d) non-compostable; (e) recyclable and/or (f) non-recyclable.

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61. The system of any one of the preceding claims wherein the means for roasting the coffee beans comprises heating means selected from: means for microwave heating, radiant heating, conductive heating, convection heating or any combination thereof.

62. The system of any one of the preceding claims wherein the means for roasting the coffee beans comprises a roasting chamber for fluidized bed roasting of the coffee beans.

5 63. The system of any one of the preceding claims wherein an outer wall of the cartridge comprises means for engaging with the cartridge holder of the apparatus.

64. The system of claim 63 wherein said engaging means comprises a peripheral flange or rim.

10 65. The system of claim 63 or 64 wherein said engaging means is adapted to permit clamping of the cartridge within the cartridge holder of the apparatus.

66. A process for producing and dispensing brewed coffee comprising the steps of grinding and extracting unground coffee beans, comprising the steps of:

15

(a) providing a coffee cartridge as defined in any one of the preceding claims;

(b) securing the cartridge in a cartridge holder of apparatus as defined in any one of the preceding claims; and then

20

(c) grinding and extracting the roasted beans within an extraction sleeve as defined in any one of the preceding claims.

25 67. A process for producing and dispensing brewed coffee comprising the steps of roasting, grinding and extracting unground coffee beans, comprising the steps of:

(a) providing a coffee cartridge as defined in any one of the preceding claims;

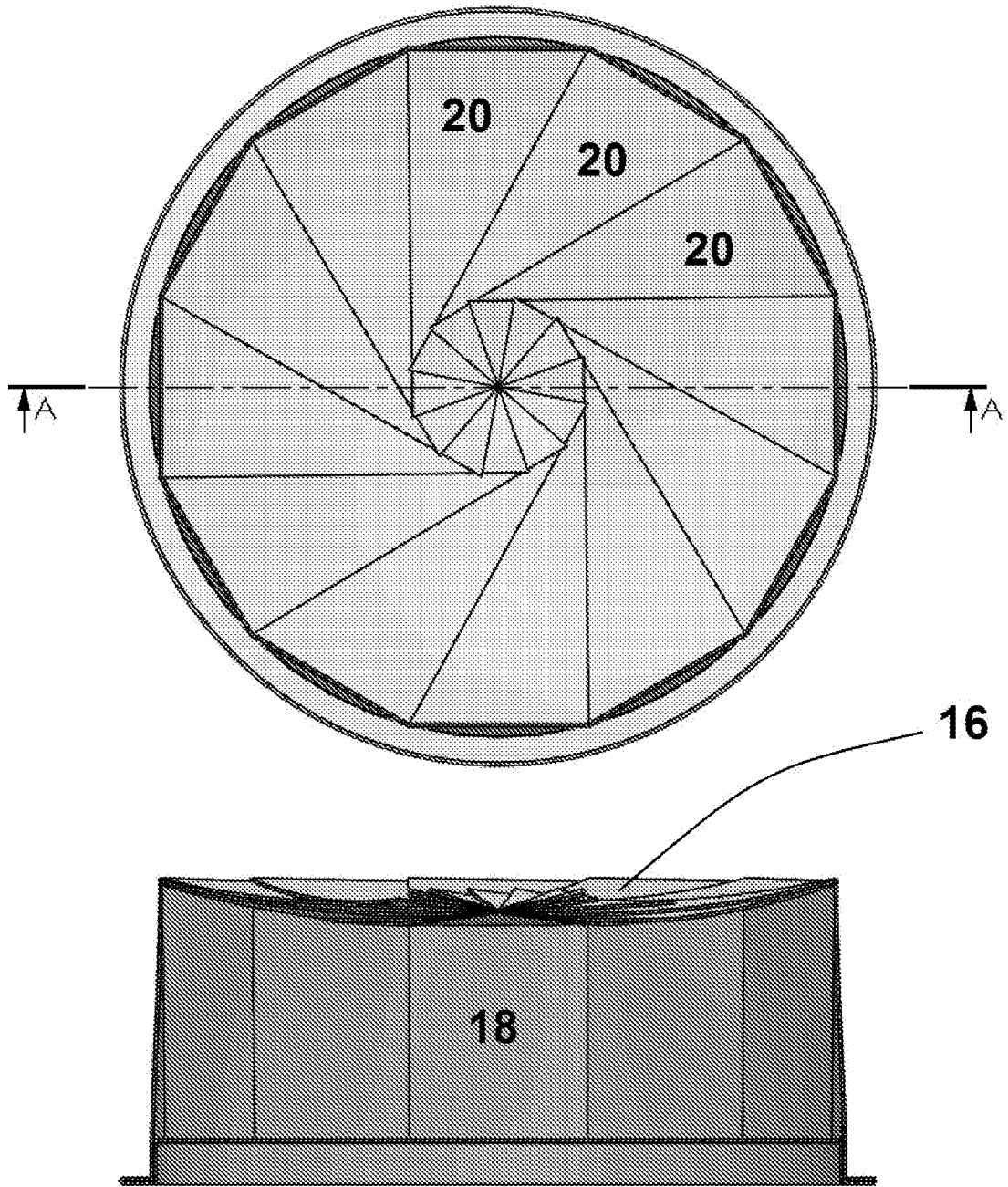
30

(b) securing the cartridge in a cartridge holder of apparatus as defined in any one of the preceding claims;

(c) displacing the beans from the cartridge, conveying them to a roasting chamber, roasting the beans by fluidized bed roasting; and then

(d) grinding and extracting the roasted beans within an extraction sleeve as defined in any one of the preceding claims.

FIGURE 1



SECTION A-A

FIGURE 2

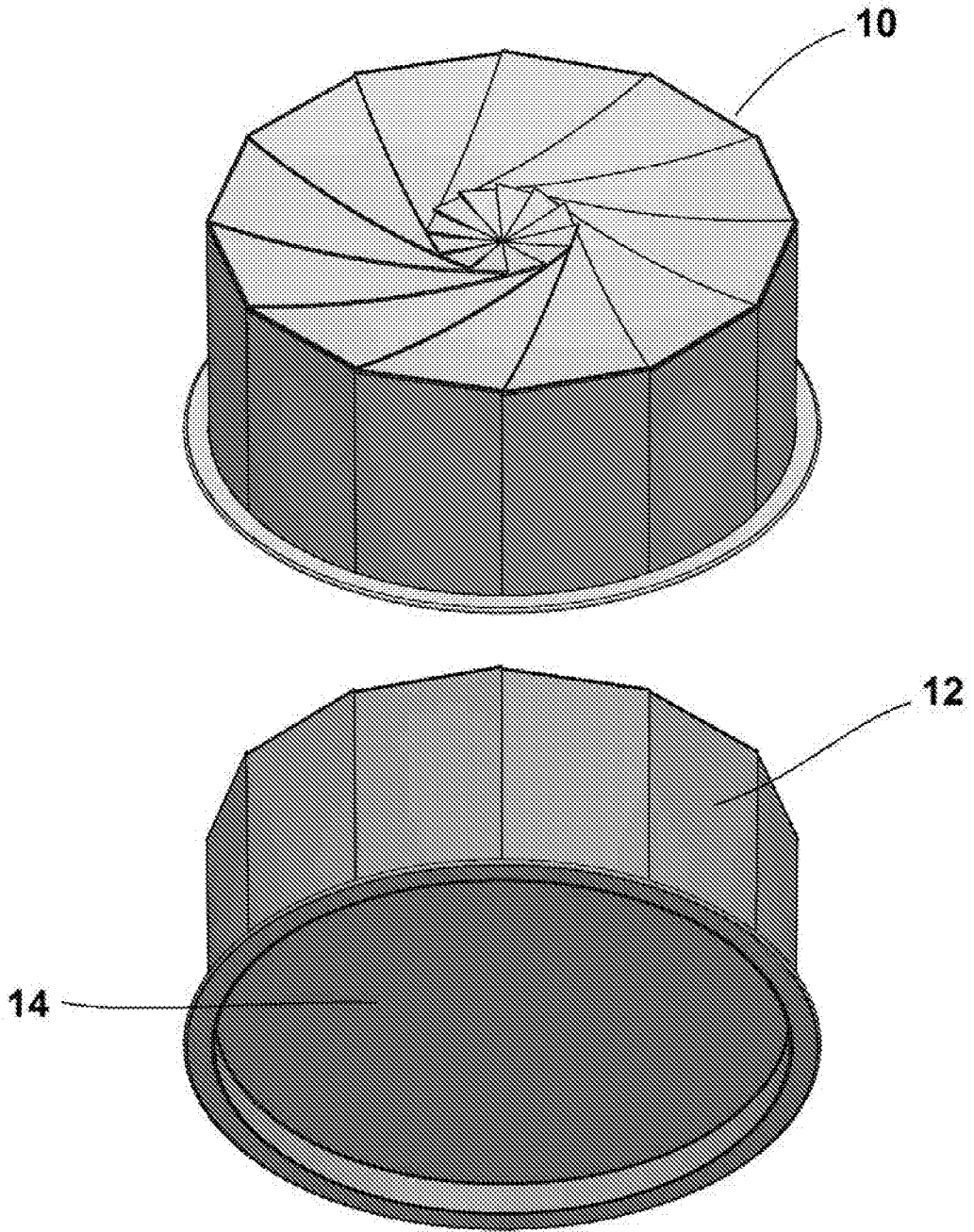
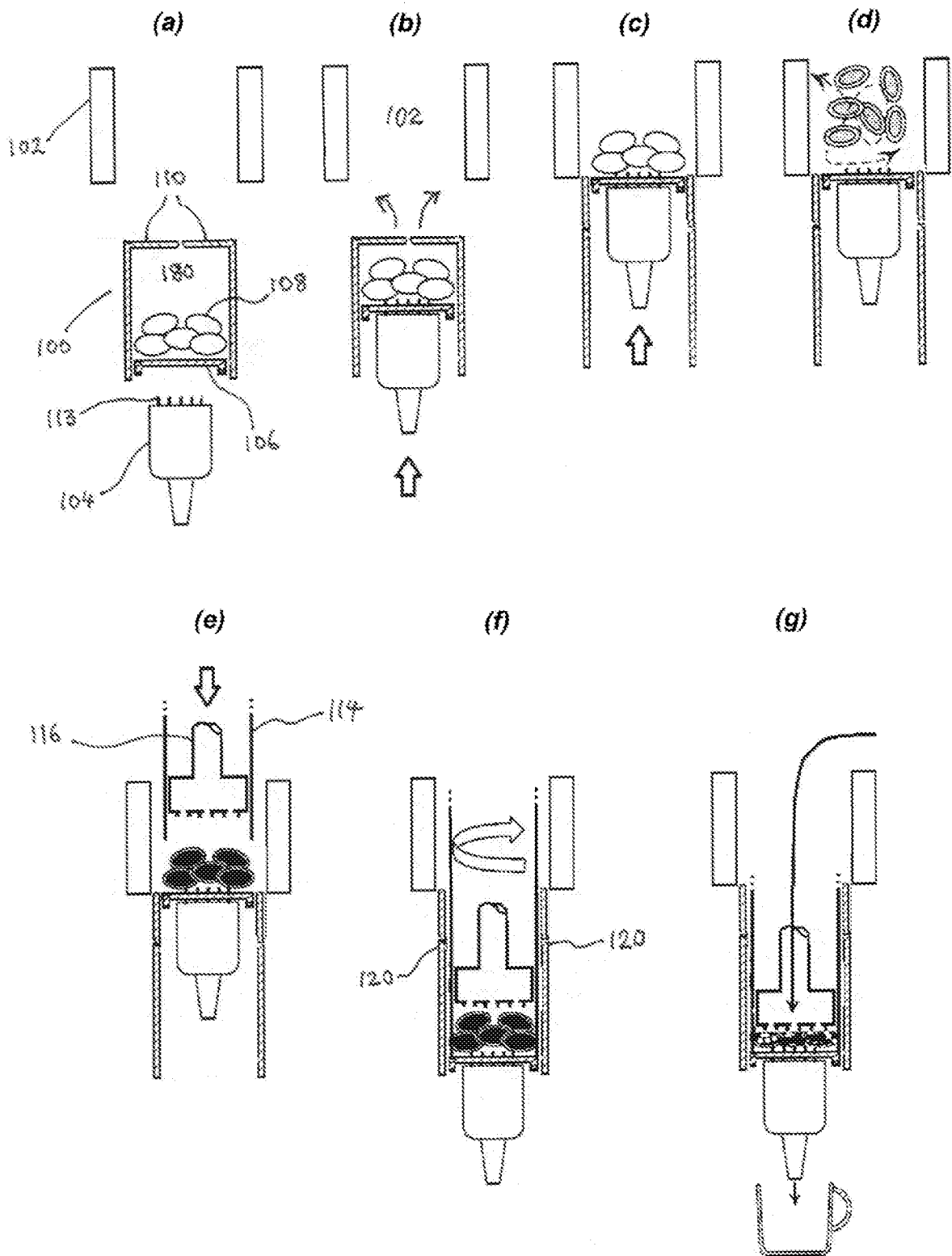


FIGURE 3



INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2017/050845

A. CLASSIFICATION OF SUBJECT MATTER
 INV. A47J31/06 A47J31/36 A47J31/42 A23F5/08 A23N12/00
 A47J31/00 B65D85/804
 ADD.
 According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
 Minimum documentation searched (classification system followed by classification symbols)
 A23F A47J A23N B65D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
 EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012/171332 A1 (LAI KIN MAN [CN] ET AL) 5 July 2012 (2012-07-05)	1,5-7, 10,11, 15-25, 27, 30-40, 42,46, 51-66
Y	paragraphs [0068] - [0075], [0082] - [0098]; figures 1-6, 32-55	2,5,7, 15-19, 23, 30-40, 42,46, 51,52, 54-62,67
A		3,4,8,9, 12-14, 26,28, 29,41, 43-45,
	-/--	

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>
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Date of the actual completion of the international search 18 July 2017	Date of mailing of the international search report 16/08/2017
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Escudero, Raquel
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INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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Y	paragraphs [0042], [0046], [0052] - [0054], [0056] - [0062], [0065] - [0074], [0082] - [0091]; figures 7-9, 13-19	2,5,7, 15-19, 23, 30-40, 42,46, 51,52, 54-62,67
A		3,4,8,9, 12-14, 26,28, 29,41, 43-45, 47-50
Y	----- US 2011/274802 A1 (A. RIVERA) 10 November 2011 (2011-11-10)	2,5-7, 10,11, 15-25, 27, 30-40, 42,46, 51-67
A	paragraphs [0013], [0048], [0063] - [0066]; figures 3A, 16A-17E	3,4,8,9, 12-14, 26,28, 29,41, 43-45, 47-50
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Y	paragraphs [106114], [0120] - [0137], [0148], [0155] - [0159]; figures 1-7, 25A, 30-58, 93-96	1,2,5-7, 10,11, 15-25, 27, 30-40, 42,46, 51-67
A		3,4,8,9, 12-14, 26,28, 29,41, 43-45, 47-50
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INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2017/050845

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	paragraph [0034]; figures 9a, 9b	1,2,5-7, 10,11, 15-25, 27, 30-40, 42,46, 51-66
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