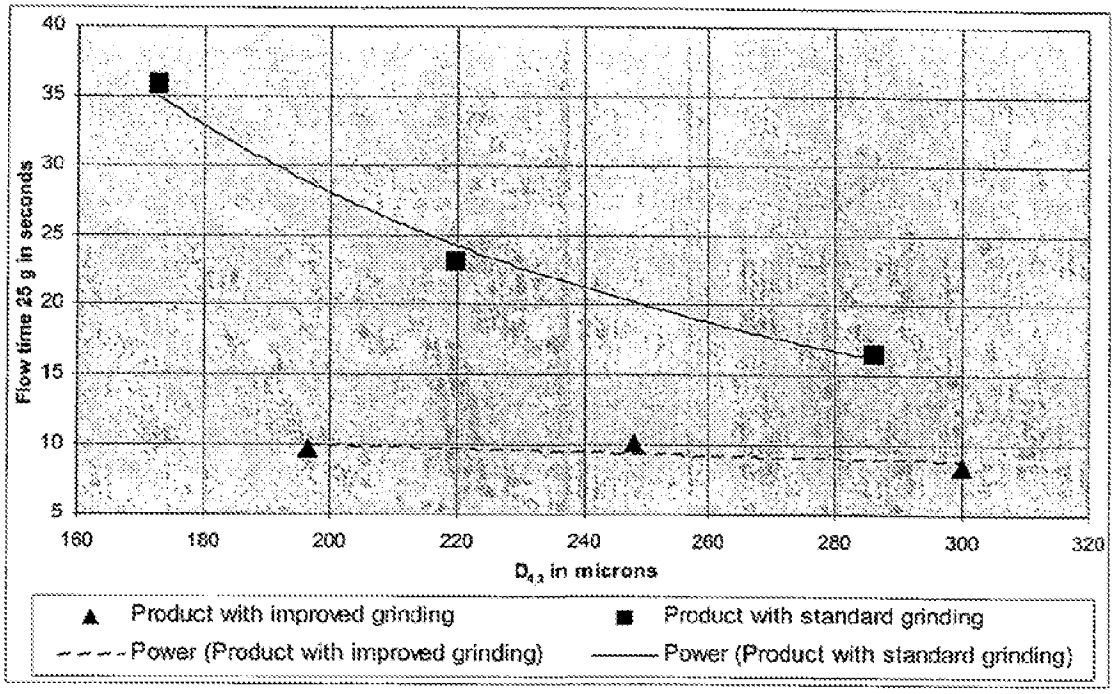


FIG. 2

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 1 of 387

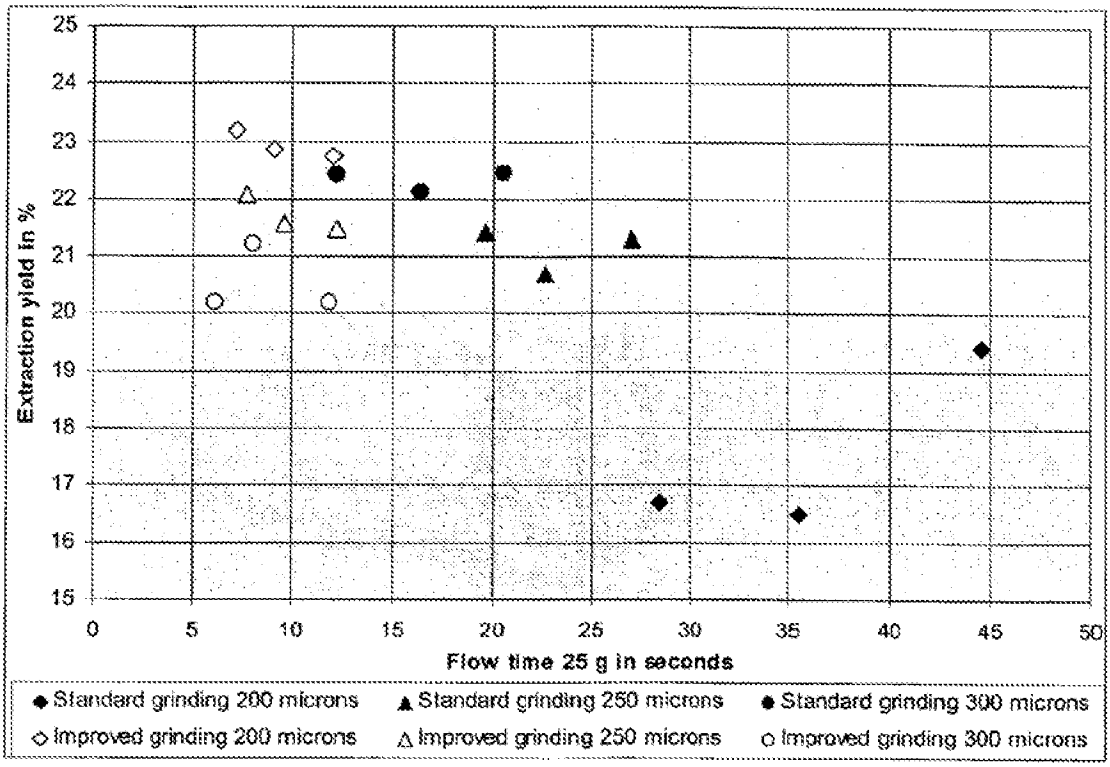


FIG. 3

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 2 of 387

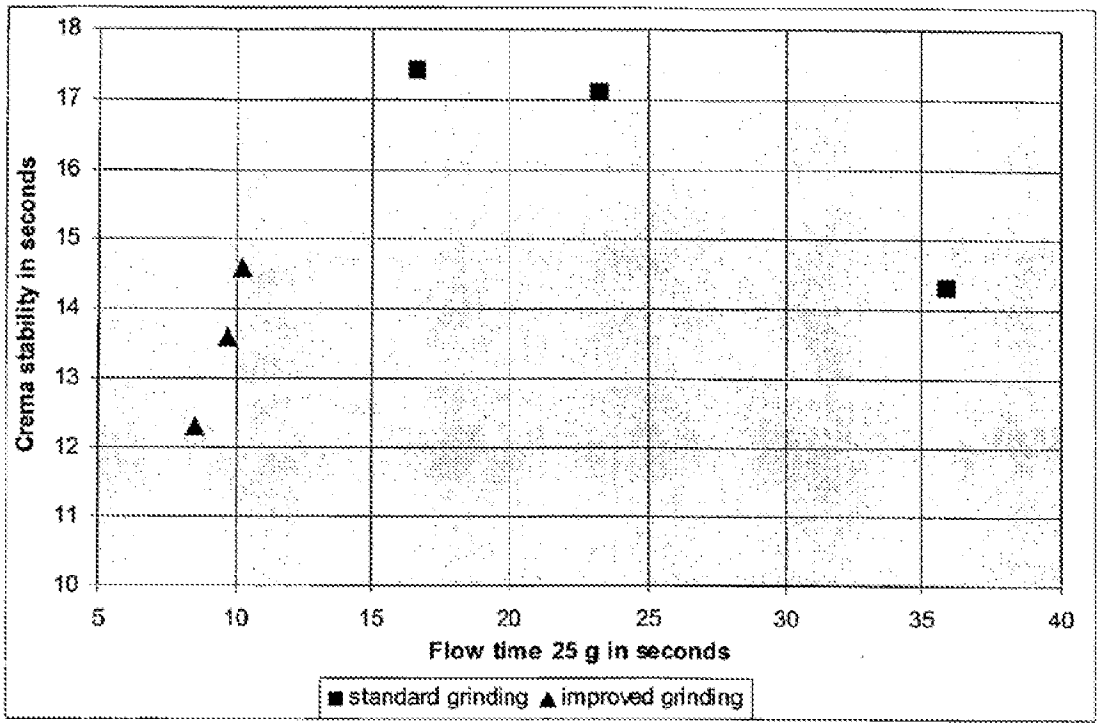


FIG. 4

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 3 of 387

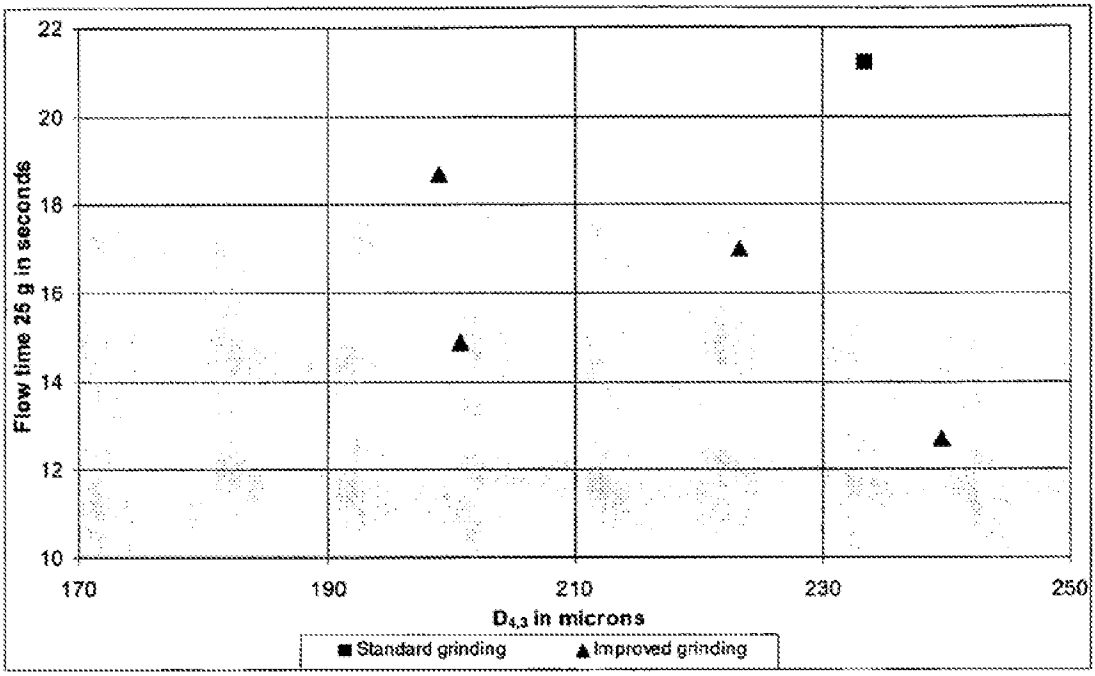


FIG. 5

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 4 of 387

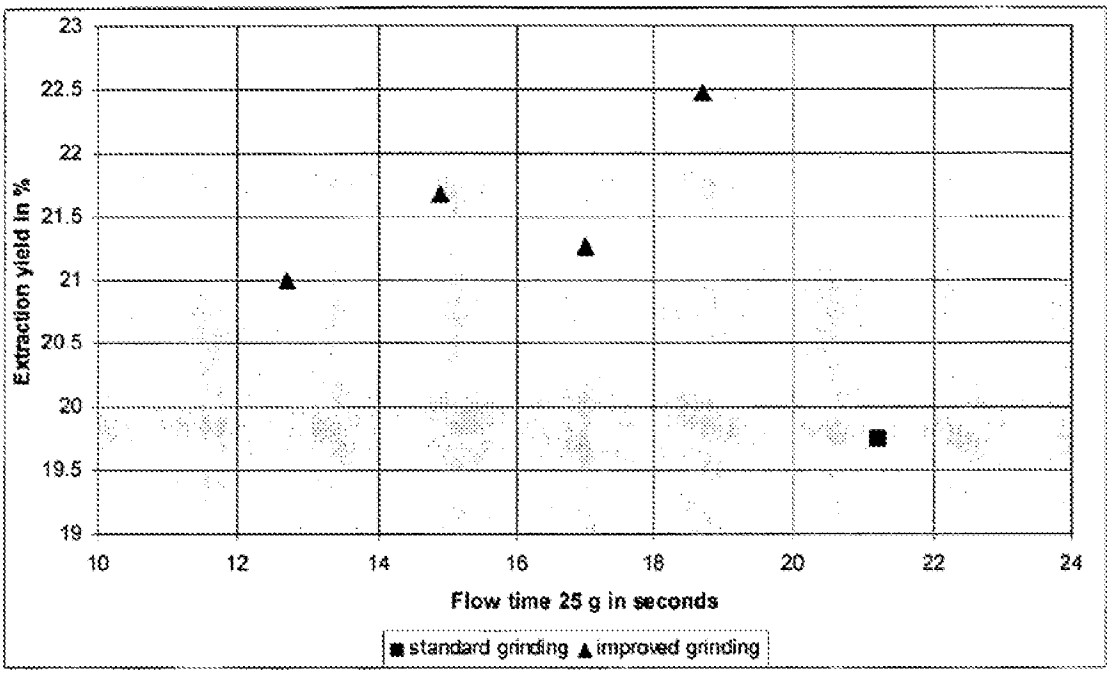


FIG. 6

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 5 of 387

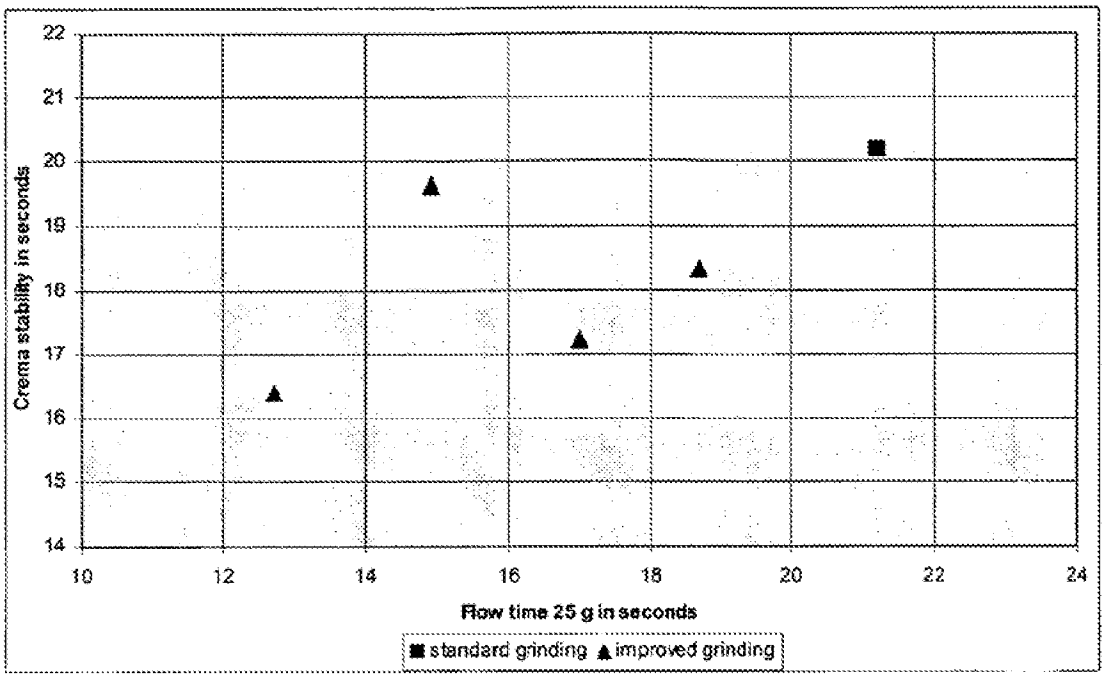


FIG. 7

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 6 of 387

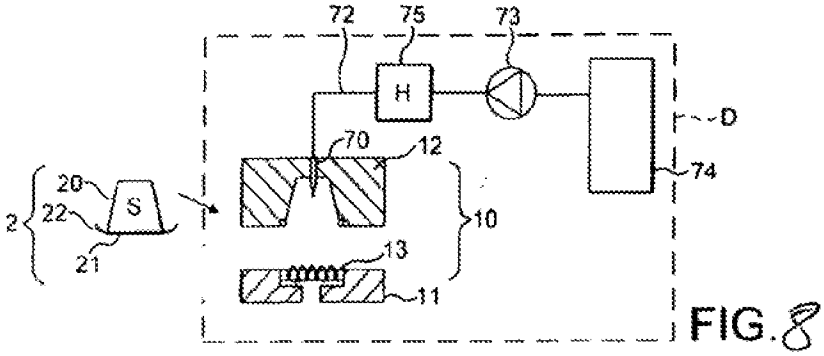


FIG. 8

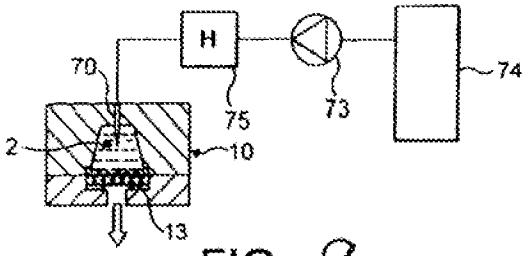


FIG. 9

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 7 of 387

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 01 5331

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 1 566 127 A2 (NESTEC SA [CH]) 24 August 2005 (2005-08-24) * abstract; figure 1 * -----	1-18	INV. A47J31/40 A23F5/08
A	EP 0 844 195 A1 (NESTLE SA [CH]) 27 May 1998 (1998-05-27) * claim 1; example 1 * -----	1-18	
A	US 5 082 676 A (LOVE GRAHAM [DE] ET AL) 21 January 1992 (1992-01-21) * examples 1-10 * -----	1-18	

TECHNICAL FIELDS SEARCHED (IPC)

A47J
A23F
B65D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	20 December 2006	Saunders, Thomas

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 8 of 387

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 06 01 5331

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

20-12-2006

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1566127 A2	24-08-2005	NONE	
EP 0844195 A1	27-05-1998	AT 207443 T	15-11-2001
		DE 69616346 D1	29-11-2001
		DE 69616346 T2	18-04-2002
US 5082676 A	21-01-1992	NONE	

EPO FORM P0459

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 9 of 387

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 1566127 A2 **[0035] [0060]**

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 10 of 387

(12) UK Patent Application (19) GB (11) 2469874 (13) A

(43) Date of A Publication 03.11.2010

(21) Application No: 0907612.6

(22) Date of Filing: 01.05.2009

(51) INT CL:
A47J 31/06 (2006.01) *A47J 31/24* (2006.01)

(58) Documents Cited:
EP 1208781 A3 WO 2009/008700 A1
WO 2006/053016 A3 US 20060288874 A1

(58) Field of Search:
INT CL A47J
Other: EPODOC, WPI

(71) Applicant(s):
Kraft Foods R & D Inc
Three Lakes Drive, Northfield, Illinois 60093, United States of America

(72) Inventor(s):
Nick Andrew Hansen
Andrew Bentley
Elizabeth Hinckley
Mark Norton

(74) Agent and/or Address for Service:
Boult Wade Tennant
Verulam Gardens, 70 Gray's Inn Road, LONDON, WC1X 8BT, United Kingdom

(54) Title of the Invention: **Beverage preparation machines**
Abstract Title: **Beverage preparation machine for producing crema**

(57) A beverage preparation machine 10 for preparing a beverage from one or more beverage ingredients, characterised by the provision of means for controlling the volume of gas or air in at least part of a delivery system of the machine to produce predetermined characteristics in a prepared beverage. The volume of gas may be controlled by inducting additional gas into the delivery system 10, venting gas from the delivery system 10 or purging the delivery system 10. The control system can calculate the volume of gas resident in the machine. By controlling the gas to liquid ratio a high quality crema can be achieved.

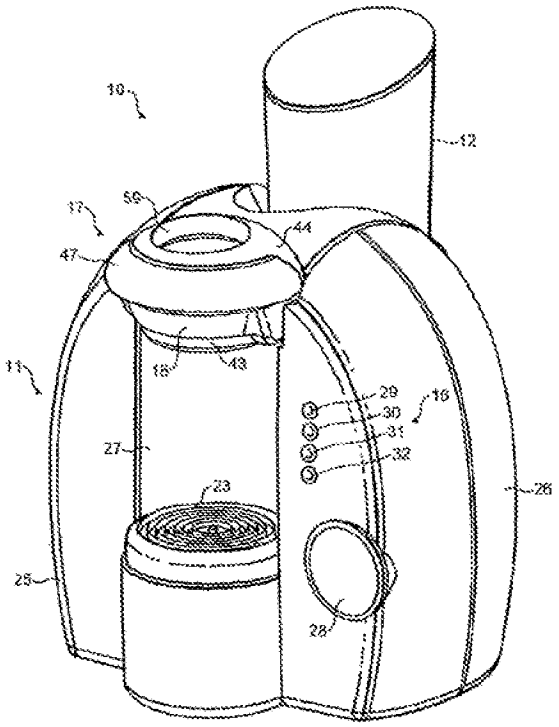


FIG. 1

GB 2469874 A

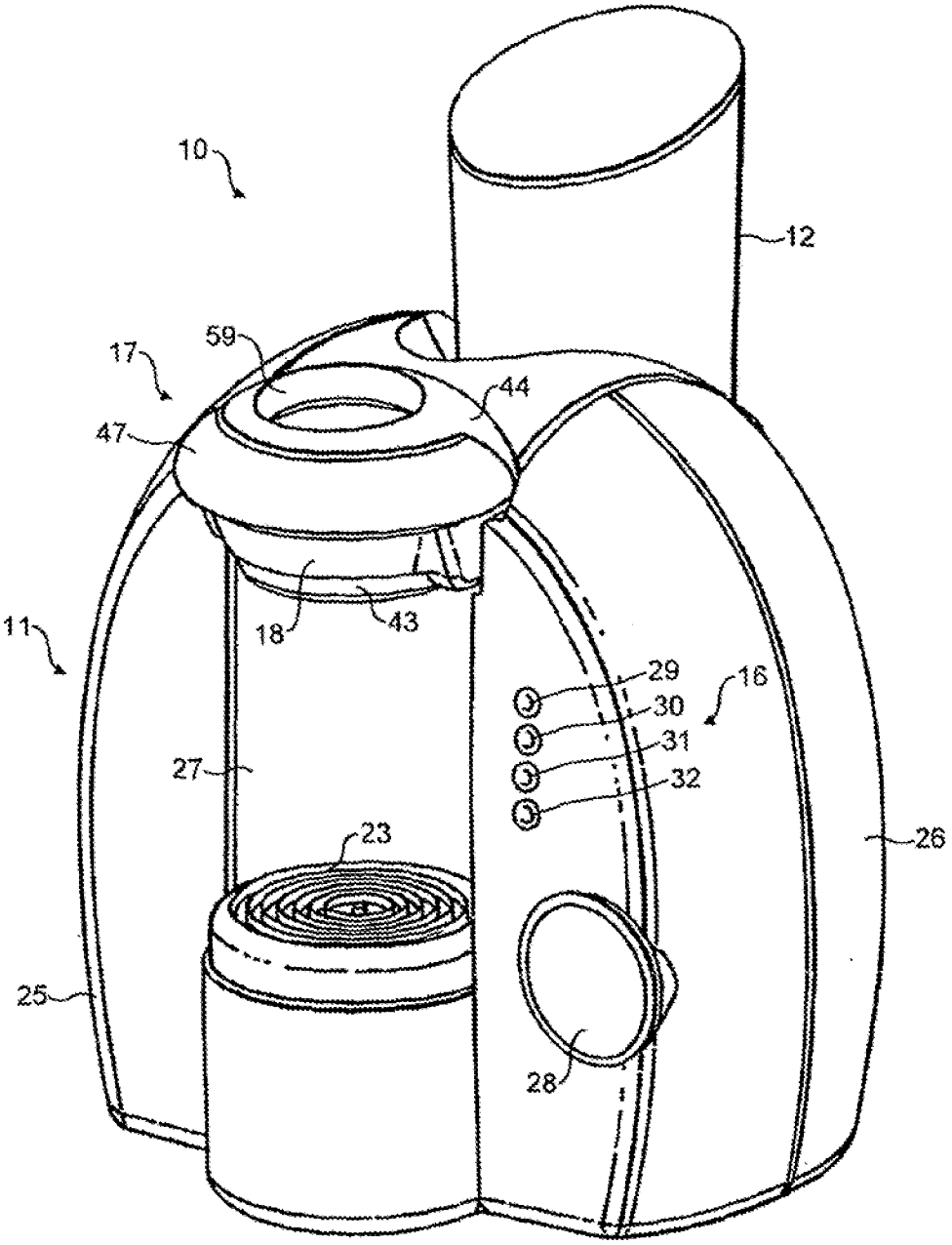


FIG. 1

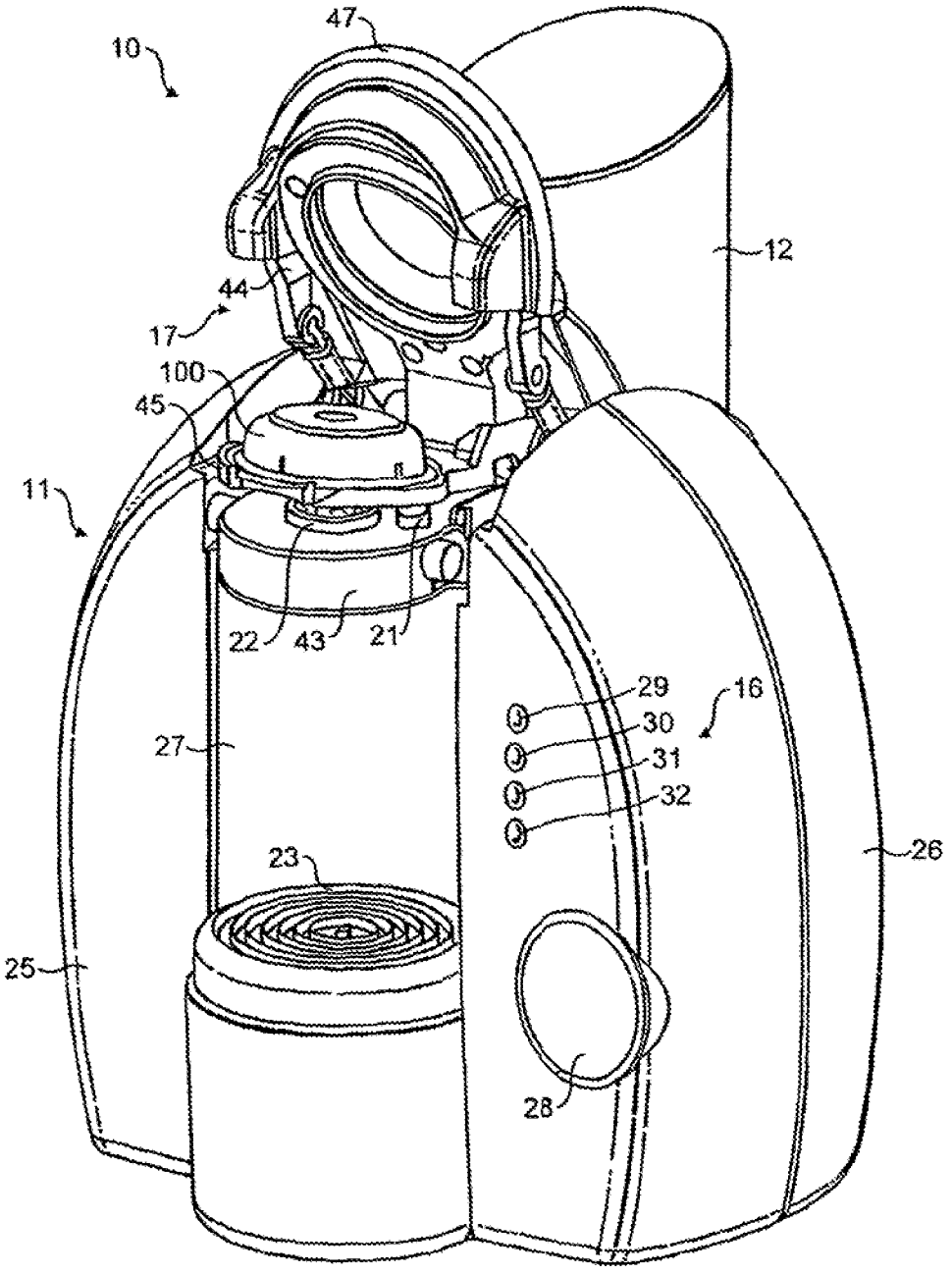


FIG. 2

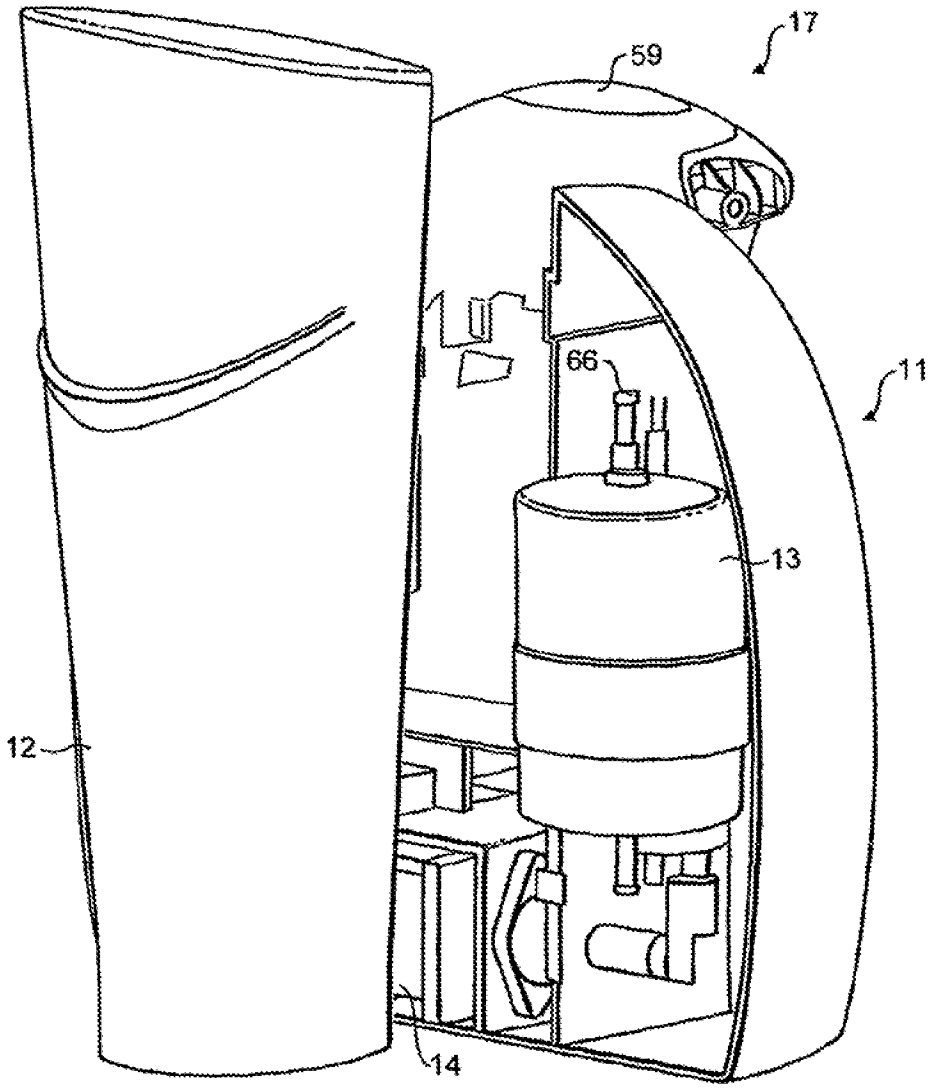


FIG. 3

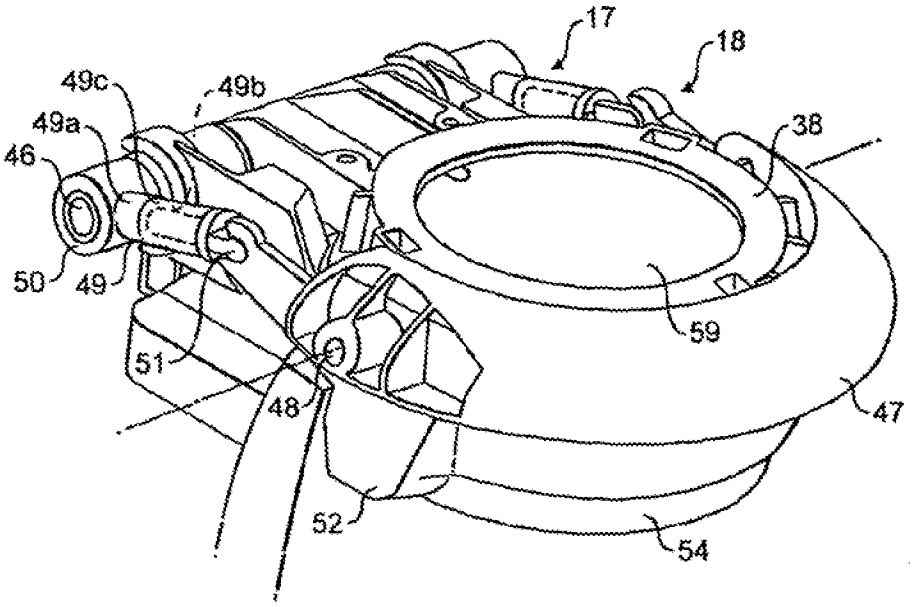

17
18
49c
49b
49a
46
38
50
49
59
51
48
47
52
54

FIG. 4

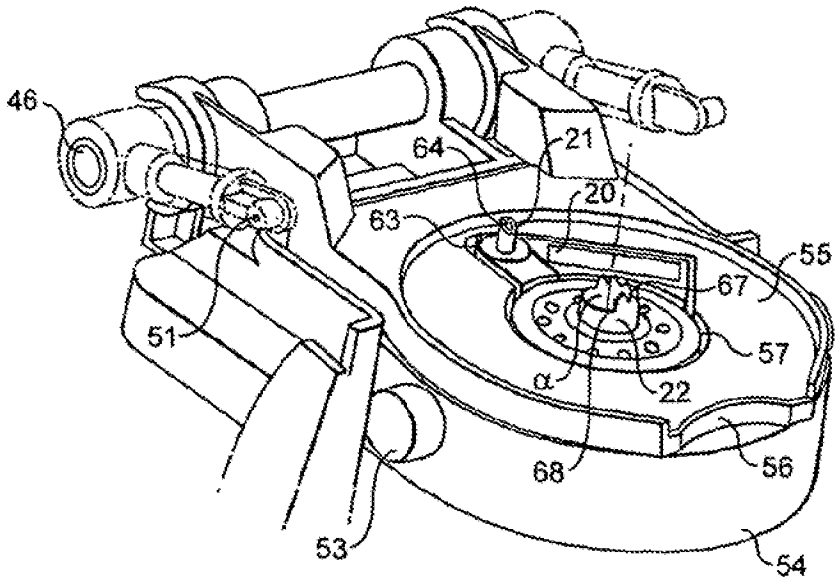

46
64
21
20
63
55
67
51
57
α
22
68
56
53
54

FIG. 5

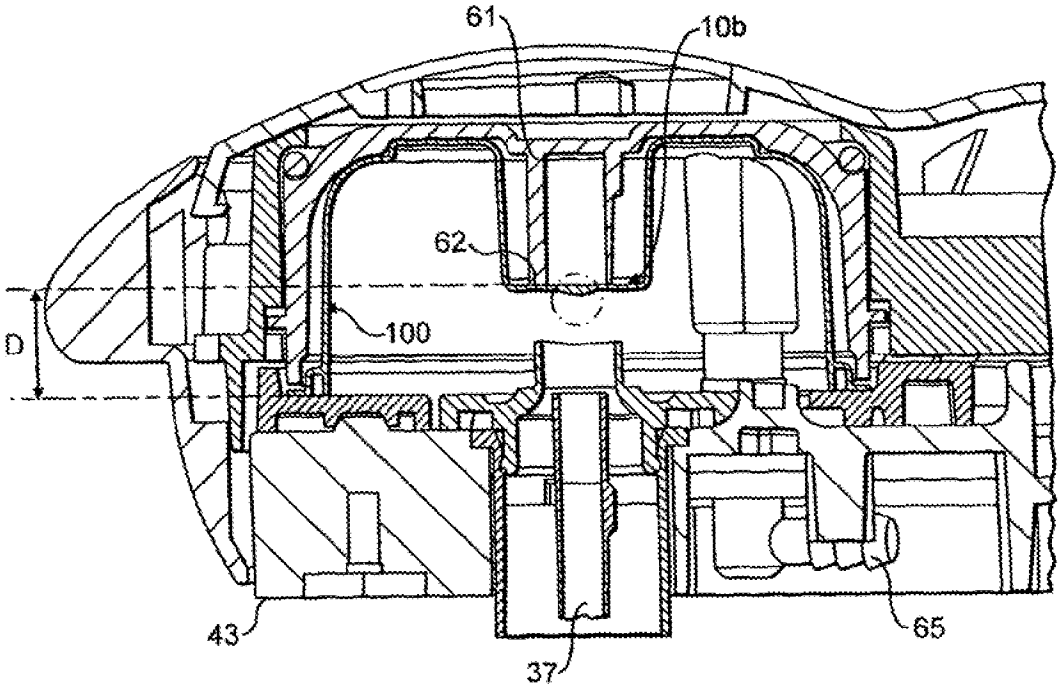


FIG. 6

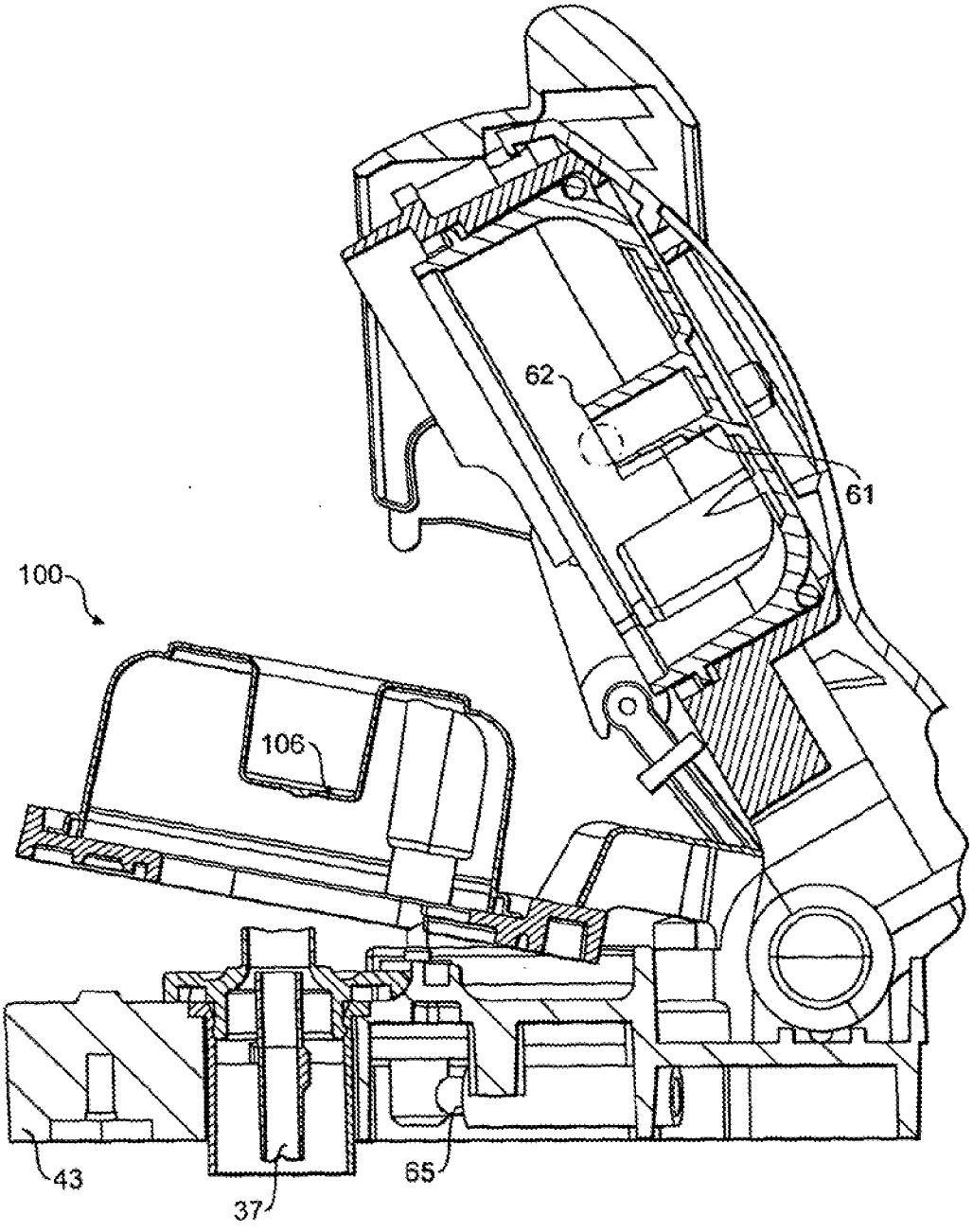


FIG. 7

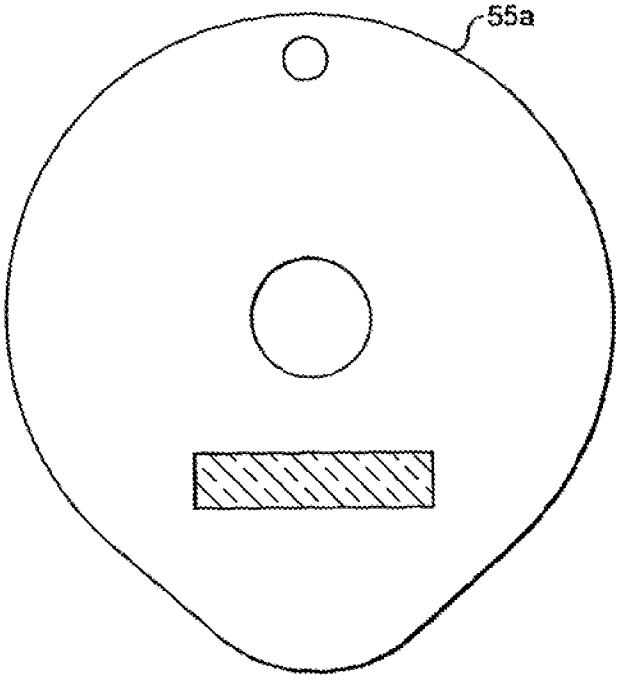


FIG. 7a

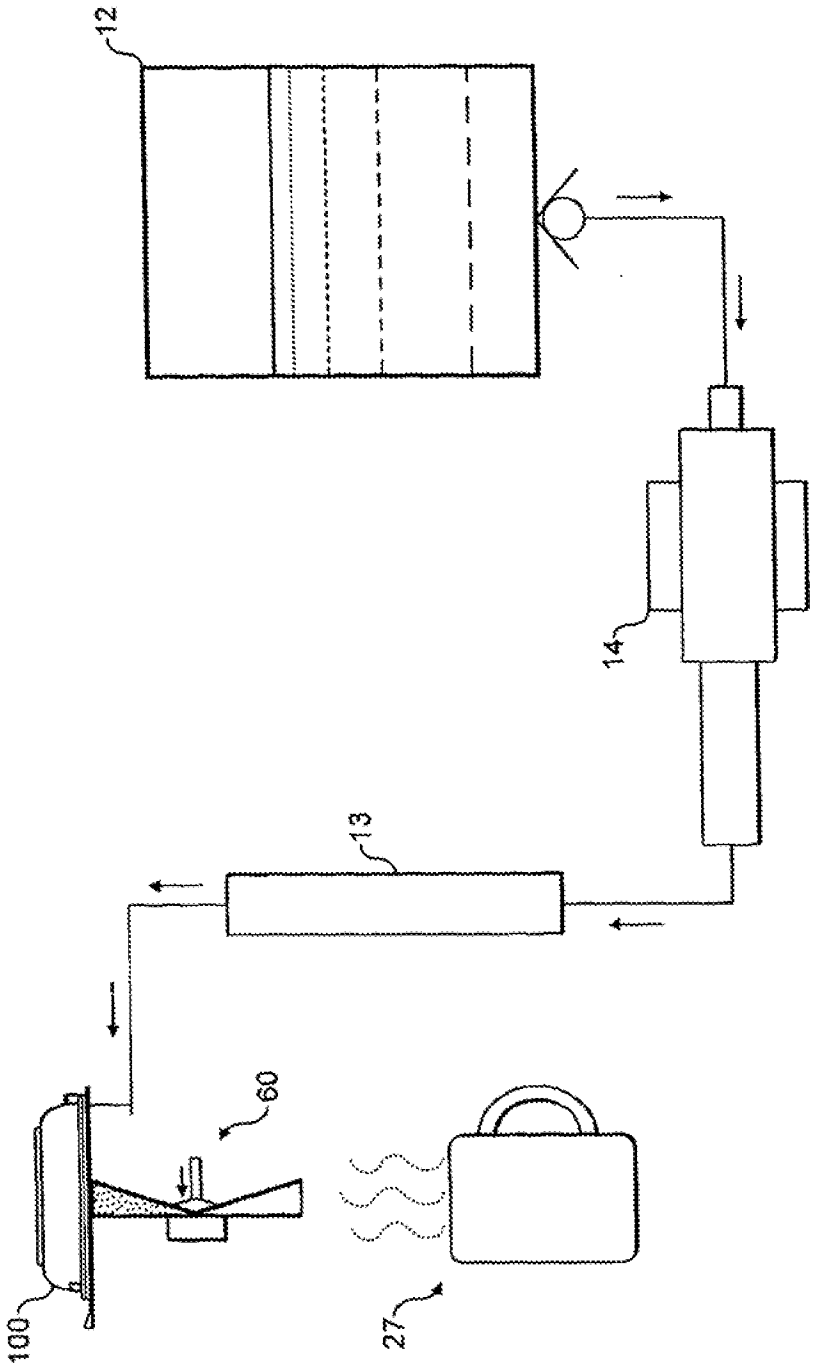


FIG. 8

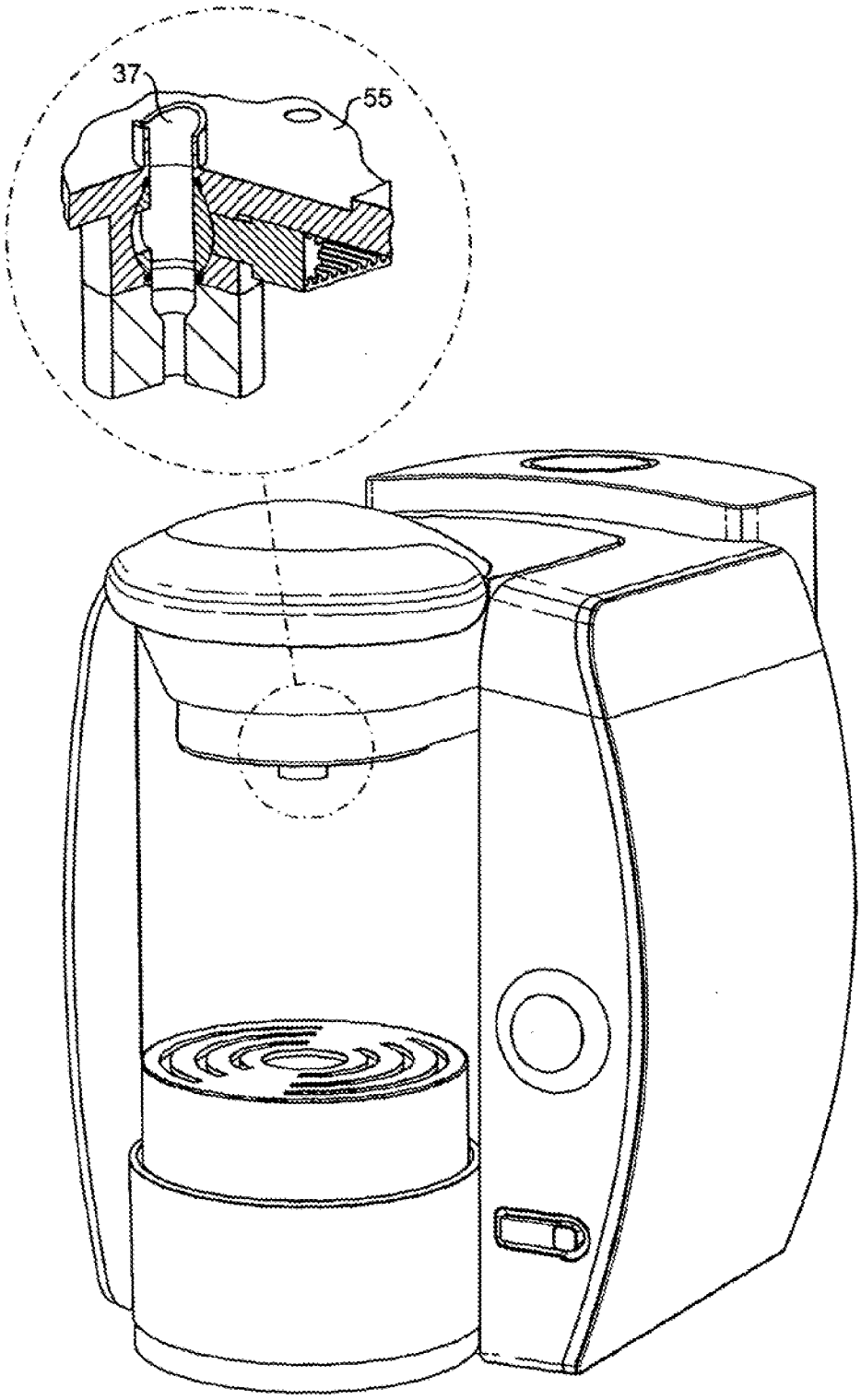


FIG. 9

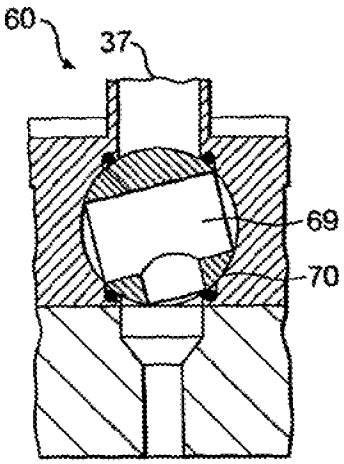


FIG. 10

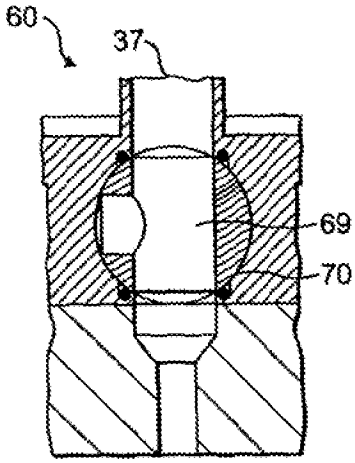


FIG. 11

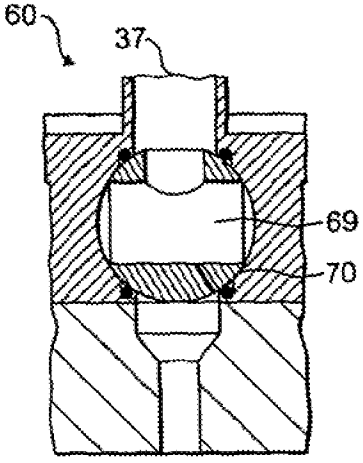


FIG. 12

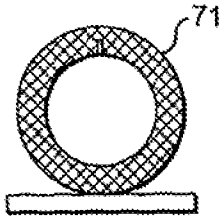


FIG. 13a

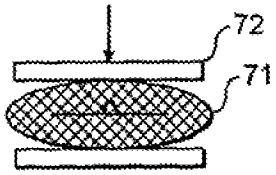


FIG. 13b

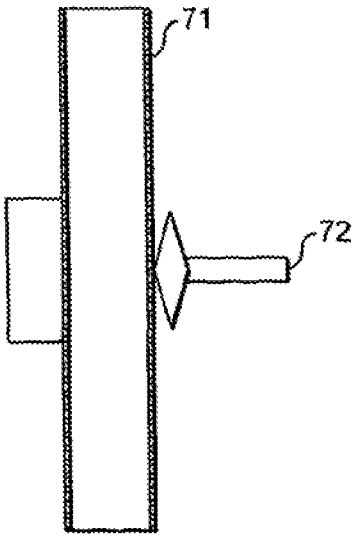


FIG. 14

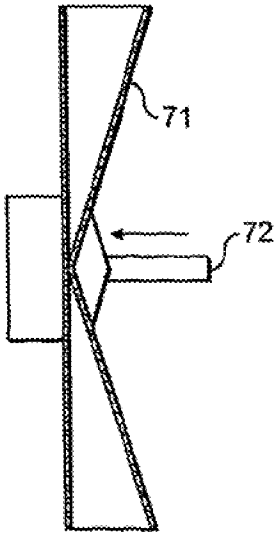


FIG. 15

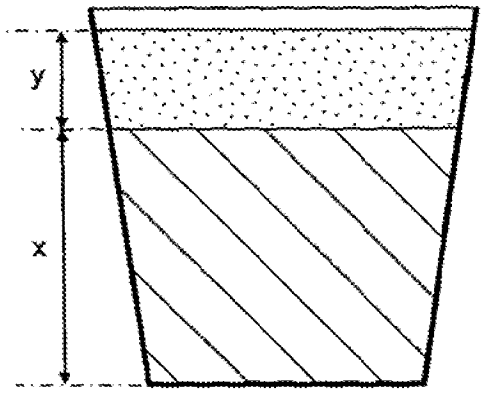


FIG. 16a

STEP	WATER PUMP STATE/SPEED	AIR PURGE PUMP/PWM	RECIRCULATION VALVE STATE	RESTRICTION BYPASS VALVE STATE	STOP CONDITION/DURATION OF STEP
Set valves	No change/0	Stop/0	Recirculate	Open	Time >=1 second
Heat	Stop/0	Stop/0	Recirculate	Open	Boiler temperature >=97°C
Set valves	No change/0	No change/0	Brew	Open	Time >=1 second
Remove gas	Run/50	No change/0	No change	Open	Time >=2 seconds
Set valves	Stop/0	No change/0	No change	Closed	Time >=5 seconds
Pressure wet	Run/100	No change/0	No change	No change	Disc inlet pressure >=2 bar
Soak	Stop/0	No change/0	No change	No change	Time >=10 seconds
Brew	Run/30	Stop/0	No change	No change	Time >=32 seconds
Stop pump	Stop/0	Stop/0	No change	No change	Time >=0.5 seconds
Open purge	Stop/0	Stop/0	No change	Open	Time >=3 seconds
Pause	No change/0	No change/0	No change	Open	Time <=1 seconds
Air purge	Stop/0	Run/50	No change	Open	Time >=8 seconds
Pause	Stop/0	Stop/0	Recirculate	No change	Time >=2 seconds
Reset	Stop/0	Stop/0	Recirculate	Closed	Time >=0 seconds

FIG. 16b

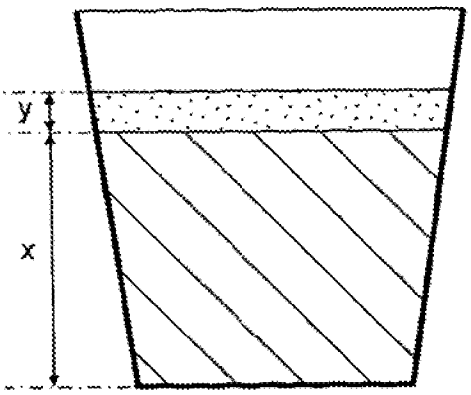


FIG. 17a

STEP	WATER PUMP STATE/SPEED	AIR PURGE PUMP/PWM	RECIRCULATION VALVE STATE	RESTRICTION BYPASS VALVE STATE	STOP CONDITION/DURATION OF STEP
Set valves	No change/0	Stop/0	Recirculate	Open	Time >=1 second
Heat	Stop/0	Stop/0	Recirculate	Open	Boiler temperature >=97°C
Set valves	No change/0	No change/0	Brew	Open	Time >=1 second
Remove gas	Run/70	No change/0	No change	Open	Time >=8 seconds
Set valves	Stop/0	No change/0	No change	Closed	Time >=5 seconds
Pressure wet	Run/100	No change/0	No change	No change	Disc inlet pressure >=2 bar
Soak	Stop/0	No change/0	No change	No change	Time >=10 seconds
Brew	Run/30	Stop/0	No change	No change	Time >=32 seconds
Stop pump	Stop/0	Stop/0	No change	No change	Time >=0.5 seconds
Open purge	Stop/0	Stop/0	No change	Open	Time >=3 seconds
Pause	No change/0	No change/0	No change	Open	Time <=5 seconds
Air purge	Stop/0	Run/50	No change	Open	Time >=8 seconds
Pause	Stop/0	Stop/0	Recirculate	Open	Time >=2 seconds
Reset	Stop/0	Stop/0	Recirculate	Open	Time >=0 seconds

FIG. 17b

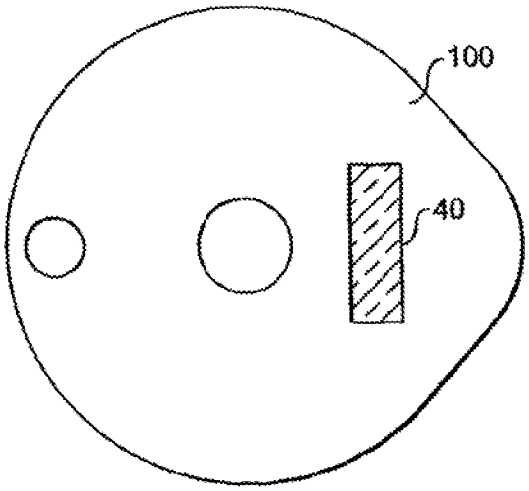

100
40

FIG. 18

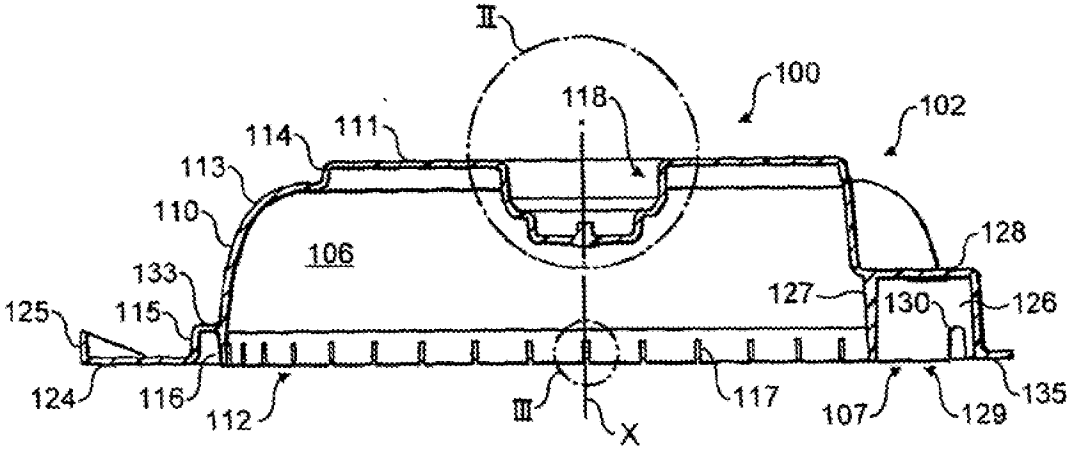

II
100
118
102
114
111
113
110
106
128
133
127
130
126
125
115
124
116
112
III
X
117
107
129
135

FIG. 19

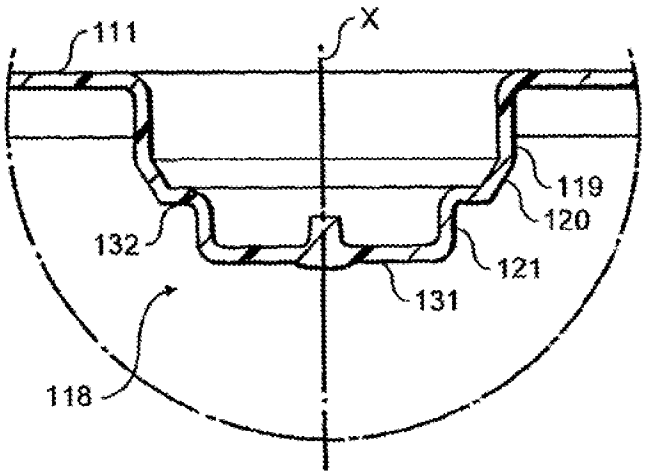


FIG. 20

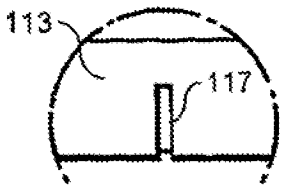


FIG. 21

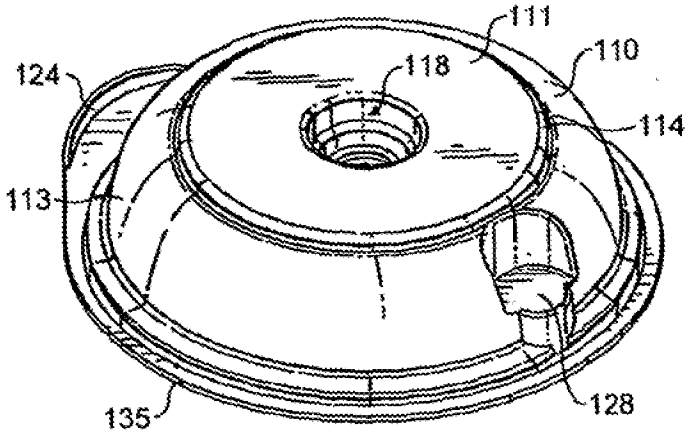


FIG. 22

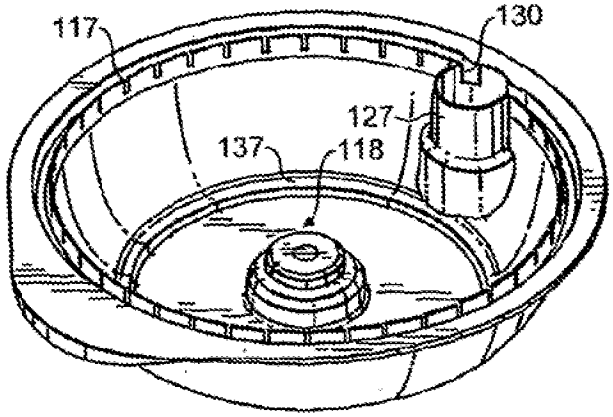


FIG. 23

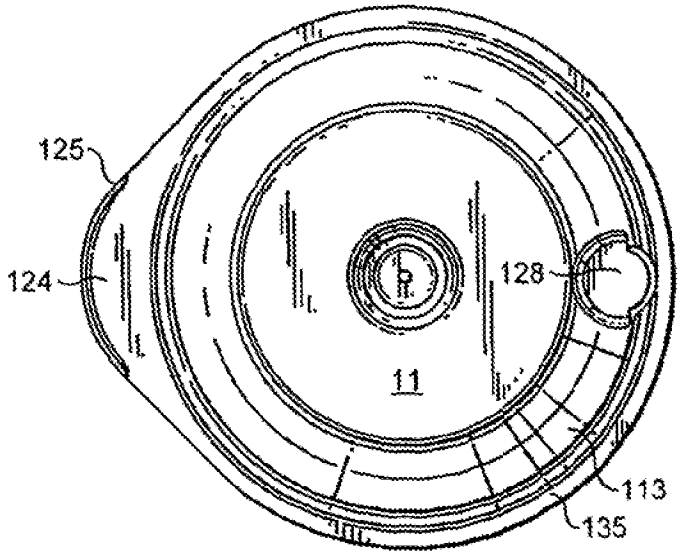


FIG. 24

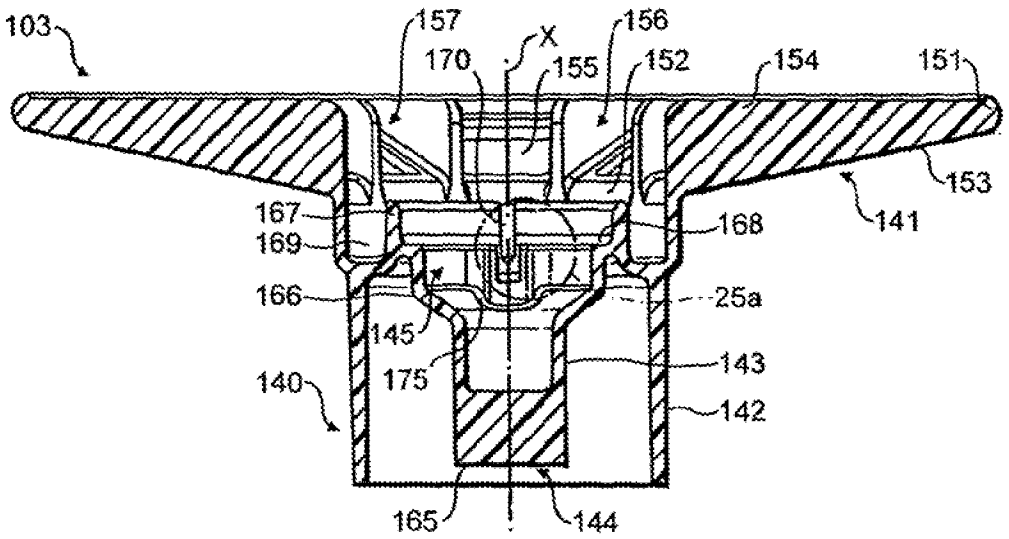


FIG. 25

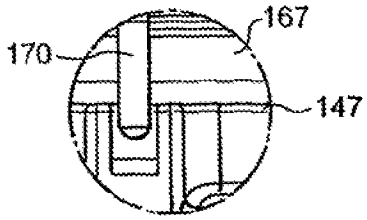


FIG. 25a

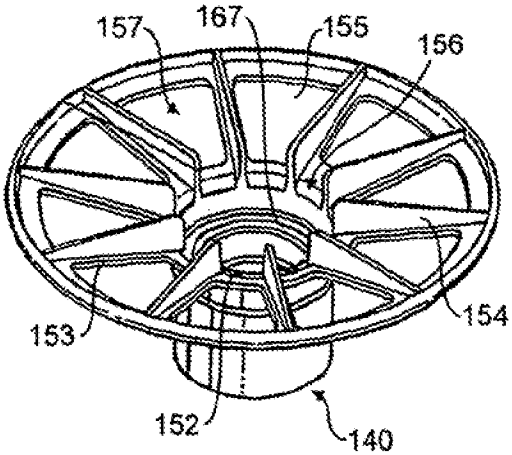


FIG. 26

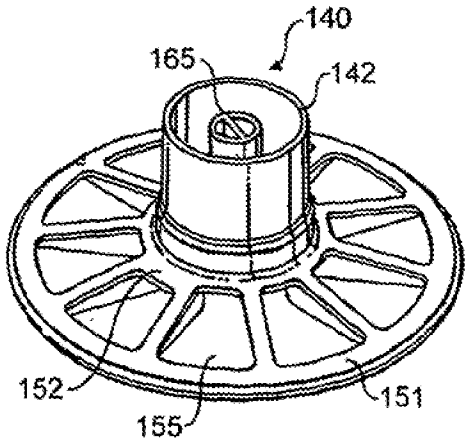


FIG. 27

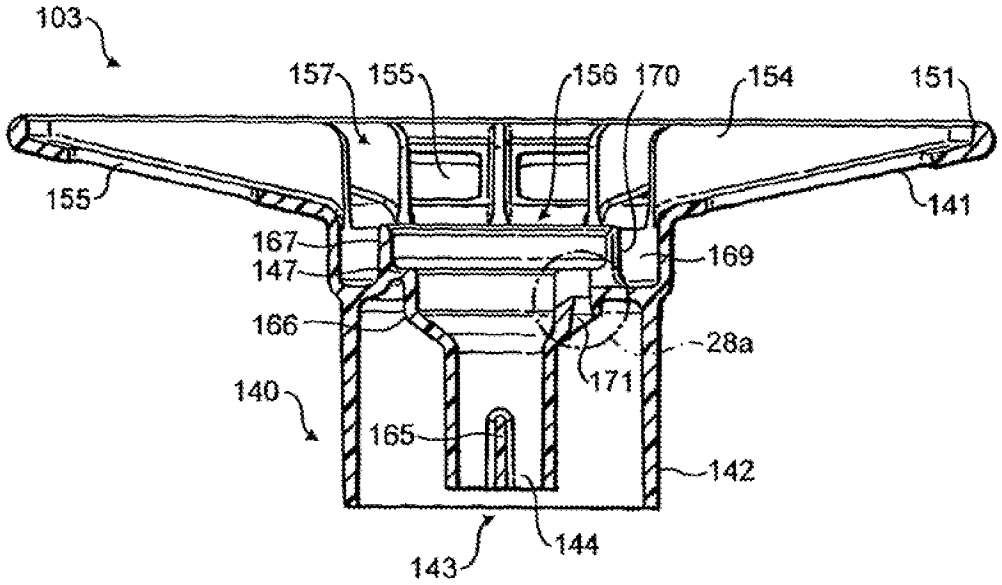


FIG. 28

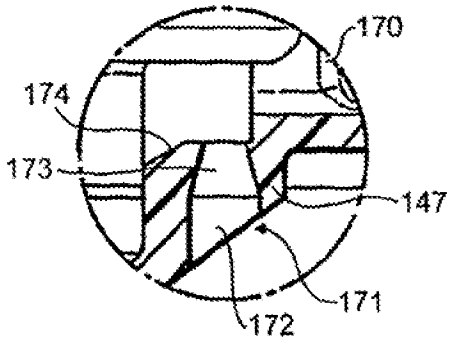


FIG. 28a

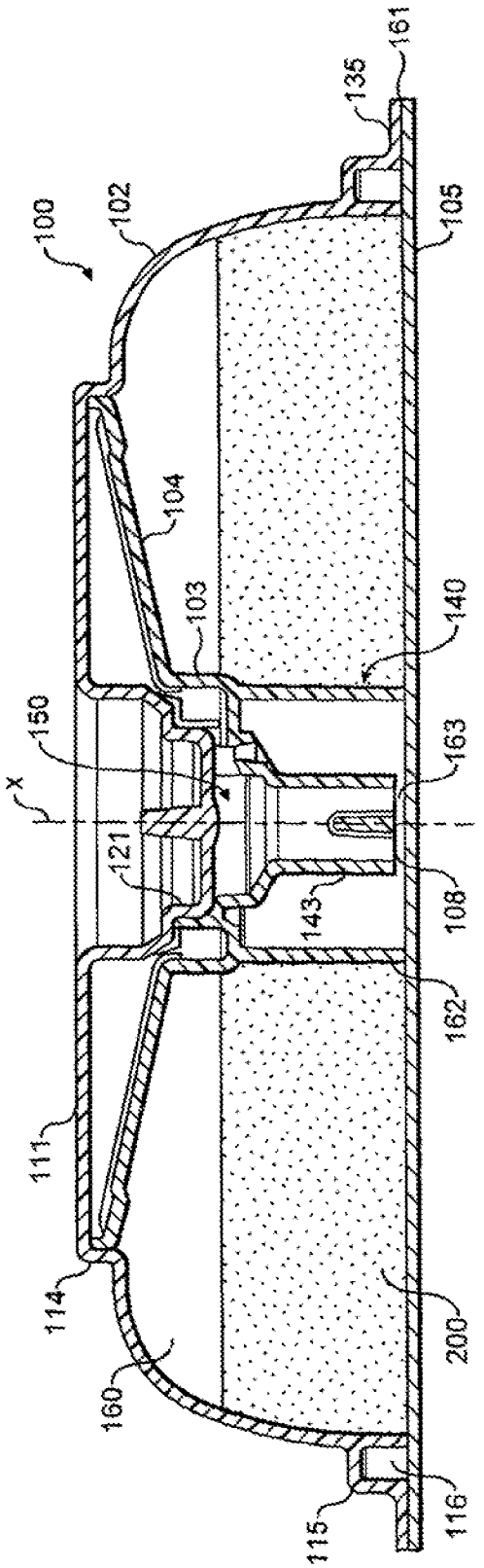

161
135
100
102
105
104
103
140
150
163
X
121
143
108
162
111
114
200
160
115
116

FIG. 29

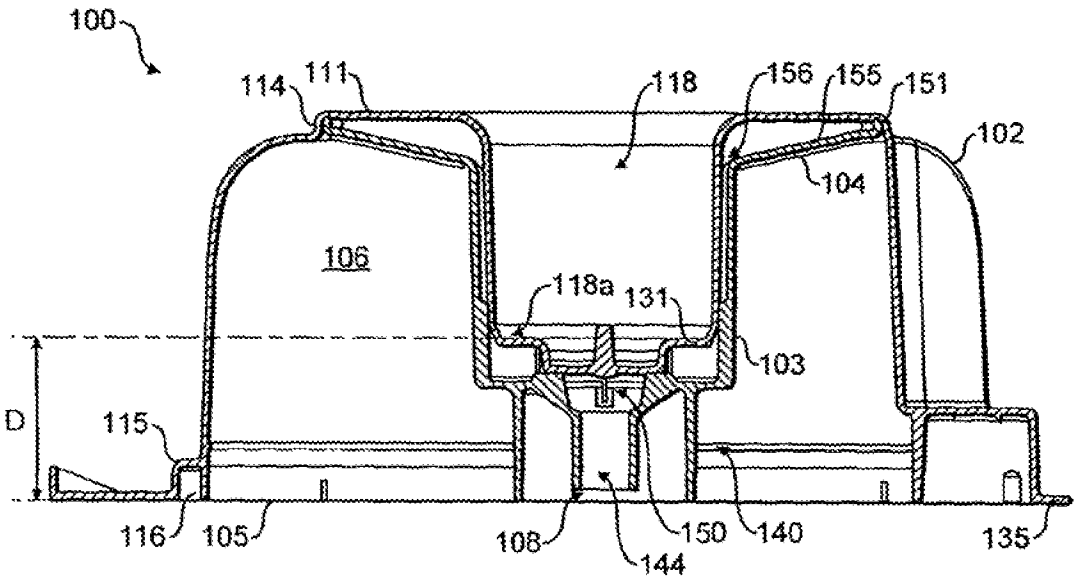

100
114
111
118
156
155
151
102
104
106
118a
131
103
D
115
116
105
108
144
150
140
135

FIG. 30

BEVERAGE PREPARATION MACHINES

The present invention relates to improvements in beverage preparation machines and in particular to a beverage preparation machine of the type which uses pre-packaged containers of beverage ingredients.

Coffee houses have been a part of the "coffee culture" since the 17th century. Throughout the years methods of making coffee have been refined and skilled people trained to produce the best coffee beverages. The first coffee machines were developed in the early 1800s and an automatic espresso machine was invented in the 1930s. The automation of the coffee making process has, in turn, lead to a rapid growth, particularly in the last ten years, in the number of coffee houses/shops with more specialist drinks, such as espresso and cappuccino, being in high demand. These types of beverages have historically been regarded as luxury items because of the need for expensive, complex machines capable of producing the high pressures necessary for making them, which had to be properly operated and maintained by a trained barista to produce good quality. Coffee aficionados agree that an espresso can be spoiled by a badly trained operator despite the use of a good quality machine and good quality coffee. This trend, however, has not only lead to an increased demand from consumers for luxury top quality beverages, but also a desire for a greater variety of speciality beverages, and the ability to make such beverages in the comfort of one's own home.

Although there is no agreed technical definition, it is generally understood that, compared to drip coffee, barista quality espresso has a thicker consistency, due to a higher amount of dissolved solids and fine oil droplets suspended throughout the drink. It has a smooth, yet thick, dark reddish brown crema making up 10 to 30% of the beverage. The crema is a polyphasic emulsion of air and the oils, proteins and sugars extracted from the coffee which is produced at a high pressure, traditionally in the region of 9 to 10 bar. The higher pressures increase the rate of coffee wetting and improve extraction as well as being responsible for the development of the crema.

It is acknowledged, by discerning espresso drinkers, that espresso produced using water which is cooler than the optimum temperature tastes sour and that produced with water which is hotter than this temperature tastes bitter. The optimum temperature is claimed to be between 92 and 96°C. Other factors which affect the quality of the espresso include the roasting and age of the coffee beans, the grind size, the compaction of the grinds prior to brewing, and the brew time. The "best" espresso is achieved by balancing these key elements of the brewing process.

Domestic coffee machines have also developed significantly since the first filter machines were invented in the 1960s and coffee machines are now essential pieces of kitchen equipment in many households. Some such machines dispense individual servings of a beverage directly into a drinking receptacle, and derive the beverage from a bulk supply of beverage ingredients or from individual packages

of beverage ingredients such as pods, pads or cartridges. In the following specification such packages will be referenced by the general term cartridges. Machines which use such cartridges eliminate the need for cleaning and can enable the user to make a selection of beverages. An example of one type of such cartridge is described in EP-A-1440903. The beverages are formed from brewing, mixing, dissolving or suspending the beverage ingredients in water. For example, for coffee beverages, heated water is forced through the cartridges to form the extracted solution. The use of cartridges in such machines has become increasingly popular due to their convenience and the quality of the beverage produced.

An example of a machine for preparing beverages using this type of cartridge is described in EP-A-1440644. This type of machine provided, inter alia, an improvement over the prior art known at the time in that it operated at a lower pressure than the previously known machines, which were designed for the commercial or industrial markets rather than the domestic market. Hence it was more suitable for the domestic market in terms of cost, reliability and performance. However, the problem that faces systems that operate at a lower pressure is that they are generally not capable of producing barista quality espressos, which require a significantly higher pressure.

With the change in consumer trends, however, there is a desire for domestic machines which are capable of producing barista quality espresso and a range of other beverages,

for which no training is necessary, which are affordable and which require little or no cleaning.

Some machines available on the market claim to produce higher quality beverages but for various reasons, they are comparatively expensive machines. Examples of such machines are the Gaggia L'Amante ™, the Gaggia Evolution ™, the Nespresso Delonghi Latissimma 660 ™, and the Krups XN2101 ™.

Most of these machines require specially designed cartridges of increased complexity and a particular specification of materials to cope with the high pressures involved in the brewing process for espresso. These cartridges generally incorporate filters and the process uses the geometry of the cartridge to enable the desired quality of the beverage to be produced under high pressure. This constrains the use of the cartridges in the machine for which it is designed.

It is, however, desirous to provide an improved beverage preparation machine capable of making a selection of beverages, including a premium quality espresso as well as non-espresso beverages, preferably using pre-packed beverage cartridges. The machine may also be a bulk brewer or other non-cartridge machine

It is also desirous to provide a machine which is backwardly compatible with existing cartridges, such as those described in EP-A-1440903, which are used in existing low pressure beverage preparation machines.

Accordingly, the present invention provides a method of preparing beverages using a beverage preparation machine for preparing beverages from one or more beverage ingredients, characterised by controlling the volume of gas in at least a part of a delivery system of the machine to produce predetermined characteristics in a prepared beverage.

The volume of gas is preferably actively controlled by increasing the volume to increase the gas:liquid ratio in the beverage produced, decreasing the volume to decrease the gas:liquid ratio or maintaining the volume.

Preferably the volume of gas in the delivery system is controlled by inducting additional gas into the delivery system, venting gas from the delivery system and/or purging the delivery system.

The method preferably further comprises the step of measuring the actual volume of gas resident in the delivery system.

An actual volume of gas resident in the delivery system may be calculated from stored parameters relating to a volume of gas remaining in the delivery system after a last operation of the machine.

Control of the volume of gas is preferably effected on a beverage by beverage basis and is preferably effected automatically according to the type of beverage being produced.

Alternatively the control of the volume of gas is effected manually.

The volume of gas upstream and/or downstream of the beverage ingredients may be controlled.

Preferably the volume of gas is controlled by selectively opening and/or closing valve means in the delivery system prior to and/or during beverage preparation.

The invention also provides a beverage preparation machine for preparing a beverage from one or more beverage ingredients, characterised by the provision of means for controlling the volume of gas in at least a part of a delivery system of the machine to produce predetermined characteristics in a prepared beverage.

The machine preferably comprises means for determining the actual volume of gas resident in the delivery system.

The means for determining the actual volume of gas resident in the delivery system may comprise means for calculating the actual volume from stored parameters relating to a volume of gas remaining in the delivery system after a last operation of the machine.

Preferably the stored parameters comprise a basic volume parameter stored in the control means, said basic volume being the actual volume of gas which resides in the delivery system of an unused machine or a machine after a purging cycle has been run.

The stored parameters may comprise parameters relating to the actual volume of gas remaining in the delivery system after each type of beverage which the machine is programmed to prepare.

The means for determining the actual volume of gas resident in the delivery system preferably comprise means for measuring the actual volume of gas in the delivery system.

Parameters relating to predetermined volumes of gas required to be present in the delivery system for preparing a predetermined range of beverages are preferably stored in the control means, said control means being programmed to calculate the difference between the predetermined volume required for a beverage in preparation and the actual volume present.

The means for controlling the actual volume of gas may comprise valve and/or purge means for venting gas and/or pump means for injecting additional gas into the delivery system.

Preferably the valve means comprise an outlet valve downstream and/or a valve upstream of the beverage ingredients.

Operation of the valve means is preferably controlled relative to the beverage preparation cycle to vary the actual volume of gas present in the delivery system.

Preferred embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a front perspective view of a prior art beverage preparation machine with the cartridge head in a closed position;

Figure 2 is a front perspective view of the machine of Figure 1 with the cartridge head in an open position;

Figure 3 is a rear elevation of the machine of Figure 1 with some parts omitted for clarity;

Figure 4 is a front perspective view of a cartridge head of the machine of Figure 1 with some parts omitted for clarity;

Figure 5 is another front perspective view of the cartridge head of Figure 4, with some parts omitted for clarity;

Figure 6 is a cross-sectional view of the cartridge head of Figure 4 in a closed position accommodating a version of a beverage cartridge;

Figure 7 is a cross-sectional side elevation of the cartridge head of Figure 4 in an open position accommodating the beverage cartridge;

Figure 7a is a plan view of a rubber seal for the cartridge head of Figure 4;

Figure 8 is a schematic showing the various component parts of the machine of Figure 1 incorporating a new variable outlet valve;

Figure 9 is a section of schematic of an outflow from the cartridge head incorporating the variable outlet valve of Figure 8;

Figures 10-12 are cross-sectional front elevations of one embodiment of the variable valve in the outflow of Figure 9 showing it's closed, open and restricted positions respectively;

Figures 13a and 13b are cross-sectional end elevations of an alternative variable outlet valve used in the outflow of Figure 9 in its open and closed position respectively;

Figures 14 and 15 are cross-sectional side elevations of the valve of Figures 13a and 13b;

Figure 16a is a side elevation of a beverage receptacle containing a coffee beverage having a large volume of crema produced using an improved gas management system;

Figure 16b is a chart showing the brew parameters used in producing the beverage illustrated in Figure 16a;

Figure 17a is a side elevation of a beverage receptacle containing a coffee beverage having a small volume of crema produced using the improved gas management system;

Figure 17b is a chart showing the brew parameters used in producing the beverage illustrated in Figure 17a;

Figure 18 is a plan view of a beverage cartridge suitable for use in the beverage preparation machine of Figure 1;

Figure 19 is cross-sectional side elevation of an outer member of the cartridge of Figure 18;

Figure 20 is a cross-sectional side elevation of a detail of the outer member of Figure 19 showing an inwardly directed cylindrical extension;

Figure 21 is a cross-sectional side elevation of a detail of the outer member of Figure 19 showing a slot;

Figure 22 is a perspective view from above of the outer member of Figure 19;

Figure 23 is a perspective view from above of the outer member of Figure 19 in an inverted orientation;

Figure 24 is a plan view from above of the outer member of Figure 19;

Figure 25 is a cross-sectional drawing of an inner member of the cartridge;

Figure 25a is a cross-sectional drawing of a detail of the inner member of Figure 25 showing an aperture;

Figure 26 is a perspective view from above of the inner member of Figure 25;

Figure 27 is a perspective view from above of the inner member of Figure 25 in an inverted orientation;

Figure 28 is another cross-sectional drawing of the inner member of Figure 25;

Figure 28a is a cross-sectional drawing of another detail of the inner member of Figure 25 showing an air inlet;

Figure 29 is a cross-sectional side elevation of the cartridge in an assembled condition; and

Figure 30 is a cross-sectional side elevation of another version of cartridge.

In order to cater for the desired wide selection of good quality beverage types, having different characteristics, the present invention involves one or more significant improvements to known beverage preparation machines. These improvements enable sufficiently high pressures to be generated and maintained for the production of good quality espressos, and the pressure to be varied in a manner which is invisible to the user and requires no

manual intervention. Furthermore they enable the crema to be improved in a way not previously possible.

These improvements, which will be described in more detail below, include:-

1. providing a variable geometry valve downstream of the beverage cartridge to enable the beverage preparation machine to operate at a range of pressures; and

2. providing greater control over the end appearance of the dispensed beverage, in particular beverages with crema, by controlling the volume of gas passed through the beverage ingredients.

The aforementioned improvements will be described with reference to a known beverage preparation machine 10 which is illustrated in Figures 1 to 7 of the accompanying drawings. It should be noted, however, that the improvements find application in a wide range of beverage preparation machines capable of using a wide range of cartridges which, as noted above, include pods, pads, rigid and semi-rigid cartridges.

The beverage preparation machine 10 of Figures 1 to 3 generally comprises a housing 11, a tank 12, a water heater 13, a control processor (not shown), a user interface 16 and a cartridge head 17. The cartridge head 17 in turn generally comprises a cartridge holder 18 for holding, in use, a beverage cartridge 100 and cartridge recognition means 20. The cartridge head 17 further comprises inlet and outlet

piercers 21,22 for forming in the beverage cartridge 100, in use, an inlet 107 for liquid to enter the cartridge 100 and an outlet 108 for the prepared beverage to exit the beverage cartridge 100.

Although water is likely to be the most common liquid used in preparing beverages such as coffee, the machine 10 is also capable of handling other liquids, such as milk or milk preparations, for mixing with the beverage ingredients 200. Any references herein to water should also be taken to include any form of liquid used in preparing beverages.

The housing 11 is preferably made in whole or in part from a suitable plastics material or metal. The housing 11 preferably comprises a clam-shell design having a front half 25 and a rear half 26 which allow access during assembly for fitting of the machine 10 components.

The front half 25 of the housing 11 defines a dispensing station 27 where dispensation of the beverage takes place, which includes a cupstand 23 with a drip tray located beneath. The machine user interface 16 is also located on the front of the housing 11 and comprises a plurality of control switches, for example, a start/stop button 28, and a number of status indicators 29-32. The status indicators 29-32 are preferably light emitting diodes (LED) which, for example, indicate readiness of the machine 10, whether an error has occurred in the machine 10 operation, and the mode of operation of the machine 10. The LEDs 29-32 may be controlled to illuminate at a constant intensity, to flash intermittently, or both depending on the

status of the machine 10. The LEDs 29-32 may have a variety of colours including green, red and yellow. The start/stop button 28 controls commencement of the dispense cycle and is preferably a manually operated push-button, switch or similar.

The tank 12 is located to the rear of the housing 11 and is preferably incorporated in, or connected to, the rear half 26 of the housing 11. The tank 12 has an inlet for filling the tank 12 with water, or other liquid, which is closed off when the tank 12 is in position in the machine 10. An outlet is provided towards a lower end of the tank 12 which communicates with the pump 14. The tank 12 may be made from a transparent or translucent material to allow a consumer to view the quantity of water remaining in the tank 12. Alternatively, the tank 12 may be made from an opaque material but have provided a viewing window therein. In addition, or in place of the above, the tank 12 may be provided with a low level sensor which prevents operation of the pump 14 and optionally triggers a warning indicator, such as an LED, when the liquid level in the tank descends to a preselected level. The tank 12 preferably has an internal capacity of approximately 1.5 litres.

The pump 14 is operatively connected between the tank 12 and the water heater 13, as shown schematically in Figure 8, and is controlled by the control processor. A suitable pump provides a flow rate of 900 ml/min of water at a pressure of 6 bar. The flow rate of water through the machine 10 can be controlled by the control processor to be a percentage of the maximum flow rate of the pump 14 by

cycle chopping the electrical supply to the pump. Preferably the pump can be driven at any of 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% or 100% of the maximum rated flow rate. The accuracy of the volume of water pumped is preferably + or - 5% leading to a + or - 5% accuracy in the final volume of the dispensed beverage. A volumetric flow sensor (not shown) is preferably provided in the flow line either upstream or downstream of the pump 14. Preferably, the volumetric flow sensor is a rotary sensor.

The heater 13 is located in the interior of the housing 11. One suitable heater 13 has a power rating of 1550 W and is able to heat water received from the water pump 14 from a starting temperature of approximately 20 °C to a nominal operating temperature of around 85°C in under 1 minute. Preferably the dwell time between the end of one dispense cycle and the heater 13 being able to commence a subsequent dispense cycle is less than 10 seconds. The heater maintains the selected temperature to within + or - 2 °C during the dispense cycle. The water for the dispense cycle is delivered to the cartridge head 17 at a predetermined temperature. The heater 13 is able to quickly adjust the delivery temperature to the required temperature, generally between 80°C and 98°C and possibly higher from the incoming water temperature. Where desired, the machine 10 can incorporate a steam purge. The preferred means of generating the steam purge is to utilise a water heater 13 in the form of a flash (also known as an instantaneous or flow) heater. Typically such flash heaters comprise a tube through which the water passes wherein the tube is heated by one or more resistive elements. The flash heater can be used not only

for heating water for forming beverages but also, at higher power settings, for generating a steam purge by boiling off water remaining with the flash heater tube after the beverage has been formed. An advantage of flash heaters is that there is no significant delay whilst water in a boiler heats up. Flash heaters heat water on demand and switch off immediately after each brewing cycle and are therefore very energy efficient.

Water output from the heater 13 is fed via a suitable delivery system to the cartridge head 17 and cartridge 100 by means of a valve. If the pressure of the water flow is acceptable, the water is passed to the cartridge 100. If the pressure is below or above predetermined limits then the water is diverted by means of the valve to a waste recovery receptacle.

The delivery system comprises conduits which connect the tank 12, the water pump 14, the water heater 13 and the cartridge head 17 (as shown in Figure 8) to transport the water from the tank 12 to the cartridge 100.

The cartridge holder 18 is designed to be capable of handling the opening forces generated by the pressure inside the cartridges 100, which is around 250kg for espresso beverages. During operation of the machine 10 the cartridges 100 attempt to expand, but the integrity of the cartridges 100 must be maintained. In addition the user must not be able to open the holder 18 whilst the system is pressurised and suitable locking mechanisms are provided to achieve this.

One suitable design of cartridge head 17, as described in WO-A-2006/014936, is shown in Figures 4 to 7. The cartridge holder 18 of the cartridge head 17 comprises a fixed lower part 43, a rotatable upper part 44 and a pivotable cartridge mount 45 positioned between the fixed lower part 43 and the rotatable upper part 44. The upper part 44, lower part 43 and cartridge mount 45 are rotated about a common hinge axis 46. Figures 4 to 7 show the holder 18 with some components of the machine 10 omitted for clarity.

The rotatable upper part 44 and pivotable cartridge mount 45 are moved relative to the fixed lower part 43 by means of a clamping mechanism. The clamping mechanism comprises a clamping lever having first and second members or parts 47 and 48. The first part 47 of the clamping lever comprises a U-shaped arm which is pivotably mounted to the upper part 44 at two first pivot points 48, one on each side of the holder 18.

The second part of the clamping lever comprises two over-centre arms 49, one on each side of the holder 18 which are each pivotably mounted to the upper part 44 at a second pivot point 50 located on the hinge axis 46 coupling the upper part 44 to the fixed lower part 43. Each over-centre arm 49 is a reciprocal member comprising a cylinder 49a, a stem 49b and a resilient sleeve 49c. The cylinder 49a has an internal bore and is rotatably mounted at one end at the hinge axis 46. A first end of the stem 49b is slidingly received in the bore of the cylinder 49a. The opposite end of the stem 49b is rotatably mounted to the U-shaped arm 47

at a third pivot point 51. The third pivot points 51 are unconnected to, and freely moveable relative to, the upper part 44 and lower part 43. The resilient sleeve 49c is mounted externally on the stem 49b and extends, in use, between abutment surfaces on the cylinder 49a and stem 49b. The resilient sleeve 49c accommodates shortening of the over-centre arm 49 but biases the over-centre arm 49 into an extended configuration. Movement of the third pivot points 51 towards and away from the hinge axis 46 is thus possible by relative movement of the stems 49b in the cylinders 49a. The resilient sleeves 49c are preferably formed from silicone. Whilst the illustrated embodiment uses two over-centre arms 49, it will be apparent that the closure mechanism may be configured with only one over-centre arm 49.

The U-shaped arm 47 extends around the front of the holder 18 and comprises two downwardly dependant hook members 52, one on each side of the holder 18, each comprising a cam surface facing the hinge axis 46. The fixed lower part 43 of the holder 18 is provided with two bosses 53, or detents, located one on each side of the lower part 43 at or near a front edge 54 thereof aligned generally with the hook members 52.

As shown in Figure 4, the U-shaped arm 47 may be formed from a one piece plastics moulding comprising an ergonomic hand grip and the hook members 52 integral to the arm 47.

The cartridge mount 45 is rotatably mounted between the upper and lower parts 43, 44 of the holder 18. The mount 45

is provided with a substantially circular recess 55 which receives in use the beverage cartridge 100 (which is described in greater details below). The recess 55 includes an irregularity 56 for accommodating the handle portion 24 of the beverage cartridge 100 which also acts to prevent rotation of the beverage cartridge 100 in the holder 18. The cartridge mount 45 is sprung relative to the fixed lower part 43 such that in the open position, as shown in Figure 7, the cartridge mount 45 is biased out of contact with the fixed lower part 43 so that the cartridge mount 45 is moved out of contact with the outlet and inlet piercer members 21, 22. The cartridge mount 45 is provided with an aperture 57 for receiving there through the inlet and outlet piercers 21, 22 and a head of the cartridge recognition means 20 when the cartridge mount 45 is moved into the closed position.

The upper part 43 comprises a generally circular body 58 housing a circular viewing window 59 through which a consumer can view the beverage cartridge 100 during a dispense cycle and also visually confirm whether a cartridge 100 is loaded in the machine 10. The viewing window 59 is cup-shaped having a downwardly directed rim. In addition, the viewing window 59 is provided with a clamping member in the form of an inwardly directed tubular extension 61 as shown in Figure 7. The extension 61 is directed towards the lower part 44 and lies within the volume of the cartridge head when in the closed position as shown in Figure 6. The viewing window 59 is able to move axially relative to the housing 58 of the upper part 43. One arrangement of accomplishing the relative movement is to provide a wave spring (not shown), or similar resilient means such as a

rubberised ring, positioned between the viewing window 59 and the circular housing 58. In an alternative arrangement, a series of helical compression springs (not shown) are provided extending between the viewing window 59 and the housing 58. In both cases the resilient means allows the viewing window 59 to move axially relative to the circular housing 58 by a small degree.

When the holder 18 is in the closed position, a distal end 62 of the tubular extension 61 of viewing window 59 bears against the clamping surface 18a of the beverage cartridge 100 biasing it against the lower part 44 as shown in Figure 6 (in which the arrangement is illustrated containing a cartridge having a greater depth). The pressure exerted by the tubular extension 61 on the outer member 102 ensures a fluid tight seal between the cartridge 100 and the holder 18. It should be noted that the height of the viewing window 59, and hence also the cartridge head 17, is such that cartridges 100 of various depths can be inserted. In Figure 6 the arrangement is shown with a relative deep cartridge. The same cartridge head 17 can also accommodate shallower cartridges. In this case there will be a gap between the upper surface 11 of the cartridge 100 and the window 59. However the cartridge 100 is fully sealed at inlet and outlet by the pressure applied by the tubular extension 61.

The lower part 43 comprises the inlet and outlet piercers 21, 22 and the head of the cartridge recognition means 20. The inlet piercer 21 comprises a hollow needle-like tube 63 having a sharpened end 64 for perforating the

laminate 108 of the beverage cartridge 100 in use. The inlet piercer 21 is in fluid communication with a water conduit 65, as shown in Figure 7, which passes through the lower part 43 and is connected to an outlet conduit 66 of the water heater 13. The outlet piercer 22 is similar in type to the outlet piercer described in the EP-A-0389141 and EP-A-0 334572 and comprises an open ended cylinder of circular or D-shaped cross-section having dimensions larger than the beverage discharge spout 109. An arcuate portion 67 of the upper end of the outlet piercer 22 is serrated to pierce and eventually cut the laminate of the beverage cartridge 100. The remainder of the upper end is cut back longitudinally of the cylinder at least to the base of the teeth 68 of the serrated portion to fold or pull the cut laminate 108 away from the outlet aperture before the beverage is dispensed there through. The outlet piercer 22 pierces the laminate 105 externally of the discharge spout 143 and when the cartridge mount 45 is in the closed position, rests in the annulus between the discharge spout 143 and the outer wall 42 of the discharge funnel 140. The outlet piercer 22 folds back the cut laminate 105 into the annulus. Thereby both the outlet piercer 22 and the cut laminate 105 are held out of the way of the discharged beverage.

The outlet piercer 22 is surrounded by a ledge which is raised relative to its surroundings by 0.5mm.

Advantageously, the outlet piercer 22 is removable from the lower part 43 to enable it to be thoroughly cleaned, for example, in a dishwasher. The removable outlet piercer 22 is received in a recess in the lower part 43 where it is

seated. The inlet piercer 21 and/or the outlet piercer 22 may be made of a metal, such as stainless steel, or from a plastics material. Advantageously, the use of plastic cutting elements is enabled by use of a laminate 105 which is able to be punctured and cut by a non-metallic material. Consequently, the piercers 21, 22 can be made less sharp which lowers the risk of injury to the consumer. In addition, plastic piercing elements are not prone to rust. Preferably, the inlet piercer 21 and the outlet piercer 24 are formed as a single, integral unit which is removable from the lower part 43.

In use, the upper part 44 of the holder 18 is movable from an open position in which it is orientated vertically or towards the vertical as shown in Figure 2, to a closed position in which it is orientated substantially horizontally and in interengagement with the fixed lower part 43 and cartridge mount 45. The upper part 44 is moved from the open to the closed positions by operation of the clamping lever. To close the upper part 44 a user takes hold of the clamping lever by the U-shaped arm 47 and pulls downwards. Consequently, the upper part 44 rotates which first brings the tubular extension 61 of the viewing window 59 into contact with the clamping surface 118a of the beverage cartridge 100. Continued rotation of the upper part 44 rotates the upper part 44 and cartridge mount 45 down into contact with the lower part 43. Further rotation of the U-shaped arm 47 causes the U-shaped arm 47 to rotate relative to the upper part 44 and the lower part 43 resulting in the hook members 52 of the upper part 44 engaging the bosses 53 of the lower part 43 with the cam

surface riding over the bosses 53. During this last stage of rotation the cartridge 100 is compressed between the cartridge mount 45 and the viewing window 59. As a result, the viewing window 59 is moved axially slightly relative to the circular housing 58 of the upper part 44 against the bias of the wave spring or helical springs. This movement allows for a take up of tolerances in the beverage cartridge 100 and beverage preparation machine 10 and ensures that the amount of compressive force applied to the cartridge 100 is kept within an acceptable range. The clamping force of the mechanism as moderated by the action of the wave spring or helical springs ensures a clamping pressure on the cartridge 100. It has been found that a force of between 150N and 400N is required to counter the pressure in the cartridge 100. During closure of the cartridge head the laminate 105 of the cartridge 100 is tensioned as it is brought into contact with the ledge surrounding the outlet piercer 22 which causes the laminate 105 to flex out of plane as the distal end of the outer tube 42 of the cylindrical funnel is moved upwardly by 0.5mm relative to the flange 147. This movement also ensures that the great majority of the compressive force applied to the cartridge 100 acts through the central region of the cartridge 100 through the load-bearing inner member 103. These clamping forces help prevent failure of the cartridge 100 during pressurisation and also ensure that the inner member 103 and outer member 102 are fully seated relative to one another and thus that all internal passageways and apertures remain at their intended dimensions even during internal pressurisation.

In the closed position, the separation of the distal end 62 of the tubular extension 61 and the lower part 44 is shown by reference D in Figure 6. This distance is fixed by the dimensions of the viewing window 59, housing 58 and lower part 44. The distance D is chosen to be the same or marginally smaller than the distance d between the clamping surface 118a and laminate 105 under surface of the cartridges 100. In this way, on closure of the cartridge head 17 the cartridges 100 are subjected to a fixed, known degree of compression. In addition, both the first and second embodiments of cartridge can be clamped with the same degree of compression since distance D is the same for both cartridge types.

An imaginary datum line can be drawn between the first and second pivot points 48, 50 of the holder 18. As can be seen in Figure 7, in the open position the third pivot points 51 are located on the side of the datum line nearest the fixed lower part 43. As the upper part 44 reaches the closed position, the third pivot points 51 of the clamping lever pass through the datum line joining the first and second pivot points 48, 50 to the opposite side of the line, furthest from the fixed lower part 43. Consequently, the U-shaped arm 47 'snaps through' from a first stable position to a second stable position. The snap through action is accommodated by shortening of the over-centre arms 49 and consequential compression of the resilient sleeves 49c. Once the third pivot points 51 are past the imaginary datum line, the recovery of the resilient sleeves 49c acts to continue the motion of the third pivot points 51 away from the imaginary datum line. The clamping lever thus has a bi-

stable operation in that the lever is stable in the open or closed positions but unstable at the point when the third pivot points 51 lie on the imaginary datum line joining the first and second pivot points 48, 50. Thus, the snap-through action of the clamping lever provides a positive closure mechanism which leads to a definite closure action wherein in the final stages of the clamping lever's rotation, the snap-through action of the U-shaped arm 47 and second arms forces the hook members 52 firmly into engagement with the bosses 53. In addition, the resilient sleeves 49c provide a resistance to re-opening of the upper part 44 since a minimum force is required to compress the sleeves 49c sufficiently to move the third pivot points 51 back into line with the datum line joining the first and second pivot points 48, 50. Advantageously, the interengagement of the hook members 52 and the bosses 53 prevents separation of the upper and lower parts other than by rotation of the clamping lever. This is useful in preventing opening of the cartridge head 17 during operation when the cartridge head 17 is subject to internal pressurisation.

The pressure exerted by the upper section 44 ensures a full fluid tight seal between the cartridge 100 and the cartridge holder 18. The clamping forces help prevent failure of the cartridge 100 during pressurisation and also ensure that all of the internal passageways and apertures within the cartridge 100 remain at their intended dimensions even during internal pressurisation. To improve the seal with the cartridges 100 the applicant has now found that lining the recess 55 of the cartridge mount 45 with a rubber seal 55a (see Figure 7a) improves the machine's ability to

withstand the significantly higher pressures generated during the brewing cycle.

Control of the brew cycle is effected by the control processor of the beverage preparation machine 10, which comprises a processing module and a memory. The control processor is operatively connected to, and controls operation of, the heater 13, pump 14, user interface 16, and other components described below.

The operational behaviour of the machine 10 is determined by software embedded in the control processor, for example as described in EP-A-1440644. The memory of the control processor includes one or more variables for one or more operational parameters for the beverage preparation machine 10. In the prior art machines these are generally the temperature of the liquid passed through the beverage cartridge 100 during the operating stage, the speed of charging the beverage cartridge 100, the presence or otherwise of a soak step, the total dispensed volume of the beverage, the flow rate of the liquid during the discharge stage, and the period of the purge stage.

One purpose of the cartridge recognition means 20 is, inter alia, to allow the machine 10 to recognise the type of beverage cartridge 100 that has been inserted and to adjust one or more operational parameters accordingly. The variables for the operational parameters are stored in the memory. The cartridge 100 comprises a code 120 provided on or in the cartridge 100 representing the operational parameters required for optimal dispensation of the beverage

in that cartridge 100. An example of the code is described in EP-A-1440644.

The control processor memory further stores information on the type of beverage dispensed so that the operating cycle of the machine 10 may be adjusted for the next cartridge 100. This is especially advantageous where two or more beverage cartridges 100 are used sequentially to form a beverage. For example a coffee cartridge may be dispensed followed by a milk cartridge to form a cappuccino beverage. Alternatively a chocolate cartridge could be used followed by a milk cartridge to produce a creamy hot chocolate beverage. By using a memory that stores information on the first beverage dispensed, the manner of dispensing the second cartridge, say a milk cartridge, may be altered to achieve an optimum beverage. In the above example the milk dispensed for hot chocolate may, typically, be diluted less than the milk added to the coffee. In addition, the milk dispensed for chocolate may be dispensed at a slower flow rate to lessen the degree of foaming of the beverage. Many combinations of cartridges are possible and operating parameters as will be obvious to the skilled person. In addition, the memory may be used to allow the machine 10 to 'predict' the type of beverage that a user will next want to dispense. For example, if a user predominantly drinks one beverage type then the machine can instruct the water heater to remain at the optimum temperature for that beverage type.

Operation of the known prior art machines 10 comprises insertion of a beverage cartridge 100 into the cartridge head 17, carrying out a dispense cycle in which the beverage

is dispensed and removal of the cartridge 100 from the machine.

To insert the cartridge 100 the cartridge holder 18 is opened as described above to expose the cartridge mount 45. The cartridge 100 is then placed on the cartridge mount 45 received within the recess 46. The cartridge holder 18 is then closed by operation of the clamping handle 51 as described above. During closure the inlet and outlet piercers pierce the cartridge 100 to form the cartridge inlet 107 and outlet 108.

To commence the operating cycle the user operates the start/stop button 28. The operating cycle comprises the steps of cartridge recognition and the beverage preparation cycle.

Cartridge recognition is performed by the optical cartridge recognition means 20 as described above assuming that the outputs from the cartridge sensor and lock sensor are satisfactory. Once the barcode 40 has been decoded the operational parameters of the machine 10 are adjusted by the control processor. The preparation cycle is then automatically commenced. The preparation cycle has four main stages, although not all of these are used for all beverage types:

1. Pre-wet
2. Pause
3. Brew stage
4. Purge

In the pre-wet stage the cartridge 100 is charged with liquid from the storage tank 12 by means of the pump 14. The charging with water causes the beverage ingredients 200 in the chamber 160 to be wetted. The charging may take place at a "fast" flow rate of 600 ml/min or a "slow" flow rate of 325 ml/min. The slow charging rate is particularly useful for cartridges 100 containing viscous liquid beverage ingredients where the ingredients require some dilution before they are able to be pumped at a higher volume flow rate. The volume of liquid injected into the cartridge 100 is selected to ensure that liquid or beverage does not drip out of the cartridge outlet 108 during this stage.

The pause stage allows the beverage ingredients 200 to soak in the liquid injected during the pre-wet stage for a predetermined period of time. Both the pre-wetting and soaking stages are known to increase the yield of the extractibles from the beverage ingredients 200 and to improve the end flavour of the beverage. Pre-wetting and soaking are particularly used where the beverage ingredients are roast and ground coffee.

In the brew stage liquid is passed through the cartridge 100 in order to produce the beverage from the beverage ingredients 200. The temperature of the liquid is determined by the control processor which sends instructions to the heater 13 to heat the liquid passing from the tank 12 to the cartridge head 17. Liquid enters the cartridge holder 18 via an inlet valve and the inlet piercer and then passes into the inlet chamber 126 of the beverage cartridge 100.

Brewing and/or mixing of the beverage in the beverage cartridge 100 occurs, as described in EP-A-1440644, before the prepared beverage exits the cartridge outlet 104, enters the outlet valve 37 and is directed into a suitably placed receptacle in the dispensing station 27.

During the purge cycle the temperature of the water heater 13 is raised sufficiently high to convert the water remaining in the system to steam and blowing the pressurised steam through the beverage preparation machine 10 and the beverage cartridge 100. This ensures that all beverage is dispensed and that the flow path is cleared ready for dispensing another beverage. The purge cycle may not commence immediately on cessation of the brew/mixing stage to allow for the majority of the fluid to clear the flow path.

Once the operating cycle has been completed, the machine automatically stops and the consumer removes the cartridge 100 by opening the cartridge holder 18 and manually removing and disposing of the cartridge 100. Alternatively, the machine 10 may be provided with an automatic ejection mechanism for removing the cartridge automatically on opening the cartridge holder 18.

The first of the significant improvements to the known beverage preparation machines 10 referred to above is the provision of variable geometry valve 60 (see Figures 9 to 15) provided adjacent the cartridge outlet 108 to provide post-cartridge pressure control. This enables the machine 10 to produce a wide variety of beverages, as it allows the

cartridges 100 to be selectively brewed at either high or low pressure or a varying pressure during the brew cycle, depending on the type of brew cycle required for the beverage ingredients in the cartridge as identified by the cartridge recognition means 20, thus providing an automated variable pressure system. The modified machine is capable of producing beverages at a range of pressures, for example from 0 to 9 bar, and more preferably from 0 to 6 bar.

The variable geometry valve 60 is positioned downstream of the cartridge 100, and preferably positioned in the beverage outlet 37, which is partially housed in, and extends from, the lower section 43 of the cartridge head 17 (see Figures 6 and 7). The valve 60 has at least an open and a restricted state, and more preferably all of the states identified below:-

1. Open (Figure 11)
2. Restricted (Figure 12)
3. Closed (Figure 10)
4. Cleaning/purging.

Various types of valve may be used for the outlet valve 60, such as ball valves, pinch valves, sleeve valves, seat valves or disc valves. The embodiment illustrated in Figures 10 to 12 is a ball type valve which has a rotating element 69 located in a chamber 70 in the beverage outlet 37. The rotating element 69 is rotatable between preset positions to provide the required states. The diameter of the bore of the valve 60 in the unrestricted position is preferably at least

5mm which is required, for example, for cartridges 100 providing low pressure filter beverages.

An alternative suitable valve is a pinch valve illustrated in Figures 13 to 15 which comprises a flexible tube 71, preferably made of silicon rubber or an elastomeric material, and a clamping mechanism 72. In the unrestricted position (Figures 13a and 14) the beverage flows freely through the tube 71. The clamping mechanism 72 is activated to provide a restricted position (Figures 13b and 15) and closed position.

The valve 60 is controlled automatically by the control processor of the machine 10. Once the type of cartridge 100 inserted into the machine 10 has been identified, by the decoding the barcode 40, the control processor selects the correct initial setting and, if appropriate, any subsequent operation of the valve 60 for the relevant beverage type.

The machine 10 can operate in a range of modes, with the valve 60 in one or more positions, some examples of which are:-

1. Valve Open Throughout The Brewing Cycle

When the valve 60 is in its open position the operating pressure is below 2 bar allowing a steady state through flow rate of up to 400 ml/min. The beverage is dispensed under similar conditions to those described in EP-A-1440644. This mode is particularly useful as it renders the machine 10 backwardly compatible with existing cartridges for preparing

low pressure beverages, such as tea, foamed milk or chocolate.

2. Valve Restricted Throughout The Brewing Cycle

When the valve 60 is in its restricted position it creates a relatively high back pressure within the cartridge 100, which results in an operating pressure of up to 4, 6 or even 9 bar and provides a steady state through flow rate of 60 to 300 ml/min. This is sufficient to obtain the necessary solids extraction and emulsification of oils in the beverage ingredients 200 for an espresso beverage. The consequential restriction in the beverage outlet 37 provides a shearing and mixing action in the beverage flowing through the valve 60, giving rise to good air/liquid emulsification and resulting in an improved crema. This mode can advantageously be used for preparing higher pressure beverages, such as espressos and cappuccinos, from cartridges 100 which do not have means for entraining air to effect the mixing action, i.e. so called non-eductor cartridges.

3. Valve Closed Then Restricted

If the valve 60 is closed immediately at the start of the brewing cycle (before the pump 14 commences and during the pre-wet cycle), this enables a higher pressure to be developed within the cartridge 100 than when the valve 60 is in it's restricted position.

Further combinations may be appropriate, such as valve closed then open or valve closed then restricted then open according to the desired effect to be achieved.

If required, the valve 60 can be pulsed between various positions during the brewing cycle, or a part thereof. This manner of valve operation during the delivery cycle enables beverages with a crema having a graduated colour and/or bubble size to be produced.

During the purge cycle the valve 60 is controlled by the control processor to divert the steam to a drain area rather than to the dispensing station 27 to preserve the appearance of the beverage and prevent contamination.

The second of the significant improvements to the known beverage preparation machines 10 referred to above is the addition to the brew control system of gas management. Surprisingly the applicant has now discovered that the characteristics of beverages prepared in this type of beverage preparation machine 10 can be modified beyond boundaries hereto seen in prior art machines. The surprising effect is enacted by controlling the volume of gas in the delivery system during the preparation of the beverage to prescribe the amount of high quality crema resulting in a controlled amount of crema on a beverage varying from a delicate layer up to a surprisingly deep layer in the final beverage. The applicant has found a way to successfully use gases within the beverage preparation machine to modify the gas:liquid ratio to produce a surprising volume of good stable crema in prepared beverages never seen before in

prior art machines. Maintaining a greater volume of gas resident in the delivery system enables a much larger gas:liquid ratio to be achieved during brewing and dispensing and this produces a correspondingly larger volume of crema. Decreasing the volume of gas enables the ratio to be decreased to reduce the crema volume. The bubble size is also influenced by the gas:liquid ratio, so a lower ratio can be used to provide a tight and creamy crema and a higher ratio used to provide a more loose and bubbly crema. This improvement therefore provides the ability to optimise the crema volume and bubble size for each beverage dispensed. It has been found that by manipulating the gas good quality espressos can be brewed with a crema volume greater than 25% of the beverage volume whilst minimising the occurrence of bubbles having a diameter of more than 172 microns which is not previously seen to be possible in known beverage preparation machines of this type.

The improvement is achieved by adapting the control of the brew cycle to provide means for managing the volume of gas within the delivery system which conveys the water from the tank 12 to the beverage ingredients 200 and to the dispensing outlet. All further references in this specification to the delivery system are intended to include any predetermined section thereof, for example the section extending from the water heater 13 to the cartridge 100 and may also include, if relevant, some gas contained within a headspace of the cartridge 100.

The "basic volume" of gas which can reside within the delivery system of any given machine 10 is dependant on its

construction. The "actual volume" at any given time will vary according to whether the machine 10 has just been used to prepare a beverage, what type of beverage it was used for and whether a steam purge cycle has been run. Thus the improved brew cycle control incorporates means for varying the volume of gas in the delivery system according to the type of beverage to be dispensed (i.e. one requiring a crema with smaller and fewer bubbles or one which requires a greater froth of larger bubbles) taking into account the actual volume of gas already present. The means for varying the volume of gas may be achieved by combinations of:-

1. purging the delivery system after a brewing cycle is complete, and prior to a subsequent high pressure brew, which will increase the gas:liquid ratio;
2. venting gas from the delivery system prior to high pressure brewing, which will decrease the gas:liquid ratio; and
3. inducting gas into the delivery system prior to high pressure brewing, which will increase the gas:liquid ratio.

Valve means are preferably provided to enable the volume of gas within the delivery system to be reduced and an air pump to enable gas (typically air) to be injected into the system. A separate, dedicated air valve may be incorporated in the delivery system, either upstream or downstream of the cartridge 100. Preferably the variable geometry valve 60 described above may be used as the valve means.

To enable this improved brew cycle control to be effected, additional parameters to those described in connection with the basic machine 10 may be stored in the memory of the control processor. These additional parameters include the basic volume of gas for the specific construction of machine 10 (which will apply to the machine 10 which is unused or after it has been purged) and the volume required during high pressure brewing for optimising the crema for each specific beverage. Preferably the additional parameters also include the actual volume of gas which will remain in the delivery system after each type of brew operation which the machine 10 is capable of. However this is not wholly necessary if the machine 10 is programmed to run a steam purge cycle after every beverage is dispensed, which effectively resets the actual volume to the basic volume, because it flushes the dispensing system downstream of the water heater 13 of any remaining liquid.

The brew cycle will therefore include an additional step, namely a gas adjustment cycle before the pre-wet cycle. The gas adjustment cycle thus includes:-

1. An assessment of the required volume of gas for the type of beverage to be prepared. This will most conveniently be the selection from the processor memory of the required parameter associated with the cartridge code 120;

2. The determination of the actual volume of gas currently resident in the delivery means according to the

last operation of the machine 10. This will be the basic volume for an unused machine or if a purge cycle has been run. If the machine has just been used to prepare a beverage and no purge cycle run, the processor ideally selects from the memory the parameter for the remaining gas according to the last beverage. Alternatively, means may also be provided to specifically monitor the volume of gas within the delivery system at any point in time;

3. A calculation of the volume of gas to be inducted into or vented from the delivery system to achieve the required volume;

4. The modification of the volume of gas, if required, by the induction of additional gas (typically air) or the venting of excess gas.

In one example the beverage preparation machine 10 has a basic volume of gas of 36ml in the section of the delivery means extending between the water heater 13 and the beverage ingredients 200.

There are a number of different modes of operation for step 4 depending on the outcome of step 3, depending on what type of valve means are used. If the valve means are downstream of the cartridge, i.e. an outlet valve, one way of controlling the volume of air upstream of the beverage ingredients 200 prior to high pressure brewing is by closing the outlet valve at different points in the brew cycle as follows:-

1. The Correct Volume of Gas is Present

If the processor calculates that it requires the full basic volume of gas (36ml) for the beverage to be dispensed, as determined from the reading of the code 120, it closes the outlet valve at the start of the brew cycle, before any water flows from the water heater 13. This means that the compression of gas in the delivery system will commence immediately and the cartridge 100 will be subject to higher pressures during the pre-wet and soak cycles, with the valve only opening to dispense the resultant beverage. As the outlet valve is closed before the pump 14 is started, all of the 36ml of trapped gas is mixed in to the resulting beverage and a larger volume of slightly coarser crema is obtained (Figure 16a). In the example shown the volume of crema Y in a graduated glass, flat bottomed beaker was 20ml compared to the volume of liquid X, which was 50ml.

The chart shown in Figure 16b represents an example of brew cycle parameters used to produce a beverage in this mode with a large volume of crema under test conditions.

In this chart, a stop condition of 0 seconds (e.g. against the remove gas step) indicates that the step is not carried out.

2. Too Much Gas is Present

If, on the other hand, a beverage with a small volume of crema is indicated by the cartridge 100 inserted and there is an excess of gas present in the system, the outlet

valve is closed after the pump 14 has operated for a short time until the excess gas in the delivery system has escaped through the open valve at low pressure. With the valve being closed later in the brew cycle, the required volume of gas is vented to atmosphere via the cartridge 100 and valve, so a smaller quantity of trapped gas is left to be compressed and mixed in to the resulting beverage during high pressure brewing and consequently a smaller volume of finer crema is obtained (Figure 17a). In the example shown the volume of crema Y in a graduated glass, flat bottomed beaker was 5ml compared to the volume of liquid X, which was 50ml.

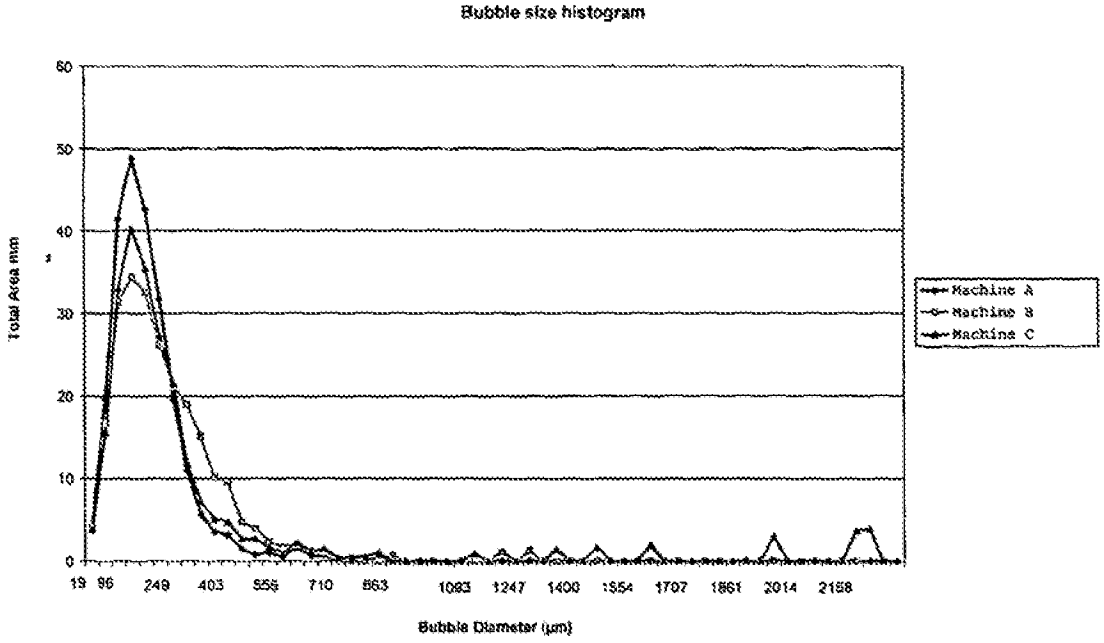
The chart shown in Figure 17b represents an example of brew parameters used to produce a beverage in this mode with a small volume of crema under test conditions.

3. Insufficient Gas Present

If step 3 indicates that more gas needs to be inducted, the outlet valve is closed immediately and the air pump operated until the deficit has been made up. Thereafter high pressure brewing commences.

The following graph is a digital image analysis showing a comparison of the crema characteristics produced by the present beverage preparation machine 10 (machine A) utilising the gas management system and two prior art machines (machines B and C) without such gas management system. Comparing the profiles for each machine from the peak (~172μm diameter) rightwards (increasing bubble size), it can be seen that machine A exhibits a very tight

distribution of small bubbles within the crema. Machine C (the Nespresso Latissma (tm)which is a high pressure machine which has a pressure rating of around 19 bar and operates at a pressure between 9 and 15 bar) produces a broader/coarser distribution with a number of larger diameter bubbles, whilst machine B (the applicant's own Tassimo/Bosch Machine(tm) similar to that described in EP-A-1440644 which is a low pressure machine operating at pressures below 2 bar) is coarser still, though without the larger bubbles seen for machine C.



The tail to the left of the chart (extremely small bubbles) is characteristic of the limits of the image analysis systems used to produce the graph, though is qualitatively similar.

Some elements of the control of the gas in the beverage machine 10 may also be effected manually by the use of suitable buttons for the user to press, to indicate the type of beverage being produced and the required crema characteristics.

Whilst this improvement has been described with reference to beverage machines 10 which use cartridges 100, it may also be used in bulk brewers and other non-cartridge machines.

Embodiments of cartridges 100 which are suitable for use in the machine 10 having the improvements described above are shown in Figures 18 to 30.

The cartridge 100 generally comprises an outer member 102, an inner member 103 and a laminate 105. The outer member 102, inner member 103 and laminate 105 are assembled to form the cartridge 100 which has an interior 106 for containing one or more beverage ingredients, an inlet 107, an outlet 108 and a beverage flow path linking the inlet 107 to the outlet 108 and which passes through the interior 106. The inlet 107 and outlet 108 are initially sealed by the laminate 105 and are opened in use by piercing or cutting of the laminate 105. The beverage flow path is defined by spatial inter-relationships between the outer member 102, inner member 103 and laminate 105 as discussed below. Other components may optionally be included in the cartridge 100, such as a filter 104, as will be described further below.

A first version of cartridge 100 which will be described is shown in Figures 19 to 29. The first version of the cartridge 100 is particularly designed for use in dispensing espresso-style products such as roast and ground coffee where it is desirable to produce a crema. However, this version of the cartridge 100 may be used with other products such as chocolate, coffee, tea, sweeteners, cordials, flavourings, alcoholic beverages, flavoured milk, fruit juices, squashes, sauces and desserts.

As can be seen from Figure 23, the overall shape of the cartridge 100 is generally circular or disc-shaped with the diameter of the cartridge 100 being significantly greater than its height. A major axis X passes through the centre of the outer member as shown in Figure 19. Typically the overall diameter of the outer member 102 is 74.5 mm ±6mm and the overall height is 16 mm ±3mm. Typically the volume of the cartridge 100 when assembled is 30.2 ml ±20%.

The outer member 102 generally comprises a bowl-shaped shell 110 having a curved annular wall 113, a closed top 111 and an open bottom 112. The diameter of the outer member 102 is smaller at the top 111 compared to the diameter at the bottom 112, resulting from a flaring of the annular wall 113 as one traverses from the closed top 111 to the open bottom 112. The annular wall 113 and closed bottom 112 together define a receptacle having an interior 134.

A hollow inwardly directed cylindrical extension 118 is provided in the closed top 111 centred on the major axis X. As more clearly shown in Figure 20, the cylindrical

extension 18 comprises a stepped profile having first, second and third portions 119, 120 and 121. The first portion 119 is right circular cylindrical. The second portion 120 is frusto-conical in shape and is inwardly tapered. The third portion 121 is another right circular cylinder and is closed off by a lower face 131. The diameter of the first, second and third portion 119, 120 and 121 incrementally decreases such that the diameter of the cylindrical extension 118 decreases as one traverses from the top 111 to the closed lower face 131 of the cylindrical extension 118. A generally horizontal shoulder 132 is formed on the cylindrical extension 118 at the junction between the second and third portions 120 and 121.

An outwardly extending shoulder 133 is formed in the outer member 102 towards the bottom 112. The outwardly extending shoulder 133 forms a secondary wall 115 co-axial with the annular wall 113 so as to define an annular track forming a manifold 116 between the secondary wall 115 and the annular wall 113. The manifold 116 passes around the circumference of the outer member 102. A series of slots 117 are provided in the annular wall 113 level with the manifold 116 to provide gas and liquid communication between the manifold 116 and the interior 134 of the outer member 102. As shown in Figure 21, the slots 117 comprise vertical slits in the annular wall 113. Between twenty and forty slots are provided. In the embodiment shown thirty-seven slots 117 are provided generally equi-spaced around the circumference of the manifold 16. The slots 117 are preferably between 1.4 and 1.8 mm in length. Typically the length of each slot 117 is 1.6 mm representing 10% of the overall height of the

outer member 102. The width of each slot 117 is between 0.25 and 0.35 mm. Typically, the width of each slot 117 is 0.3 mm. The width of the slots 117 is sufficiently narrow to prevent the beverage ingredients passing there through into the manifold 116 either during storage or in use.

An inlet chamber 126 is formed in the outer member 102 at the periphery of the outer member 102. A cylindrical wall 127 is provided, as most clearly shown in Figure 23, which defines the inlet chamber 126 within, and partitions the inlet chamber 126 from, the interior 134 of the outer member 102. The cylindrical wall 127 has a closed upper face 128 which is formed on a plane perpendicular to the major axis X and an open lower end 129 co-planar with the bottom 12 of the outer member 102. The inlet chamber 26 communicates with the manifold 116 via two slots 130 as shown in Figure 19. Alternatively, between one and four slots may be used to communicate between the manifold 116 and the inlet chamber 126.

A lower end of the outwardly extending shoulder 133 is provided with an outwardly extending flange 135 which extends perpendicularly to the major axis X. Typically the flange 135 has a width of between 2 and 4 mm. A portion of the flange 135 is enlarged to form a handle 124 by which the outer member 102 may be held. The handle 124 is provided with an upturned rim 125 to improve grip.

The outer member 102 is formed as a single integral piece from high density polyethylene, polypropylene, polystyrene, polyester, or a laminate of two or more of

these materials. A suitable polypropylene is the range of polymers available from DSM UK Limited (Redditch, United Kingdom). The outer member may be opaque, transparent or translucent. The manufacturing process may be injection moulding.

The inner member 103 as shown in Figures 25 to 28, comprises an annular frame 141 and a downwardly extending cylindrical funnel 140. A major axis X passes through the centre of the inner member 103 as shown in Figure 25.

As best shown in Figures 26 and 27, the annular frame 141 comprises an outer rim 151 and an inner hub 152 joined by ten equi-spaced radial spokes 153. The inner hub 152 is integral with and extends from the cylindrical funnel 140. Filtration apertures 155 are formed in the annular frame 141 between the radial spokes 153. A filter 104 is disposed on the annular frame 141 so as to cover the filtration apertures 155. The filter is preferably made from a material with a high wet strength, for example a non-woven fibre material of polyester. Other materials which may be used include a water-impermeable cellulosic material, such as a cellulosic material comprising woven paper fibres. The woven paper fibres may be admixed with fibres of polypropylene, polyvinyl chloride and/or polyethylene. The incorporation of these plastic materials into the cellulosic material renders the cellulosic material heat-sealable. The filter 104 may also be treated or coated with a material which is activated by heat and/or pressure so that it can be sealed to the annular frame 141 in this way.

As shown in the cross-sectional profile of Figure 25, the inner hub 152 is located at a lower position than the outer rim 151, resulting in the annular frame 141 having a sloping lower profile.

The upper surface of each spoke 153 is provided with an upstanding web 154 which divides a void space above the annular frame 141 into a plurality of passages 157. Each passage 157 is bounded on either side by a web 154 and on a lower face by the filter 104. The passages 157 extend from the outer rim 151 downwardly towards, and open into, the cylindrical funnel 140 at openings 156 defined by the inner extremities of the webs 154.

The cylindrical funnel 140 comprises an outer tube 142 surrounding an inner discharge spout 143. The outer tube 142 forms the exterior of the cylindrical funnel 140. The discharge spout 143 is joined to the outer tube 142 at an upper end of the discharge spout 143 by means of an annular flange 147. The discharge spout 143 comprises an inlet 145 at an upper end which communicates with the openings 156 of the passages 157 and an outlet 144 at a lower end through which the prepared beverage is discharged into a cup or other receptacle. The profile of the discharge spout 43 comprises a stepped profile with a distinct dog-leg 166 near an upper end of the tube 143.

As shown in Figure 25, the discharge spout 143 is provided with a partition 165 which extends part way up the discharge spout 143 from the outlet 144. The partition 165

helps to prevent the beverage spraying and/or splashing as it exits the discharge spout 143.

A rim 167 is provided upstanding from the annular flange 147 joining the outer tube 142 to the discharge spout 143. The rim 167 surrounds the inlet 145 to the discharge spout 143 and defines an annular channel 169 between the rim 167 and the upper portion of the outer tube 142. The rim 167 is provided with an inwardly directed shoulder 168. At one point around the circumference of the rim 167 an aperture 170 is provided in the form of a slot which extends from an upper edge of rim 167 to a point marginally below the level of the shoulder 168 as most clearly shown in Figures 25 and 25a. The slot has a width of 0.64 mm.

An air inlet 171 is provided in annular flange 147 circumferentially aligned with the aperture 170 as shown in Figures 28 and 28a. The air inlet 171 comprises an aperture passing through the flange 147 so as to provide communication between a point above the flange 147 and the void space below the flange 147 between the outer tube 142 and discharge spout 143. Preferably, and as shown, the air inlet 171 comprises an upper frusto-conical portion 173 and a lower cylindrical portion 172. The air inlet 171 is typically formed by a mould tool such as a pin. The tapered profile of the air inlet 171 allows the mould tool to be more easily removed from the moulded component. The wall of the outer tube 142 in the vicinity of the air inlet 171 is shaped to form a chute leading from the air inlet 171 to the inlet 145 of the discharge spout 143. As shown in Figure 28a, a canted shoulder 174 is formed between the air inlet

171 and the chute to ensure that the jet of beverage issuing from the slot 170 does not immediately foul on the upper surface of the flange 147 in the immediate vicinity of the air inlet 171.

The inner member 103 may be formed as a single integral piece from polypropylene or a similar material as described above and by injection moulding in the same manner as the outer member 102.

Alternatively, the inner member 103 and/or the outer member 102 may be made from a biodegradable polymer. Examples of suitable materials include degradable polyethylene (for example, SPITEK supplied by Symphony Environmental, Borehamwood, United Kingdom), biodegradable polyester amide (for example, BAK 1095 supplied by Symphony Environmental), poly lactic acids (PLA supplied by Cargil, Minnesota, USA), starch-based polymers, cellulose derivatives and polypeptides.

The laminate 105 is formed from two layers, a first layer of aluminium and a second layer of cast polypropylene. The aluminium layer is between 0.02 and 0.07 mm in thickness. The cast polypropylene layer is between 0.025 and 0.065 mm in thickness. In one embodiment the aluminium layer is 0.06 mm and the polypropylene layer is 0.025 mm thick. This laminate 105 is particularly advantageous as it has a high resistance to curling during assembly. As a result the laminate 105 may be pre-cut to the correct size and shape and subsequently transferred to the assembly station on the production line without undergoing distortion. Consequently,

the laminate 108 is particularly well suited to welding. Other laminate materials may be used including PET/Aluminium/PP, PE/EVOH/PP, PET/metallised/PP and Aluminium/PP laminates. Roll laminate stock may be used instead of die cut stock.

The cartridge 100 may be closed by a rigid or semi-rigid lid instead of a flexible laminate 105.

Assembly of the cartridge 100 involves the following steps:

a) the inner member 103 is inserted into the outer member 102;

b) the filter 104 is cut to shape and placed onto the inner member 103 so to be received over the cylindrical funnel 140 and come to rest against the annular frame 141;

c) the inner member 103, outer member 102 and filter 104 are joined by ultrasonic welding;

d) the cartridge 100 is filled with one or more beverage ingredients;

e) the laminate 105 is affixed to the outer member 102.

These steps will be discussed in greater detail below.

The outer member 103 is orientated with the open bottom 112 directed upwards. The inner member 103 is then inserted into the outer member 102 with the outer rim 151 being received as a loose fit in an axial extension 114 at top 111 of the cartridge 100. The cylindrical extension 118 of the

outer member 102 is at the same time received in the upper portion of the cylindrical funnel 140 of the inner member 103.

The third portion 121 of the cylindrical extension 118 is seated inside the support rim 167. The shoulder 132 of the cylindrical extension 118 between the second portion 120 and third portion 121 bears against the upper edge of the support rim 167 of the inner member 103. An interface zone is thus formed between the inner member 103 and the outer member 102 comprising a face seal between the cylindrical extension 118 and the support rim 167 which extends around nearly the whole circumference of the cartridge 100. The seal between the cylindrical extension 118 and the support rim 167 is not fluid-tight though since the slot 170 in the support rim 167 extends through the support rim 167 and downwardly to a point marginally below the shoulder 168. Consequently the interface fit between the cylindrical extension 118 and the support rim 167 transforms the slot 170 into an aperture providing gas and liquid communication between the annular channel 169 and the discharge spout 143. The aperture is typically 0.64 mm wide by 0.69 mm long.

The filter 104 is then placed over the inner member 103 such that the filter material contacts the annular rim 151. An ultrasonic welding process is then used to join the filter 104 to the inner member 103 and at the same time, and in the same process step, the inner member 103 to the outer member 102. The inner member 103 and filter 104 are welded around the outer rim 151. The inner member 103 and outer

member 102 are joined by means of weld lines around the outer rim 151 and also the upper edges of the webs 154.

As shown most clearly in Figure 29, the outer member 102 and inner member 103 when joined together define a void space in the interior 106 below the annular flange 141 and exterior the cylindrical funnel 140 which forms a filtration chamber. The filtration chamber 160 and passages 157 above the annular frame 141 are separated by the filter paper 104.

The filtration chamber 160 contains the one or more beverage ingredients 200. The one or more beverage ingredients 200 are packed into the filtration chamber 160. For an espresso-style beverage the ingredient is typically roast and ground coffee. The density of packing of the beverage ingredients in the filtration chamber 130 can be varied as desired. Typically, for a filtered coffee product the filtration chamber contains between 5.0 and 10.2 grams of roast and ground coffee in a filtration bed of thickness of typically 5 to 14 mm. Optionally, the interior 106 may contain one or more bodies, such as spheres, which are freely movable within the interior 106 to aid mixing by inducing turbulence and breaking down deposits of beverage ingredients during discharge of the beverage.

The laminate 105 is then affixed to the outer member 102 by forming a weld 161 around the periphery of the laminate 105 to join the laminate 105 to the lower surface of the outwardly extending flange 135. The weld 161 is extended to seal the laminate 105 against the lower edge of the cylindrical wall 127 of the inlet chamber 126. Further,

a weld 162 is formed between the laminate 105 and the lower edge of the outer tube 142 of the cylindrical funnel 140. The laminate 105 forms the lower wall of the filtration chamber 160 and also seals the inlet chamber 126 and cylindrical funnel 140. However, a small gap 163 exists prior to dispensation between the laminate 105 and the lower edge of the discharge spout 43. A variety of welding methods may be used, such as heat and ultrasonic welding, depending on the material characteristics of the laminate 105.

Advantageously, the inner member 103 spans between the outer member 102 and the laminate 105. The inner member 103 is formed from a material of relative rigidity, such as polypropylene. As such, the inner member 103 forms a load-bearing member that acts to keep the laminate 105 and outer member 102 spaced apart when the cartridge 100 is compressed. It is preferred that the cartridge 100 is subjected to a compressive load of between 130 and 280N in use. The compressive force acts to prevent the cartridge failing under internal pressurisation and also serves to squeeze the inner member 103 and outer member 102 together. This ensures that the internal dimensions of passageways and apertures in the cartridge 100 are fixed and unable to change during pressurisation of the cartridge 100.

In use the water, under pressure, enters the cartridge 100 through the inlet 107 into the inlet chamber 126. From there the water is directed to flow through the slots 117 and round the manifold 116 and into the filtration chamber 160 of the cartridge 1 through the plurality of slots 117. The water is forced radially inwardly through the filtration

chamber 160 and mixes with the beverage ingredients 200 contained therein. The water is at the same time forced upwardly through the beverage ingredients 200. The beverage formed by passage of the water through the beverage ingredients 200 passes through the filter 104 and filtration apertures 155 into the passages 157 lying above the annular frame 141.

Beverage in the radial passages 157 flows downwardly along the passages 157 formed between the webs 154 and through the openings 156 and into the annular channel 169 of the cylindrical funnel 140. From the annular channel 169 the beverage is forced under pressure through the aperture 128 by the back pressure of beverage collecting in the filtration chamber 160 and passages 157. The beverage is thus forced through aperture as a jet and into an expansion chamber formed by the upper end of the discharge spout 143. As shown in Figure 29, the jet of beverage passes directly over the air inlet 171. Passage of the beverage through the restriction of the aperture causes the pressure of the beverage to be reduced. As the beverage enters the discharge spout 143 the pressure of the beverage is still relatively low. As a result air is entrained into the beverage stream in the form of a multitude of small air bubbles as the air is drawn up through the air inlet 171. The jet of beverage issuing from the aperture is funnelled downwards to the outlet 144 where the beverage is discharged into a receptacle such as a cup where the air bubbles form the desired crema. Thus, the aperture and the air inlet 171 together form an eductor which acts to entrain air into the beverage. Flow of beverage into the eductor should be kept

as smooth as possible to reduce pressure losses. It should be noted that, in the high pressure state, the air eduction mechanism is de-activated.

The sealing of the filter 104 onto the spokes 153 and the welding of the rim 151 with the outer member 102 ensures that there are no short-circuits and all the beverage has to pass through the filter 104.

Figure 30 shows a second embodiment of beverage cartridge 100 which can be used in the beverage preparation machine 10 of the present invention. Like components between the first and second embodiments have been referenced with like numerals. Many of the components and functions of the second embodiment of cartridge 100 are the same as for the first embodiment. However, it can be seen from Figure 30 that the cartridge 100 has a greater overall height compared to the cartridge 100 shown in Figure 29. The outer member 102 is taller and thereby defines a larger void space in which a larger quantity of beverage ingredients 200 can be stored. The second embodiment of cartridge 100 is therefore suitable for dispensing larger volumes of beverage. The diameter of the outer member 102 and cartridge 100 are the same as in the first embodiment. Typically the storage volume of the cartridge 100 when assembled is 50 to 58 ml ±20%. As with the first embodiment, the upper surface of the outer member 102 is provided with a recess having a clamping surface 118 located at a bottom thereof. According to the present invention, the separation D between surface 118a and the underside of the laminate 105 is the same as for the first embodiment. As a result, the elongated recess extends

approximately 60% of the distance towards the laminate 105. This advantageously allows for a simplified clamping arrangement to be used as described below.

Also, the second embodiment of cartridge 100 lacks an eductor air inlet 171.

The first and second embodiments of cartridge 1 described above are given as examples of an "eductor" type of cartridge and a "non-eductor" type cartridge which may be used with the improved beverage preparation machine described above.

CLAIMS:

1. A method of preparing beverages using a beverage preparation machine for preparing beverages from one or more beverage ingredients, characterised by controlling the volume of gas in at least a part of a delivery system of the machine to produce predetermined characteristics in a prepared beverage.

2. A method of preparing beverages as claimed in claim 1 in which the volume of gas is actively controlled by increasing the volume to increase the gas:liquid ratio in the beverage produced, decreasing the volume to decrease the gas:liquid ratio or maintaining the volume.

3. A method of preparing beverages as claimed in any one of the preceding claims in which the volume of gas in the delivery system is controlled by inducting additional gas into the delivery system, venting gas from the delivery system and/or purging the delivery system.

4. A method of preparing beverages as claimed in any one of the preceding claims further comprising the step of measuring the actual volume of gas resident in the delivery system.

5. A method of preparing beverages as claimed in any one of the preceding claims in which an actual volume of gas resident in the delivery system is calculated from stored parameters relating to a volume of gas remaining in the delivery system after a last operation of the machine.

6. A method of preparing beverages as claimed in any one of the preceding claims in which the control of the volume of gas is effected on a beverage by beverage basis.

7. A method of preparing beverages as claimed in any one of the preceding claims in which the control of the volume of gas is effected automatically according to the type of beverage being produced.

8. A method of preparing beverages as claimed in any one of claims 1 to 5 in which the control of the volume of gas is effected manually.

9. A method of preparing beverages as claimed in any one of the preceding claims in which the volume of gas upstream of the beverage ingredients is controlled.

10. A method of preparing beverages as claimed in any one of the preceding claims in which the volume of gas downstream of the beverage ingredients is controlled.

11. A method of preparing beverages as claimed in any one of the preceding claims in which the volume of gas is controlled by selectively opening and/or closing valve means in the delivery system prior to and/or during beverage preparation.

12. A beverage preparation machine for preparing a beverage from one or more beverage ingredients, characterised by the provision of means for controlling the volume of gas in at

least a part of a delivery system of the machine to produce predetermined characteristics in a prepared beverage.

13. A beverage preparation machine as claimed in claim 12 further comprising means for determining the actual volume of gas resident in the delivery system.

14. A beverage preparation machine as claimed in claim 13 in which the means for determining the actual volume of gas resident in the delivery system comprise means for calculating the actual volume from stored parameters relating to a volume of gas remaining in the delivery system after a last operation of the machine.

15. A beverage preparation machine as claimed in claim 14 in which the stored parameters comprise a basic volume parameter stored in the control means, said basic volume being the actual volume of gas which resides in the delivery system of an unused machine or a machine after a purging cycle has been run.

16. A beverage preparation machine as claimed in claim 14 or claim 15 in which the stored parameters comprise parameters relating to the actual volume of gas remaining in the delivery system after each type of beverage which the machine is programmed to prepare.

17. A beverage preparation machine as claimed in claim 13 in which the means for determining the actual volume of gas resident in the delivery system comprise means for measuring the actual volume of gas in the delivery system.

18. A beverage preparation machine as claimed in any one of claims 13 to 17 in which parameters relating to predetermined volumes of gas required to be present in the delivery system for preparing a predetermined range of beverages are stored in the control means, said control means being programmed to calculate the difference between the predetermined volume required for a beverage in preparation and the actual volume present.

19. A beverage preparation machine as claimed in any one of claims 13 to 18 in which the means for controlling the actual volume of gas comprise valve and/or purge means for venting gas and/or pump means for injecting additional gas into the delivery system.

20. A beverage preparation machine as claimed in claim 19 in which the valve means comprise an outlet valve downstream of the beverage ingredients.

21. A beverage preparation machine as claimed in claim 19 or claim 20 in which the valve means comprise a valve upstream of the beverage ingredients.

22. A beverage preparation machine as claimed in any one of claims 18 to 22 in which the operation of the valve means is controlled relative to the beverage preparation cycle to vary the actual volume of gas present in the delivery system.

Amendments to the Claims have been filed as follows:

CLAIMS:

1. A method of preparing beverages using a beverage preparation machine for preparing beverages from one or more beverage ingredients, characterised by controlling the volume of air resident in at least a part of a delivery system of the machine to produce predetermined characteristics in a prepared beverage.

2. A method of preparing beverages as claimed in claim 1 in which the volume of air is actively controlled by increasing the volume to increase the air:liquid ratio in the beverage produced, decreasing the volume to decrease the air:liquid ratio or maintaining the volume.

3. A method of preparing beverages as claimed in any one of the preceding claims in which the volume of air in the delivery system is controlled by inducting additional gas into the delivery system, venting air from the delivery system and/or purging the delivery system.

4. A method of preparing beverages as claimed in any one of the preceding claims further comprising the step of measuring the actual volume of air resident in the delivery system.

5. A method of preparing beverages as claimed in any one of the preceding claims in which an actual volume of air resident in the delivery system is calculated from stored parameters relating to a volume of air remaining in the delivery system after a last operation of the machine.

6. A method of preparing beverages as claimed in any one of the preceding claims in which the control of the volume of air is effected on a beverage by beverage basis.

7. A method of preparing beverages as claimed in any one of the preceding claims in which the control of the volume of air is effected automatically according to the type of beverage being produced.

8. A method of preparing beverages as claimed in any one of claims 1 to 5 in which the control of the volume of a is effected manually.

9. A method of preparing beverages as claimed in any one of the preceding claims in which the volume of air upstream of the beverage ingredients is controlled.

10. A method of preparing beverages as claimed in any one of the preceding claims in which the volume of air downstream of the beverage ingredients is controlled.

11. A method of preparing beverages as claimed in any one of the preceding claims in which the volume of air is controlled by selectively opening and/or closing valve means in the delivery system prior to and/or during beverage preparation.

12. A beverage preparation machine for preparing a beverage from one or more beverage ingredients, characterised by the provision of means for controlling the volume of air

resident in at least a part of a delivery system of the machine to produce predetermined characteristics in a prepared beverage.

13. A beverage preparation machine as claimed in claim 12 further comprising means for determining the actual volume of air resident in the delivery system.

14. A beverage preparation machine as claimed in claim 13 in which the means for determining the actual volume of air resident in the delivery system comprise means for calculating the actual volume from stored parameters relating to a volume of air remaining in the delivery system after a last operation of the machine.

15. A beverage preparation machine as claimed in claim 14 in which the stored parameters comprise a basic volume parameter stored in the control means, said basic volume being the actual volume of air which resides in the delivery system of an unused machine or a machine after a purging cycle has been run.

16. A beverage preparation machine as claimed in claim 14 or claim 15 in which the stored parameters comprise parameters relating to the actual volume of air remaining in the delivery system after each type of beverage which the machine is programmed to prepare.

17. A beverage preparation machine as claimed in claim 13 in which the means for determining the actual volume of air

resident in the delivery system comprise means for measuring the actual volume of air in the delivery system.

18. A beverage preparation machine as claimed in any one of claims 13 to 17 in which parameters relating to predetermined volumes of air required to be present in the delivery system for preparing a predetermined range of beverages are stored in the control means, said control means being programmed to calculate the difference between the predetermined volume required for a beverage in preparation and the actual volume present.

19. A beverage preparation machine as claimed in any one of claims 13 to 18 in which the means for controlling the actual volume of air comprise valve and/or purge means for venting air and/or pump means for injecting additional air into the delivery system.

20. A beverage preparation machine as claimed in claim 19 in which the valve means comprise an outlet valve downstream of the beverage ingredients.

21. A beverage preparation machine as claimed in claim 19 or claim 20 in which the valve means comprise a valve upstream of the beverage ingredients.

22. A beverage preparation machine as claimed in any one of claims 18 to 22 in which the operation of the valve means is controlled relative to the beverage preparation cycle to vary the actual volume of air present in the delivery system

Application No: GB0907612.6 **Examiner:** Dr Matthew Parker

Claims searched: 1-22 **Date of search:** 19 August 2009

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-3,6-12,19-22	WO2009/008700 A1 (MECCANO), see Figure 2 and air inlet 15
X	1-4,8,9,13,17	EP1208781 A3 (BIALETTI), see abstract
X	1-3,6-12,19-22	WO2006/053016 A3 (VICKER), see Figure 3
X	1-3,6-12,19-22	US2006/288874 A1 (ZIESEL), see abstract

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[X] :

Worldwide search of patent documents classified in the following areas of the IPC

A47J

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
A47J	0031/06	01/01/2006
A47J	0031/24	01/01/2006

Intellectual Property Office is an operating name of the Patent Office www.ipo.gov.uk

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
5 August 2004 (05.08.2004)

PCT

(10) International Publication Number
WO 2004/065258 A2

(51) International Patent Classification[7]: B65D 81/00, B65B 43/42, A47J 31/40, B65B 59/00

(21) International Application Number: PCT/GB2004/000276

(22) International Filing Date: 23 January 2004 (23.01.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

0301738.1	24 January 2003 (24.01.2003)	GB
0301745.6	24 January 2003 (24.01.2003)	GB
0301739.9	24 January 2003 (24.01.2003)	GB

(71) Applicant *(for all designated States except US)*: **KRAFT FOODS R & D, INC.** [DE/DE]; Zweigniederlassung Munchen, Unterbiberger Str. 15, 81737 MUNICH (DE).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **GOMEZ, Maria** [GB/GB]; Ruscote Avenue, Banbury, Oxfordshire OX16 7QU (GB). **HALLIDAY, Andrew** [GB/GB]; Ruscote Avenue, Banbury, Oxfordshire OX16 7QU (GB). **BALLARD, Colin** [GB/GB]; Ruscote Avenue, Banbury, Oxfordshire OX16 7QU (GB). **PANESAR, Satwinder** [GB/GB]; Ruscote Avenue, Banbury, Oxfordshire OX16 7QU (GB).

(74) Agent: **BOULT WADE TENNANT**; Verulam Gardens, 70 Gray's Inn Road, London WX1X 8BT (GB).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

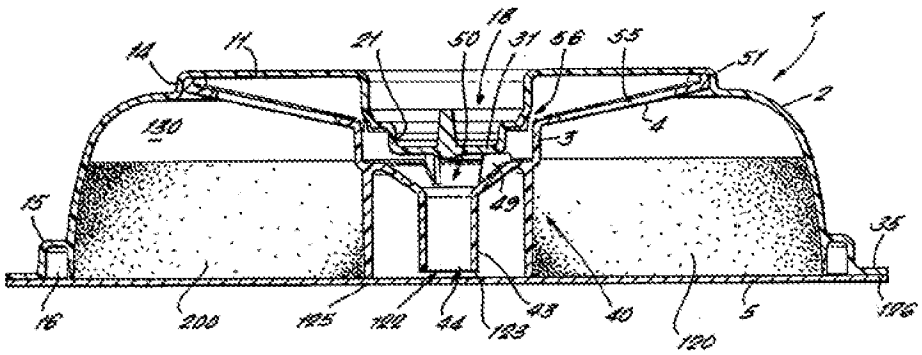
(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: CARTRIDGE AND METHOD FOR THE PREPARATION OF BEVERAGES



(57) Abstract: A cartridge (1) containing one or more liquid beverage ingredients (200) and being formed from substantially air- and water-impermeable materials, the cartridge comprising an inlet (121) for the introduction of an aqueous medium into the cartridge, a compartment (134) containing the one or more liquid beverage ingredients and an outlet (122) for a beverage produced by dilution of the one or more liquid beverage ingredients by the aqueous medium, characterised in that the compartment includes means for controlling dilution of at least a proportion of the one or more liquid beverage ingredients on introduction of the aqueous medium into the compartment.

WO 2004/065258 A2

CARTRIDGE AND METHOD FOR THE PREPARATION OF BEVERAGES

The present invention relates to a cartridge and method for the preparation of beverages and, in particular, using sealed cartridges which are formed from substantially air- and water-impermeable materials and which contain one or more ingredients for the preparation of beverages.

It has previously been proposed to seal beverage preparation ingredients in individual air-impermeable packages. For example, cartridges or capsules containing compacted ground coffee are known for use in certain coffee preparation machines which are generally termed "espresso" machines. In the production of coffee using these preparation machines the coffee cartridge is placed in a brewing chamber and hot water is passed though the cartridge at relatively high pressures, thereby extracting the aromatic coffee constituents from the ground coffee to produce the coffee beverage. Typically, such machines operate at a pressure of greater than 6×10^5 Pa. The preparation machines of the type described have to date been relatively expensive since components of the machine, such as the water pumps and seals, must be able to withstand the high pressures.

In WO01/58786 there is described a cartridge for the preparation of beverages which operates at a pressure generally in the range 0.7 to 2.0×10^5 Pa. However, the cartridge is designed for use in a beverage preparation machine for the commercial or industrial market and is relatively expensive and limited in the types of beverage produced. Hence, there remains a requirement for a cartridge for the preparation of beverages wherein the

cartridges and beverage preparation machine are suitable, in particular, for the domestic market in terms of cost, performance and reliability. There is also a need for a beverage preparation machine for such a system which is simple to operate and reliable in operation and can produce a wide range of beverage types.

It is known to provide dairy-based beverage ingredients in cartridges in the form of a powder or other dehydrated form. However, consumers consistently indicate that the use of such powdered dairy-based products adversely affects the taste, colour and texture of the final beverage. It has proven difficult to provide liquid dairy-based products in a cartridge due to the requirement to sterilise the cartridge components. Further, it has been found to be difficult to control the dilution and dispensing of the liquid milk products to arrive at a consistent and acceptable final beverage.

In addition, powdered dairy products cannot be used to produce an authentic looking frothy milk-based foam as desired by consumers for cappuccino-style beverages. A number of beverage preparation machines provide a steam wand or similar for frothing of a quantity of milk. However, the addition of the steam wand increases the cost of the machine and requires a means for generating steam. Operation of the steam wand must be done manually and requires experience to be successful. In addition, since steam is being used there is the potential for the consumer to be burnt by either the steam or hot components of the machine. Further, the consumer must keep a supply of milk available separate from the machine and carry out a further process step of a different type in order to produce a cappuccino style

beverage. This increases the complexity and time required to produce such beverages.

Hence, there remains a requirement for a system for the preparation of beverages wherein the cartridges and beverage preparation machine of the system are suitable, in particular, for the domestic market in terms of cost, performance and reliability. There is also a need for a beverage preparation machine for such a system which is simple to operate and reliable in operation and can produce a wide range of beverage types.

Accordingly, the present invention provides a cartridge containing one or more liquid beverage ingredients and being formed from substantially air- and water-impermeable materials, the cartridge comprising an inlet for the introduction of an aqueous medium into the cartridge, a compartment containing the one or more liquid beverage ingredients and an outlet for a beverage produced by dilution of the one or more liquid beverage ingredients by the aqueous medium, characterised in that the compartment includes means for controlling dilution of at least a proportion of the one or more liquid beverage ingredients on introduction of the aqueous medium into the compartment.

Advantageously, the cartridge of the present invention provides superior dilution and dispensing of liquid beverage ingredients by ensuring that the liquid beverage ingredients are dispensed more evenly over the operating cycle rather that being dispensed all at the start of the operating cycle followed by substantially pure aqueous medium, which is, for example, water. This steady dispensation of the liquid beverage ingredients leads to improved homogeneity of the dispensed liquid beverage. In addition, where the diluted

liquid beverage is subsequently subjected to foaming, by for example, jetting through an orifice, the improved homogeneity of the liquid leads to a greater consistency of foaming and improved quality and quantity of foam produced per unit volume of liquid beverage.

Preferably, the means for controlling dilution delays dilution of at least a proportion of the one or more liquid beverage ingredients on introduction of the aqueous medium into the compartment.

Preferably, in use, an aqueous medium flow path is established from the inlet to the outlet, the means for delaying dilution comprising a partition which hinders entry of at least a proportion of the one or more liquid beverage ingredients into the aqueous medium flow path. In one embodiment the partition comprises one or more apertures for controllably releasing the at least a proportion of the one or more liquid beverage ingredients into the aqueous medium flow path. Four apertures may be provided.

The partition may comprise a cup-shaped member having an open mouth directed away from the aqueous medium flow path. The cup-shaped member is preferably annular. The one or more apertures are preferably provided at or near a base of the cup-shaped member. The at least a proportion of the liquid beverage ingredients in the cup-shaped member, for example, drain by gravity through the one or more apertures in use.

In one embodiment, the cup-shaped member is spaced from a bottom of the cartridge, such that the aqueous medium flow path passes between the cup-shaped member and the bottom of the cartridge. Consequently, the at least a proportion of the liquid beverage ingredients in the cup-shaped member

drains by gravity through the one or more apertures in use vertically downwards into the aqueous medium flow path.

Preferably, the cartridge comprises an inner member and an outer member, wherein the inner member comprises the cup-shaped member. The components of the inner member and the outer member may more easily be sterilised prior to assembly when they are separated. Once the components are conjoined a number of small-apertured, tortuous pathways are created which cannot effectively be sterilised using known methods. The ability to sterilise the components is a particularly advantageous feature where the cartridges are used for dispensing dairy-based beverages such as milk.

Preferably, the cartridge further comprises means for producing a jet of the beverage, wherein said means for producing the jet of the beverage comprises an aperture in the aqueous medium flow path. The aperture may be delimited by an interface between the inner member and the outer member.

Preferably, the cartridge further comprises at least one inlet for air and means for generating a pressure reduction of the jet of beverage, whereby, in use, air from the at least one air inlet is incorporated into the beverage as a plurality of small bubbles. At least one air inlet may be provided in the inner member downstream of the aperture.

In one embodiment the at least one air inlet and means for producing a pressure reduction in the jet of beverage produces a foaming of the one or more liquid beverage ingredients of greater than 40%. Preferably, greater than 70%. Preferably, the cartridge is disc-shaped. The outer member and/or inner member are formed, for example, from polypropylene.

In one example, the liquid beverage ingredient is a concentrated liquid milk composition. Preferably, the concentrated liquid milk contains between 25 and 40% total solids. More preferably, the concentrated liquid milk contains 30% total solids. Also preferably, the concentrated liquid milk contains between 0.1 and 12% fat. Alternatively, the one or more liquid beverage ingredients are selected from the group of cocoa solids, coffee, tea, sweeteners, cordials, flavourings, alcoholic beverages, flavoured milk, fruit juices, squashes, sauces and desserts.

The present invention also provides a method of dispensing a beverage from a cartridge containing one or more liquid beverage ingredients during an operating cycle, comprising the steps of passing an aqueous medium through the cartridge to form a beverage by dilution of said one or more beverage ingredients, and dispensing the beverage into a receptacle, wherein the one or more liquid ingredients as dispensed has a concentration at the start of the operating cycle of between 30 and 70% total solids and a concentration at the end of the operating cycle of between 1 and 15% total solids.

In one embodiment the concentration at the start of the operating cycle is between 30 and 35% total solids. The concentration at the end of the operating cycle is approximately 10% total solids. The liquid ingredient may be concentrated milk. In another embodiment, the concentration at the start of the operating cycle is between 60 and 70% total solids. The concentration at the end of the operating cycle is between 12 and 15% total solids. The liquid ingredient may contain cocoa solids. In another embodiment, the concentration at the start of the operating cycle is

between 40 and 70% total solids. The concentration at the end of the operating cycle is between 1 and 2% total solids. The liquid ingredient may contain coffee.

The present invention further provides a method of dispensing a beverage from a cartridge containing one or more liquid beverage ingredients during an operating cycle, comprising the steps of passing an aqueous medium through the cartridge to form a beverage by dilution of said one or more beverage ingredients, and dispensing the beverage into a receptacle, wherein the one or more liquid beverage ingredients is foamed on dispense to a ratio of between 20 and 150%.

Preferably the one or more liquid beverage ingredients are foamed to a ratio between 70 and 100%.

The one or more liquid beverage ingredients may include one or more of concentrated milk, coffee and cocoa solids.

The present invention further provides a beverage as produced by the above methods.

The present invention also provides a method of manufacturing a cartridge for dispensation of a beverage comprising the steps of:

a. manufacturing a plurality of outer members comprising at least a first type of outer member and a second type of outer member having differing shape or configurations;

b. manufacturing a plurality of inner members comprising at least a first type of inner member and a second type of inner member having differing shape or configurations;

c. storing said plurality of outer members and said inner members;

d. selecting one of the first type of outer member or the second type of outer member from the plurality of outer members;

e. selecting one of the first type of inner member or the second type of inner member from the plurality of inner members;

f. conjoining the selected inner member to the selected outer member such the inner member is within the outer member;

g. filling the outer member with one or more beverage ingredients selected from a plurality of beverage ingredients; and

h. sealing the outer member with a lid to form the cartridge.

The method of manufacture of the present invention provides an economical means for producing cartridges for the dispensation of one of a plurality of beverages. Advantageously, the cartridge is easily assembled from the main components of the inner member, the outer member, the beverage ingredient and the lid. Different types of outer member, inner member and lid are manufactured depending on the beverage ingredient to be dispensed. However, the differing types of inner member, outer member and lid are interchangeable so that individual cartridges may be assembled from specific combinations of the stock components. This results in a reduced number of total components that need to be manufactured without affecting the flexibility of the type of cartridges that can be produced. For example, the same type of outer member may be used for dispensing filter coffee and espresso-style coffee.

The cost of manufacturing the range of beverage cartridges is reduced by using interchangeable components. In addition, the types of outer member share substantially the same external shape and configuration so that all cartridges in the range can be dispensed using the same beverage preparation machine.

Optionally the method further comprises in step b. joining a filter member to the first type and/or second type of inner member.

The first type of outer member may be suitable for containing roast and ground beverage ingredients or the like. The second type of outer member may be suitable for containing soluble or liquid beverage ingredients or the like.

The first type of inner member may be suitable for filtering roast and ground beverage ingredients and the like. The second type of inner member may be suitable for filtering roast and ground beverage ingredients and the like and for entraining a plurality of air bubbles in the dispensed beverage.

The first and second type of inner member may comprise a frame having a filter disposed thereupon, and wherein a peripheral rim of the frame is conjoined to the selected type of outer member by welding.

By using separate components for the inner and outer members which are then conjoined on assembly by a welding process the manufacture of each component and the assembly of the cartridge can be optimised. This is particularly advantageous in the present cartridge where very small tolerances are desirable since the beverage flow path through the cartridge is defined by the interface between

the outer member and the inner member. In addition the components of the inner member and the outer member may more easily be sterilised prior to assembly when they are separated. Once the components are welded together a number of small-apertured, tortuous pathways are created which cannot effectively be sterilised using known methods. The ability to sterilise the components is a particularly advantageous feature where the cartridges are used for dispensing dairy-based beverages. A welded arrangement provides a quick to assemble but secure method of conjoining the inner member and outer member. Advantageously, the welding method avoids the need for glues or other such adhesives in the interior of the cartridge which will be exposed to the beverage ingredients.

Preferably, the second type of inner member comprises means for producing a jet of the beverage, which means comprises an aperture in a beverage flow path between an inlet and an outlet of the cartridge.

Preferably, the method further comprises manufacturing and storing a third type of inner member. The third type of inner member may be suitable for dispensing soluble beverage ingredients and the like.

Preferably, the method further comprises manufacturing and storing a fourth type of inner member. The fourth type of inner member may be suitable for dispensing a liquid beverage ingredients and the like.

The third or fourth type of inner member may comprise a skirt surrounding an outlet, the skirt comprising an upper extension having an upper rim which engages, on assembly of the cartridge, a co-operating formation of the selected type of outer member to form a snap-fit arrangement for

conjoining the third or fourth type of inner member to the selected type of outer member.

The present invention also provides a cartridge system for dispensing a plurality of beverages comprising:

a. a plurality of outer members comprising at least a first type of outer member and a second type of outer member having differing shape or configurations;
b. a plurality of inner members comprising at least a first type of inner member and a second type of inner member having differing shape or configurations;
c. a plurality of beverage ingredients; and
d. at least one lid to seal the cartridge;

wherein each cartridge comprises an outer member, an inner member, one or more beverage ingredients and a lid.

The present invention also provides a method of preparing a beverage comprising the steps of:

a. inserting a first beverage cartridge containing one or more beverage ingredients into a beverage preparation machine;
b. operating said beverage preparation machine to pass an aqueous medium through the first beverage cartridge to dispense a first portion of said beverage into a receptacle;
c. inserting a second beverage cartridge containing one or more beverage ingredients into the beverage preparation machine; and
d. operating the beverage preparation machine to pass an aqueous medium through the second beverage cartridge to dispense a second portion of said beverage into the receptacle;

characterised in that one of the first or second beverage cartridges contains a liquid dairy-based ingredient.

By using two or more cartridges to prepare a beverage a large variety of beverage can be produced by the same beverage preparation machine. In addition, each cartridge can be optimised for dispensing particular beverage ingredients. In particular, the ability to dispense liquid dairy-based ingredients allows for the formation of beverages having an authentic look, taste and mouth feel which have previously only been possible using non-cartridge based systems such as the use of a separate steam wand to froth bulk quantities of milk. The present method provides a reliable and easy to operate system for forming such beverages.

Preferably, one of the first or second beverage cartridges contains an ingredient for forming a brewed portion of a beverage.

Preferably, the method further comprises the step of removing the first beverage cartridge before inserting the second beverage cartridge.

In one embodiment, the beverage ingredient in the first or second beverage cartridge is roast and ground coffee. In another embodiment, the beverage ingredient in the first or second beverage cartridge is leaf-based tea. In another, the beverage ingredient in the first or second beverage cartridge is a liquid coffee ingredient.

Preferably, the liquid beverage ingredient is a concentrated dairy-based product. Advantageously, the concentrated dairy-based product is concentrated liquid milk. Preferably, the concentrated liquid milk contains

between 25 and 40% total solids. More preferably, the concentrated liquid milk contains 30% total solids. In addition, preferably, the concentrated liquid milk contains between 0.1 and 12% fat.

Preferably, the method further comprises the step of foaming the one or more liquid dairy-based ingredients during dispensation.

The present invention also provides a beverage preparation system comprising a beverage preparation machine having means for receiving a range of beverage cartridges and means for passing an aqueous medium through said beverage cartridges, a first beverage cartridge containing one or more beverage ingredients for preparing a first portion of said beverage, and a second beverage cartridge containing one or more beverage ingredients for preparing a second portion of said beverage, characterised in that one of the first or second beverage cartridges contains a liquid dairy-based ingredient.

It will be understood that by the term "cartridge" as used herein is meant any package, container, sachet or receptacle which contains one or more beverage ingredients in the manner described. The cartridge may be rigid, semi-rigid or flexible.

The cartridge of the present invention contains one or more liquid beverage ingredients suitable for the formation of a beverage product. The beverage product may be, for example, one of coffee, tea, chocolate or a dairy-based beverage including milk.

In the following description the terms "upper" and "lower" and equivalents will be used to describe the relational positioning of features of the invention. The

terms "upper" and "lower" and equivalents should be understood to refer to the cartridge (or other components) in its normal orientation for insertion into a beverage preparation machine and subsequent dispensing as shown, for example, in Figure 4. In particular, "upper" and "lower" refer, respectively, to relative positions nearer or further from a top surface 11 of the cartridge. In addition, the terms "inner" and "outer" and equivalents will be used to describe the relational positioning of features of the invention. The terms "inner" and "outer" and equivalents should be understood to refer to relative positions in the cartridge (or other components) being, respectively, nearer or further from a centre or major axis X of the cartridge 1 (or other component).

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

Figure 1 is cross-sectional drawing of an outer member of first and second embodiments of cartridge;

Figure 2 is a cross-sectional drawing of a detail of the outer member of Figure 1 showing an inwardly directed cylindrical extension;

Figure 3 is a cross-sectional drawing of a detail of the outer member of Figure 1 showing a slot;

Figure 4 is a perspective view from above of the outer member of Figure 1;

Figure 5 is a perspective view from above of the outer member of Figure 1 in an inverted orientation;

Figure 6 is a plan view from above of the outer member of Figure 1;

Figure 7 is a cross-sectional drawing of an inner member of the first embodiment of cartridge;

Figure 8 is a perspective view from above of the inner member of Figure 7;

Figure 9 is a perspective view from above of the inner member of Figure 7 in an inverted orientation;

Figure 10 is a plan view from above of the inner member of Figure 7;

Figure 11 is a cross-sectional drawing of the first embodiment of cartridge in an assembled condition;

Figure 12 is a cross-sectional drawing of an inner member of the second embodiment of cartridge;

Figure 13 is a cross-sectional drawing of a detail of the inner member of Figure 12 showing an aperture;

Figure 14 is a perspective view from above of the inner member of Figure 12;

Figure 15 is a perspective view from above of the inner member of Figure 12 in an inverted orientation;

Figure 16 is another cross-sectional drawing of the inner member of Figure 12;

Figure 17 is a cross-sectional drawing of another detail of the inner member of Figure 12 showing an air inlet;

Figure 18 is a cross-sectional drawing of the second embodiment of cartridge in an assembled condition;

Figure 19 is cross-sectional drawing of an outer member of third and fourth embodiments of cartridge;

Figure 20 is a cross-sectional drawing of a detail of the outer member of Figure 19 showing an inwardly directed cylindrical extension;

Figure 21 is a plan view from above of the outer member of Figure 19;

Figure 22 is a perspective view from above of the outer member of Figure 19;

Figure 23 is a perspective view from above of the outer member of Figure 19 in an inverted orientation;

Figure 24 is a cross-sectional drawing of an inner member of the third embodiment of cartridge;

Figure 25 is a plan view from above of the inner member of Figure 24;

Figure 26 is a cross-sectional drawing of a detail of the inner member of Figure 24 showing an in-turned upper rim;

Figure 27 is a perspective view from above of the inner member of Figure 24;

Figure 28 is a perspective view from above of the inner member of Figure 24 in an inverted orientation;

Figure 29 is a cross-sectional drawing of the third embodiment of cartridge in an assembled condition;

Figure 30 is a cross-sectional drawing of an inner member of the fourth embodiment of cartridge according to the present invention;

Figure 31 is a plan view from above of the inner member of Figure 30;

Figure 32 is a perspective view from above of the inner member of Figure 30;

Figure 33 is a perspective view from above of the inner member of Figure 30 in an inverted orientation;

Figure 34 is a cross-sectional drawing of the fourth embodiment of cartridge in an assembled condition;

Figure 35 is a front perspective view of a beverage preparation machine for use with the present invention;

Figure 36 is a front perspective view of the machine of Figure 35 with a cartridge head in an open position;

Figure 37 is a rear perspective view of the machine of Figure 35 with some parts omitted for clarity;

Figure 38 is another rear perspective view of the machine of Figure 35 with some parts omitted for clarity;

Figure 39 is a perspective view of the cartridge head of the machine of Figure 35 with some parts omitted for clarity;

Figure 40 is another perspective view of the cartridge head of the machine of Figure 35 with some parts omitted for clarity;

Figure 41 is a cross-sectional view of the cartridge head in a closed position;

Figure 42 is a cross-sectional view of the cartridge head in an open position;

Figure 43 is a schematic layout of the machine of Figure 35;

Figure 44a and 44b are schematic layouts of first and second code recognition means for the machine of Figure 35;

Figure 45 is a plan view of a beverage of the present invention comprising a barcode;

Figure 46a is a graph of concentration vs. operating cycle time;

Figure 46b is a graph of foamability vs. operating cycle time; and

Figure 46c is a graph of temperature vs. operating cycle time.

As shown in Figure 11, the cartridge 1 generally comprises an outer member 2, an inner member 3 and a laminate 5. The outer member 2, inner member 3 and laminate 5 are assembled to form the cartridge 1 which has an interior 120 for containing one or more beverage ingredients, an inlet 121, an outlet 122 and a beverage flow path linking the inlet 121 to the outlet 122 and which passes through the interior 120. The inlet 121 and outlet 122 are initially sealed by the laminate 5 and are opened in use by piercing or cutting of the laminate 5. The beverage flow path is defined by spatial inter-relationships between the outer member 2, inner member 3 and laminate 5 as discussed below. Other components may optionally be included in the cartridge 1, such as a filter 4, as will be described further below.

A first version of cartridge 1 which will be described for background purposes is shown in Figures 1 to 11. The first version of the cartridge 1 is particularly designed for use in dispensing filtered products such as roast and ground coffee or leaf tea. However, this version of the cartridge 1 and the other versions described below may be used with other products such as chocolate, coffee, tea, sweeteners, cordials, flavourings, alcoholic beverages, flavoured milk, fruit juices, squashes, sauces and desserts.

As can be seen from Figure 5, the overall shape of the cartridge 1 is generally circular or disc-shaped with the diameter of the cartridge 1 being significantly greater than its height. A major axis X passes through the centre of the outer member as shown in Figure 1. Typically the overall diameter of the outer member 2 is 74.5 mm ±6mm and the

overall height is 16 mm ±3mm. Typically the volume of the cartridge 1 when assembled is 30.2 ml ±20%.

The outer member 2 generally comprises a bowl-shaped shell 10 having a curved annular wall 13, a closed top 11 and an open bottom 12. The diameter of the outer member 2 is smaller at the top 11 compared to the diameter at the bottom 12, resulting from a flaring of the annular wall 13 as one traverses from the closed top 11 to the open bottom 12. The annular wall 13 and closed bottom 11 together define a receptacle having an interior 34.

A hollow inwardly directed cylindrical extension 18 is provided in the closed top 11 centred on the major axis X. As more clearly shown in Figure 2, the cylindrical extension 18 comprises a stepped profile having first, second and third portions 19, 20 and 21. The first portion 19 is right circular cylindrical. The second portion 20 is frusto-conical in shape and is inwardly tapered. The third portion 21 is another right circular cylinder and is closed off by a lower face 31. The diameter of the first, second and third portion 19, 20 and 21 incrementally decreases such that the diameter of the cylindrical extension 18 decreases as one traverses from the top 11 to the closed lower face 31 of the cylindrical extension 18. A generally horizontal shoulder 32 is formed on the cylindrical extension 18 at the junction between the second and third portions 20 and 21.

An outwardly extending shoulder 33 is formed in the outer member 2 towards the bottom 12. The outwardly extending shoulder 33 forms a secondary wall 15 co-axial with the annular wall 13 so as to define an annular track forming a manifold 16 between the secondary wall 15 and the annular wall 13. The manifold 16 passes around the

circumference of the outer member 2. A series of slots 17 are provided in the annular wall 13 level with the manifold 16 to provide gas and liquid communication between the manifold 16 and the interior 34 of the outer member 2. As shown in Figure 3, the slots 17 comprise vertical slits in the annular wall 13. Between 20 and 40 slots are provided. In the embodiment shown thirty-seven slots 17 are provided generally equi-spaced around the circumference of the manifold 16. The slots 17 are preferably between 1.4 and 1.8 mm in length. Typically the length of each slot is 1.6 mm representing 10% of the overall height of the outer member 2. The width of each slot is between 0.25 and 0.35 mm. Typically, the width of each slot is 0.3 mm. The width of the slots 17 is sufficiently narrow to prevent the beverage ingredients passing therethrough into the manifold 16 either during storage or in use.

An inlet chamber 26 is formed in the outer member 2 at the periphery of the outer member 2. A cylindrical wall 27 is provided, as most clearly shown in Figure 5, which defines the inlet chamber 26 within, and partitions the inlet chamber 26 from, the interior 34 of the outer member 2. The cylindrical wall 27 has a closed upper face 28 which is formed on a plane perpendicular to the major axis X and an open lower end 29 co-planar with the bottom 12 of the outer member 2. The inlet chamber 26 communicates with the manifold 16 via two slots 30 as shown in Figure 1. Alternatively, between one and four slots may be used to communicate between the manifold 16 and the inlet chamber 26.

A lower end of the outwardly extending shoulder 33 is provided with an outwardly extending flange 35 which extends

perpendicularly to the major axis X. Typically the flange 35 has a width of between 2 and 4 mm. A portion of the flange 35 is enlarged to form a handle 24 by which the outer member 2 may be held. The handle 24 is provided with an upturned rim 25 to improve grip.

The outer member 2 is formed as a single integral piece from high density polyethylene, polypropylene, polystyrene, polyester, or a laminate of two or more of these materials. A suitable polypropylene is the range of polymers available from DSM UK Limited (Redditch, United Kingdom). The outer member may be opaque, transparent or translucent. The manufacturing process may be injection moulding.

The inner member 3 as shown in Figures 7 to 10, comprises an annular frame 41 and a downwardly extending cylindrical funnel 40. A major axis X passes through the centre of the inner member 3 as shown in Figure 7.

As best shown in Figure 8, the annular frame 41 comprises an outer rim 51 and an inner hub 52 joined by ten equi-spaced radial spokes 53. The inner hub 52 is integral with and extends from the cylindrical funnel 40. Filtration apertures 55 are formed in the annular frame 41 between the radial spokes 53. A filter 4 is disposed on the annular frame 41 so as to cover the filtration apertures 55. The filter is preferably made from a material with a high wet strength, for example a non-woven fibre material of polyester. Other materials which may be used include a water-impermeable cellulosic material, such as a cellulosic material comprising woven paper fibres. The woven paper fibres may be admixed with fibres of polypropylene, polyvinyl chloride and/or polyethylene. The incorporation of these plastic materials into the cellulosic material

renders the cellulosic material heat-sealable. The filter 4 may also be treated or coated with a material which is activated by heat and/or pressure so that it can be sealed to the annular frame 41 in this way.

As shown in the cross-sectional profile of Figure 7, the inner hub 52 is located at a lower position than the outer rim 51, resulting in the annular frame 41 having a sloping lower profile.

The upper surface of each spoke 53 is provided with an upstanding web 54 which divides a void space above the annular frame 41 into a plurality of passages 57. Each passage 57 is bounded on either side by a web 54 and on a lower face by the filter 4. The passages 57 extend from the outer rim 51 downwardly towards, and open into, the cylindrical funnel 40 at openings 56 defined by the inner extremities of the webs 54.

The cylindrical funnel 40 comprises an outer tube 42 surrounding an inner discharge spout 43. The outer tube 42 forms the exterior of the cylindrical funnel 40. The discharge spout 43 is joined to the outer tube 42 at an upper end of the discharge spout 43 by means of an annular flange 47. The discharge spout 43 comprises an inlet 45 at an upper end which communicates with the openings 56 of the passages 57 and an outlet 44 at a lower end through which the prepared beverage is discharged into a cup or other receptacle. The discharge spout 43 comprises a frusto-conical portion 48 at an upper end and a cylindrical portion 58 at a lower end. The cylindrical portion 58 may have a slight taper such that it narrows towards the outlet 44. The frusto-conical portion 48 helps to channel beverage from the passages 57 down towards the outlet 44 without inducing

turbulence to the beverage. An upper surface of the frusto-conical portion 48 is provided with four support webs 49 equi-spaced around the circumference of the cylindrical funnel 40. The support webs 49 define channels 50 therebetween. The upper edges of the support webs 49 are level with one another and perpendicular to the major axis X.

The inner member 3 may be formed as a single integral piece from polypropylene or a similar material as described above and by injection moulding in the same manner as the outer member 2.

Alternatively, the inner member 3 and/or the outer member 2 may be made from a biodegradable polymer. Examples of suitable materials include degradable polyethylene (for example, SPITEK supplied by Symphony Environmental, Borehamwood, United Kingdom), biodegradable polyester amide (for example, BAK 1095 supplied by Symphony Environmental), poly lactic acids (PLA supplied by Cargil, Minnesota, USA), starch-based polymers, cellulose derivatives and polypeptides.

The laminate 5 is formed from two layers, a first layer of aluminium and a second layer of cast polypropylene. The aluminium layer is between 0.02 and 0.07 mm in thickness. The cast polypropylene layer is between 0.025 and 0.065 mm in thickness. In one embodiment the aluminium layer is 0.06 mm and the polypropylene layer is 0.025 mm thick. This laminate is particularly advantageous as it has a high resistance to curling during assembly. As a result the laminate 5 may be pre-cut to the correct size and shape and subsequently transferred to the assembly station on the production line without undergoing distortion. Consequently,

the laminate 5 is particularly well suited to welding. Other laminate materials may be used including PET/Aluminium/PP, PE/EVOH/PP, PET/metallised/PP and Aluminium/PP laminates. Roll laminate stock may be used instead of die cut stock.

The cartridge 1 may be closed by a rigid or semi-rigid lid instead of a flexible laminate.

Assembly of the cartridge 1 involves the following steps:

a) the inner member 3 is inserted into the outer member 2;

b) the filter 4 is cut to shape and placed onto the inner member 3 so to be received over the cylindrical funnel 40 and come to rest against the annular frame 41;

c) the inner member 3, outer member 2 and filter 4 are joined by ultrasonic welding;

d) the cartridge 1 is filled with one or more beverage ingredients;

e) the laminate 5 is affixed to the outer member 2.

These steps will be discussed in greater detail below.

The outer member 2 is orientated with the open bottom 12 directed upwards. The inner member 3 is then inserted into the outer member 2 with the outer rim 51 being received as a loose fit in an axial extension 14 at top 11 of the cartridge 1. The cylindrical extension 18 of the outer member 2 is at the same time received in the upper portion of the cylindrical funnel 40 of the inner member 3. The third portion 21 of the cylindrical extension 18 is seated inside the cylindrical funnel 40 with the closed lower face 31 of the cylindrical extension 18 bearing against the support webs 49 of the inner member 3. The filter 4 is then

placed over the inner member 3 such that the filter material contacts the annular rim 51. An ultrasonic welding process is then used to join the filter 4 to the inner member 3 and at the same time, and in the same process step, the inner member 3 to the outer member 2. The inner member 3 and filter 4 are welded around the outer rim 51. The inner member 3 and outer member 2 are joined by means of weld lines around the outer rim 51 and also the upper edges of the webs 54.

As shown most clearly in Figure 11, the outer member 2 and inner member 3 when joined together define a void space 130 in the interior 120 below the annular flange 41 and exterior the cylindrical funnel 40 which forms a filtration chamber. The filtration chamber 130 and passages 57 above the annular frame 41 are separated by the filter paper 4.

The filtration chamber 130 contains the one or more beverage ingredients 200. The one or more beverage ingredients are packed into the filtration chamber 130. For a filtered style beverage the ingredient is typically roast and ground coffee or leaf tea. The density of packing of the beverage ingredients in the filtration chamber 130 can be varied as desired. Typically, for a filtered coffee product the filtration chamber contains between 5.0 and 10.2 grams of roast and ground coffee in a filtration bed of thickness of typically 5 to 14 mm. Optionally, the interior 120 may contain one or more bodies, such as spheres, which are freely movable within the interior 120 to aid mixing by inducing turbulence and breaking down deposits of beverage ingredients during discharge of the beverage.

The laminate 5 is then affixed to the outer member 2 by forming a weld 126 around the periphery of the laminate 5 to

join the laminate 5 to the lower surface of the outwardly extending flange 35. The weld 126 is extended to seal the laminate 5 against the lower edge of the cylindrical wall 27 of the inlet chamber 26. Further, a weld 125 is formed between the laminate 5 and the lower edge of the outer tube 42 of the cylindrical funnel 40. The laminate 5 forms the lower wall of the filtration chamber 130 and also seals the inlet chamber 26 and cylindrical funnel 40. However, a small gap 123 exists prior to dispensation between the laminate 5 and the lower edge of the discharge spout 43. A variety of welding methods may be used, such as heat and ultrasonic welding, depending on the material characteristics of the laminate 5.

Advantageously, the inner member 3 spans between the outer member 2 and the laminate 5. The inner member 3 is formed from a material of relative rigidity, such as polypropylene. As such, the inner member 3 forms a load-bearing member that acts to keep the laminate 5 and outer member 2 spaced apart when the cartridge 1 is compressed. It is preferred that the cartridge 1 is subjected to a compressive load of between 130 and 280N in use. The compressive force acts to prevent the cartridge failing under internal pressurisation and also serves to squeeze the inner member 3 and outer member 2 together. This ensures that the internal dimensions of passageways and apertures in the cartridge 1 are fixed and unable to change during pressurisation of the cartridge 1.

To use the cartridge 1 it is first inserted into a beverage preparation machine and the inlet 121 and outlet 122 are opened by piercing members of the beverage preparation machine which perforate and fold back the

laminate 5. An aqueous medium, typically water, under pressure enters the cartridge 1 through the inlet 121 into the inlet chamber 26 at a pressure of between 0.1-2.0 bar. From there the water is directed to flow through the slots 30 and round the manifold 16 and into the filtration chamber 130 of the cartridge 1 through the plurality of slots 17. The water is forced radially inwardly through the filtration chamber 130 and mixes with the beverage ingredients 200 contained therein. The water is at the same time forced upwardly through the beverage ingredients. The beverage formed by passage of the water through the beverage ingredients passes through the filter 4 and filtration apertures 55 into the passages 57 lying above the annular frame 41. The sealing of the filter 4 onto the spokes 53 and the welding of the rim 51 with the outer member 2 ensures that there are no short-circuits and all the beverage has to pass through the filter 4.

The beverage then flows downwardly along the radial passages 57 formed between the webs 54 and through the openings 56 and into the cylindrical funnel 40. The beverage passes along the channels 50 between the support webs 47 and down the discharge spout 43 to the outlet 44 where the beverage is discharged into a receptacle such as a cup.

Preferably, the beverage preparation machine comprises an air purge facility, wherein compressed air is forced through the cartridge 1 at the end of the operating cycle to flush out the remaining beverage into the receptacle.

A second version of cartridge 1 will now be described for background purposes with reference to Figures 12 to 18. The second version of the cartridge 1 is particularly designed for use in dispensing espresso-style products such

as roast and ground coffee where it is desirable to produce a beverage having a froth of tiny bubbles known as a crema. Many of the features of the second version of the cartridge 1 are the same as in the first version and like numerals have been used to reference like features. In the following description the differences between the first and second versions will be discussed. Common features which function in the same manner will not be discussed in detail.

The outer member 2 is of the same construction as in the first version of cartridge 1 and as shown in Figures 1 to 6.

The annular frame 41 of the inner member 3 is the same as in the first version. Also, a filter 4 is disposed on the annular frame 41 so as to cover the filtration apertures 55. The outer tube 42 of the cylindrical funnel 40 is also as before. However, there are a number of differences in the construction of the inner member 2 of the second version compared to the first version. As shown in Figure 16, the discharge spout 43 is provided with a partition 65 which extends part way up the discharge spout 43 from the outlet 44. The partition 65 helps to prevent the beverage spraying and/or splashing as it exits the discharge spout 43. The profile of the discharge spout 43 is also different and comprises a stepped profile with a distinct dog-leg 66 near an upper end of the tube 43.

A rim 67 is provided upstanding from the annular flange 47 joining the outer tube 42 to the discharge spout 43. The rim 67 surrounds the inlet 45 to the discharge spout 43 and defines an annular channel 69 between the rim 67 and the upper portion of the outer tube 42. The rim 67 is provided with an inwardly directed shoulder 68. At one point around

the circumference of the rim 67 an aperture 70 is provided in the form of a slot which extends from an upper edge of rim 67 to a point marginally below the level of the shoulder 68 as most clearly shown in Figures 12 and 13. The slot has a width of 0.64 mm.

An air inlet 71 is provided in annular flange 47 circumferentially aligned with the aperture 70 as shown in Figures 16 and 17. The air inlet 71 comprises an aperture passing through the flange 47 so as to provide communication between a point above the flange 47 and the void space below the flange 47 between the outer tube 42 and discharge spout 43. Preferably, and as shown, the air inlet 71 comprises an upper frusto-conical portion 73 and a lower cylindrical portion 72. The air inlet 71 is typically formed by a mould tool such as a pin. The tapered profile of the air inlet 71 allows the mould tool to be more easily removed from the moulded component. The wall of the outer tube 42 in the vicinity of the air inlet 71 is shaped to form a chute 75 leading from the air inlet 71 to the inlet 45 of the discharge spout 43. As shown in Figure 17, a canted shoulder 74 is formed between the air inlet 71 and the chute 75 to ensure that the jet of beverage issuing from the slot 70 does not immediately foul on the upper surface of the flange 47 in the immediate vicinity of the air inlet 71.

The assembly procedure for the second version of cartridge 1 is similar to the assembly of the first version. However, there are certain differences. As shown in Figure 18, the third portion 21 of the cylindrical extension 18 is seated inside the support rim 67 rather than against support webs. The shoulder 32 of the cylindrical extension 18 between the second portion 20 and third portion 21 bears

against the upper edge of the support rim 67 of the inner member 3. An interface zone 124 is thus formed between the inner member 3 and the outer member 2 comprising a face seal between the cylindrical extension 18 and the support rim 67 which extends around nearly the whole circumference of the cartridge 1. The seal between the cylindrical extension 18 and the support rim 67 is not fluid-tight though since the slot 70 in the support rim 67 extends through the support rim 67 and downwardly to a point marginally below the shoulder 68. Consequently the interface fit between the cylindrical extension 18 and the support rim 67 transforms the slot 70 into an aperture 128, as most clearly shown in Figure 18, providing gas and liquid communication between the annular channel 69 and the discharge spout 43. The aperture is typically 0.64 mm wide by 0.69 mm long.

Operation of the second version of cartridge 1 to dispense a beverage is similar to the operation of the first version but with certain differences. Beverage in the radial passages 57 flows downwardly along the passages 57 formed between the webs 54 and through the openings 56 and into the annular channel 69 of the cylindrical funnel 40. From the annular channel 69 the beverage is forced under pressure through the aperture 128 by the back pressure of beverage collecting in the filtration chamber 130 and passages 57. The beverage is thus forced through aperture 128 as a jet and into an expansion chamber formed by the upper end of the discharge spout 43. As shown in Figure 18, the jet of beverage passes directly over the air inlet 71. As the beverage enters the discharge spout 43 the pressure of the beverage jet drops. As a result air is entrained into the beverage stream in the form of a multitude of small air

bubbles as the air is drawn up through the air inlet 71. The jet of beverage issuing from the aperture 128 is funnelled downwards to the outlet 44 where the beverage is discharged into a receptacle such as a cup where the air bubbles form the desired crema. Thus, the aperture 128 and the air inlet 71 together form an eductor which acts to entrain air into the beverage. Flow of beverage into the eductor should be kept as smooth as possible to reduce pressure losses. Advantageously, the walls of the eductor should be made concave to reduce losses due to 'wall effect' friction. The dimensional tolerance of the aperture 128 is small. Preferably the aperture size is fixed plus or minus 0.02 mm^2. Hairs, fibrils or other surface irregularities can be provided within or at the exit of the eductor to increase the effective cross-sectional area which has been found to increase the degree of air entrainment.

A third version of cartridge 1 will now be described for background purposes and is shown in Figures 19 to 29. The third version of the cartridge 1 is particularly designed for use in dispensing soluble products which may be in powdered, liquid, syrup, gel or similar form. The soluble product is dissolved by or forms a suspension in, an aqueous medium such as water when the aqueous medium is passed, in use, through the cartridge 1. Examples of beverages include chocolate, coffee, milk, tea, soup or other rehydratable or aqueous-soluble products. Many of the features of the third version of the cartridge 1 are the same as in the previous versions and like numerals have been used to reference like features. In the following description the differences between the third and previous versions will be discussed.

Common features which function in the same manner will not be discussed in detail.

Compared to the outer member 2 of the previous versions, the hollow inwardly directed cylindrical extension 18 of the outer member 2 of the third version has a larger overall diameter as shown in Figure 20. In particular the diameter of the first portion 19 is typically between 16 and 18 mm compared to 13.2 mm for the outer member 2 of the previous versions. In addition, the first portion 19 is provided with a convex outer surface 19a, or bulge, as most clearly shown in Figure 20, the function of which will be described below. The diameter of the third portions 21 of the cartridges 1 are however the same resulting in the area of the shoulder 32 being greater in this, the third version of the cartridge 1. Typically the volume of the cartridge 1 when assembled is 32.5 ml ±20%.

The number and positioning of the slots in the lower end of the annular wall 13 is also different. Between 3 and 5 slots are provided. In the embodiment as shown in Figure 23, four slots 36 are provided equi-spaced around the circumference of the manifold 16. The slots 36 are slightly wider than in the previous versions of the cartridge 1 being between 0.35 and 0.45 mm, preferably 0.4 mm wide.

In other respects the outer members 2 of the cartridges 1 are the same.

The construction of the cylindrical funnel 40 of the inner member 3 is the same as in the first version of cartridge 1 with an outer tube 42, discharge spout 45, annular flange 47 and support webs 49 being provided. The only difference is that the discharge spout 45 is shaped

with an upper frusto-conical section 92 and a lower cylindrical section 93.

In contrast to the previous versions and as shown in Figures 24 to 28, the annular frame 41 is replaced by a skirt portion 80 which surrounds the cylindrical funnel 40 and is joined thereto by means of eight radial struts 87 which adjoin the cylindrical funnel 40 at or near the annular flange 47. A cylindrical extension 81 of the skirt portion 80 extends upwardly from the struts 87 to define a chamber 90 with an open upper face. An upper rim 91 of the cylindrical extension 81 has an in-turned profile as shown in Figure 26. An annular wall 82 of the skirt portion 80 extends downwardly from the struts 87 to define an annular channel 86 between the skirt portion 80 and the outer tube 42.

The annular wall 82 comprises at a lower end an exterior flange 83 which lies perpendicular to the major axis X. A rim 84 depends downwardly from a lower surface of the flange 83 and contains five apertures 85 which are circumferentially equi-spaced around the rim 84. Thus, the rim 84 is provided with a castellated lower profile.

Apertures 89 are provided between the struts 87 allowing communication between the chamber 90 and the annular channel 86.

The assembly procedure for the third version of cartridge 1 is similar to the assembly of the first version but with certain differences. The outer member 2 and inner member 3 are push-fitted together as shown in Figure 29 and retained by means of a snap-fit arrangement rather than welded together. On joining the two members the inwardly directed cylindrical extension 18 is received inside the

upper cylindrical extension 81 of the skirt portion 80. The inner member 3 is retained in the outer member 2 by frictional interengagement of the convex outer surface 19a of the first portion 19 of the cylindrical extension 18 with the in-turned rim 91 of the upper cylindrical extension 81. With the inner member 3 located in the outer member 2 a mixing chamber 134 is defined located exterior to the skirt portion 80. The mixing chamber 134 contains the beverage ingredients 200 prior to dispensation. It should be noted that the four inlets 36 and the five apertures 85 are staggered circumferentially with respect to one another. The radial location of the two parts relative to each other need not be determined or fixed during assembly since the use of four inlets 36 and five apertures 85 ensures that misalignment occurs between the inlets and apertures whatever the relative rotational positioning of the components.

The one or more beverage ingredients are packed into the mixing chamber 134 of the cartridge. The density of packing of the beverage ingredients in the mixing chamber 134 can be varied as desired.

The laminate 5 is then affixed to the outer member 2 and inner member 3 in the same manner as described above in the previous versions.

In use, water enters the mixing chamber 134 through the four slots 36 in the same manner as previous versions of the cartridge. The water is forced radially inwardly through the mixing chamber and mixes with the beverage ingredients contained therein. The product is dissolved or mixed in the water and forms the beverage in the mixing chamber 134 and is then driven though the apertures 85 into the annular

channel 86 by back pressure of beverage and water in the mixing chamber 134. The circumferential staggering of the four inlet slots 36 and the five apertures 85 ensures that jets of water are not able to pass radially directly from the inlet slots 36 to the apertures 85 without first circulating within the mixing chamber 134. In this way the degree and consistency of dissolution or mixing of the product is significantly increased. The beverage is forced upwardly in the annular channel 86, through the apertures 89 between the struts 87 and into the chamber 90. The beverage passes from chamber 90 through the inlets 45 between the support webs 49 into the discharge spout 43 and towards the outlet 44 where the beverage is discharged into a receptacle such as a cup. The cartridge finds particular application with beverage ingredients in the form of viscous liquids or gels. In one application a liquid chocolate ingredient is contained in the cartridge 1 with a viscosity of between 1700 and 3900mPa at ambient temperature and between 5000 and 10000mPa at 0°C and a refractive solids of 67 Brix ±3. In another application liquid coffee is contained in the cartridge 1 with a viscosity of between 70 and 2000mPa at ambient and between 80 and 5000mPa at 0°C where the coffee has a total solids level of between 40 and 70%. The liquid coffee ingredient may contain between 0.1 and 2.0% by weight sodium bicarbonate, preferably between 0.5 and 1.0% by weight. The sodium bicarbonate acts to maintain the pH level of the coffee at or below 4.8 enabling a shelf-life for coffee-filled cartridges of up to 12 months.

A fourth version of cartridge 1 embodying the present invention is shown in Figures 30 to 34. The fourth version of the cartridge 1 is particularly designed for use in

dispensing liquid products such as concentrated liquid milk. Many of the features of the fourth version of the cartridge 1 are the same as in the previous versions and like numerals have been used to reference like features. In the following description the differences between the fourth and previous versions will be discussed. Common features which function in the same manner will not be discussed in detail.

The outer member 2 is the same as in the third version of cartridge 1 and as shown in Figures 19 to 23.

The cylindrical funnel 40 of the inner member 3 is similar to that shown in the second version of cartridge 1 but with certain differences. As shown in Figure 30 the discharge spout 43 is shaped with an upper frusto-conical section 106 and a lower cylindrical section 107. Three axial ribs 105 are provided on the inner surface of the discharge spout 43 to direct the dispensed beverage downwards towards the outlet 44 and prevent the discharged beverage from spinning within the spout. Consequently, the ribs 105 act as baffles. As in the second version of cartridge 1, an air inlet 71 is provided through the annular flange 47. However, the chute 75 beneath the air inlet 71 is more elongated than in the second version.

A skirt portion 80 is provided similar to that shown in the third version of the cartridge 1 described above. Between 5 and 12 apertures 85 are provided in the rim 84. Typically ten apertures are provided rather than the five provided in the third version of cartridge 1.

An annular bowl 100 is provided extending from and integral with the flange 83 of the skirt portion 80. The annular bowl 100 comprises a flared body 101 with an open upper mouth 104 which is directed upwards. Four feed

apertures 103 shown in Figures 30 and 31 are located in the body 101 at or near the lower end of the bowl 100 where it joins the skirt portion 80. Preferably, the feed apertures are equi-spaced around the circumference of the bowl 100. The bowl 100 joins the skirt portion 80 part-way up its length such that a discrete gap is provided between the bowl 100 and the laminate 5 when the cartridge is assembled. Thus, the apertures 85 are located below the level of the bowl 100. As can be seen from Figure 34, when the cartridge 1 is assembled and filled the bowl 100 contains a proportion of the liquid beverage ingredients therein, effectively partitioning that proportion of the beverage ingredients from the apertures 85.

The laminate 5 is of the type described above in the previous embodiments.

The assembly procedure for the fourth version of cartridge 1 is the same as that for the third version.

Operation of the fourth version of cartridge is similar to that of the third version. The water enters the cartridge 1 and the mixing chamber 134 in the same manner as before. There the water mixes with and dilutes the liquid product which is then forced out below the bowl 100 and through the apertures 85 towards the outlet 44 as described above. The proportion of the liquid product initially contained within the annular bowl 100 as shown in Figure 34 is not subject to immediate dilution by the water entering the mixing chamber 134. Rather, the diluted liquid product in the lower part of the mixing chamber 134 will tend to exit through apertures 85 rather than be forced up and into the annular bowl 100 through upper mouth 104. Consequently, the liquid product in the annular bowl 100 will remain

relatively concentrated during the initial stages of the operating cycle compared to the product in the lower part of the mixing chamber 134. The liquid product in the annular bowl 100 drips through the feed apertures 103 under gravity into the stream of product exiting the mixing chamber 134 through the apertures 85 and below the bowl 100. The annular bowl 100 acts to even out the concentration of the diluted liquid product entering the cylindrical funnel 40 by holding back a proportion of the concentrated liquid product and releasing it into the exiting liquid stream flow path steadily throughout the operating cycle as illustrated in Figure 46a where the concentration of the milk measured as a percentage of the total solids present is shown during an operating cycle of approximately 15 seconds. Line a illustrates the concentration profile with the bowl 100 whilst line b illustrates a cartridge without the bowl 100. As can be seen the concentration profile with the cup 100 is more even during the operating cycle and there is no immediate large drop in concentration as occurs without the bowl 100. The initial concentration of the milk is typically 30-35% SS and at the end of the cycle 10% SS. This results in a dilution ratio of around 3 to 1, although dilution ratios of between 1 to 1 and 6 to 1 are possible with the present invention. For other liquid beverage ingredients the concentrations may vary. For example for liquid chocolate the initial concentration is approximately 67% SS and at the end of the cycle 12-15% SS. This results in a dilution ratio (ratio of aqueous medium to beverage ingredient in dispensed beverage) of around 5 to 1, although dilution ratios of between 2 to 1 and 10 to 1 are possible with the present invention. For liquid coffee the initial concentration is

between 40-67% and the concentration at the end of dispense 1-2% SS. This results in a dilution ratio of between 20 to 1 and 70 to 1, although dilution ratios of between 10 to 1 and 100 to 1 are possible with the present invention.

From the annular channel 86 the beverage is forced under pressure through the aperture 128 by the back pressure of beverage collecting in the filtration chamber 134 and chamber 90. The beverage is thus forced through aperture 128 as a jet and into an expansion chamber formed by the upper end of the discharge spout 43. As shown in Figure 34, the jet of beverage passes directly over the air inlet 71. As the beverage enters the discharge spout 43 the pressure of the beverage jet drops. As a result air is entrained into the beverage stream in the form of a multitude of small air bubbles as the air is drawn up through the air inlet 71. The jet of beverage issuing from the aperture 128 is funnelled downwards to the outlet 44 where the beverage is discharged into a receptacle such as a cup where the air bubbles form the desired frothy appearance.

Advantageously, the inner member 3, outer member 2, laminate 5 and filter 4 can all be readily sterilised due to the components being separable and not individually comprising tortuous passageways or narrow crevices. Rather, it is only after conjoining the components, after sterilisation, that the necessary passageways are formed. This is particularly important where the beverage ingredient is a dairy-based product such as liquid milk concentrate.

The fourth embodiment of beverage cartridge is particularly advantageous for dispensing a concentrated dairy-based liquid product such as liquid milk. Previously, powdered milk products have been provided in the form of

sachets for adding to a pre-prepared beverage. However, for a cappuccino-style beverage it is necessary to foam the milk. This has been achieved previously by passing steam through a liquid milk product. However this necessitates the provision of a steam supply which increases the cost and complexity of the machine used to dispense the beverage. The use of steam also increases the risk of injury during operation of the cartridge. Accordingly the present invention provides for a beverage cartridge having a concentrated dairy-based liquid product therein. It has been found that by concentrating the milk product a greater amount of foam can be produced for a particular volume of milk when compared to fresh or UHT milk. This reduces the size required for the milk cartridge. Fresh semi-skimmed milk contains approximately 1.6% fat and 10% total solids. The concentrated liquid milk preparations of the present invention contain between 0.1 and 12% fat and 25 to 40% total solids. In a typical example, the preparation contains 4% fat and 30% total solids. The concentrated milk preparations are suitable for foaming using a low pressure preparation machine as will be described below. In particular, foaming of the milk is achieved at pressures below 2 bar, preferably approximately 1.5 bar using the cartridge of the fourth embodiment described above.

The foaming of the concentrated milk is particularly advantageous for beverages such as cappuccinos and milk shakes. Preferably the passing of the milk through the aperture 128 and over the air inlet 71 and the optional use of the bowl 100 enables foaming levels of greater than 40%, preferably greater than 70% for milk. For liquid chocolate foaming levels of greater than 70% are possible. For liquid

coffee foaming levels of greater than 70% are possible. The foamability level is measured as the ratio of the volume of the foam produced to the volume of liquid beverage ingredient dispensed. For example, where 138.3ml of beverage is dispensed, of which 58.3ml is foam the foamability is measured as [58.3/(138.3-58.3)]*100 = 72.9%. The foamability of the milk (and other liquid ingredients) is enhanced by the provision of the bowl 100 as can be seen in Figure 46b. The foamability of the milk dispensed with the bowl 100 present (line a) is greater than that of milk dispensed without the bowl present (line b). This is because the foamability of the milk is positively correlated to the concentration of the milk and as shown in Figure 35a the bowl 100 maintains a higher concentration of the milk a larger part of the operating cycle. It is also known that foamability of the milk is positively correlated to temperature of the aqueous medium as shown in Figure 46c. Thus the bowl 100 is advantageous since more of the milk remains in the cartridge until near the end of the operating cycle when the aqueous medium is at its hottest. This again improves foamability.

The cartridge of the fourth embodiment is also advantageous in dispensing liquid coffee products.

It has been found that the embodiments of beverage cartridge of the present invention advantageously provide an improved consistency of the brewed beverage when compared to prior art cartridges. Reference is made to Table 1 below which shows the results of brew yields for twenty samples each of cartridges A and B containing roast and ground coffee. Cartridge A is a beverage cartridge according to the first embodiment of the present invention. Cartridge B is a

prior art beverage cartridge as described in the applicant's document WO01/58786. The refractive index of the brewed beverage is measured in Brix units and converted to a percentage of soluble solids (%SS) using standard tables and formulae. In the examples below:

%SS = 0.7774 * (Brix value) + 0.0569.

% Yield = (%SS * Brew Volume (g))/
(100 * Coffee Weight (g))

Table 1

CARTRIDGE A

Sample	Brew Volume (g)	Coffee Weight (g)	Brix	% SS (°)	% Yield
1	105.6	6.5	1.58	1.29	20.88
2	104.24	6.5	1.64	1.33	21.36
3	100.95	6.5	1.67	1.36	21.05
4	102.23	6.5	1.71	1.39	21.80
5	100.49	6.5	1.73	1.40	21.67
6	107.54	6.5	1.59	1.29	21.39
7	102.70	6.5	1.67	1.36	21.41
8	97.77	6.5	1.86	1.50	22.61
9	97.82	6.5	1.7	1.38	20.75
10	97.83	6.5	1.67	1.36	20.40
11	97.6	6.5	1.78	1.44	21.63
12	106.64	6.5	1.61	1.31	21.47
13	99.26	6.5	1.54	1.25	19.15
14	97.29	6.5	1.59	1.29	19.35
15	101.54	6.5	1.51	1.23	19.23
16	104.23	6.5	1.61	1.31	20.98
17	97.5	6.5	1.73	1.40	21.03
18	100.83	6.5	1.68	1.36	21.14
19	101.67	6.5	1.67	1.36	21.20
20	101.32	6.5	1.68	1.36	21.24
				AVERAGE	20.99

CARTRIDGE B

Sample	Brew Volume (g)	Coffee Weight (g)	Brix	% SS (*)	% Yield
1	100.65	6.5	1.87	1.511	23.39
2	95.85	6.5	1.86	1.503	22.16
3	98.4	6.5	1.8	1.456	22.04
4	92.43	6.5	2.3	1.845	26.23
5	100.26	6.5	1.72	1.394	21.50
6	98.05	6.5	2.05	1.651	24.90
7	99.49	6.5	1.96	1.581	24.18
8	95.62	6.5	2.3	1.845	27.14
9	94.28	6.5	2.17	1.744	25.29
10	96.13	6.5	1.72	1.394	20.62
11	96.86	6.5	1.81	1.464	21.82
12	94.03	6.5	2.2	1.767	25.56
13	96.26	6.5	1.78	1.441	21.34
14	95.85	6.5	1.95	1.573	23.19
15	95.36	6.5	1.88	1.518	22.28
16	92.73	6.5	1.89	1.526	21.77
17	88	6.5	1.59	1.293	17.50
18	93.5	6.5	2.08	1.674	24.08
19	100.88	6.5	1.75	1.417	22.00
20	84.77	6.5	2.37	1.899	24.77
				AVERAGE	23.09

Performing a t-test statistical analysis on the above data gives the following results:

Table 2

t-Test: Two-Sample Assuming Equal Variances

	% Yield (Cartridge A)	*% Yield (Cartridge B)*
Mean	20.99	23.09
Variance	0.77	5.04
Observations	20	20
Pooled Variance	2.90	
Hypothesized Mean Difference	0	
df	38	
t Stat	-3.90	
P(T<=t) one-tail	0.000188	

t Critical one-tail	1.686	
P(T<=t) two-tail	0.000376	
t Critical two-tail	2.0244	
Standard Deviation	0.876	2.245

The analysis shows that the consistency of % yield, which equates to brew strength, for the cartridges of the present invention is significantly better (at a 95% confidence level) than the prior art cartridges, with a standard deviation of 0.88% compared to 2.24%. This means that beverages brewed with the cartridges of the present invention have a more repeatable and uniform strength. This is preferred by consumers who like their drinks to taste the same time after time and do not want arbitrary changes in brew strength.

The materials of the cartridges described above may be provided with a barrier coating to improve their resistance to oxygen and/or moisture and/or other contaminant ingress. The barrier coating may also improve the resistance to leakage of the beverage ingredients from within the cartridges and/or reduce the degree of leaching of extractibles from the cartridge materials which might adversely affect the beverage ingredients. The barrier coating may be of a material selected from the group of PET, Polyamide, EVOH, PVDC or a metallised material. The barrier coating may be applied by a number of mechanisms including but not limited to vapour deposition, vacuum deposition, plasma coating, co-extrusion, in-mould labelling and two/multi-stage moulding.

A beverage preparation machine 201 for use with the present invention for use with the above described beverage cartridges is shown in Figures 35 to 45. The beverage

preparation machine 201 generally comprises a housing 210 containing a water tank 220, a water heater 225, a water pump 230, an air compressor 235, a control processor, a user interface 240 and a cartridge head 250. The cartridge head 250 in turn generally comprises a cartridge holder 251 for holding, in use, the beverage cartridge 1, cartridge recognition means 252 and inlet and outlet piercers 253, 254 for forming, in use, the inlet 121 and the outlet 122 in the beverage cartridge 1.

The housing 210 contains and holds in position the other components of the machine 201. The housing 210 preferably made in whole or in part from a robust plastics material such as ABS. Alternatively, the housing 210 can be made in whole or in part from a metallic material such as stainless steel or aluminium. The housing 210 is preferably comprises a clam-shell design having a front half 211 and a rear half 212 which allow access during assembly for fitting of the machine 201 components and can afterwards be joined together to define an interior 213 of the housing 210. The rear half 212 provides a recess 214 for the attachment of the water tank 220. The housing 210 is formed with means, such as detents, abutments, bosses and threaded portions, for retaining the components of the machine 201 in position without the need for a separate chassis. This reduces the overall cost and weight of the machine 201. A base 215 of the housing 210 is preferably provided with feet for standing the machine thereon in a stable manner. Alternatively, the base 215 itself may have a shape forming a stable support.

The front half 211 of the housing 210 comprises a dispense station 270 where dispensation of the beverage

takes place. The dispense station 270 comprises a receptacle stand 271 having a hollow interior forming a drip tray 272. An upper surface 273 of the receptacle stand is provided with a grill 274 on which the receptacle is positioned. The drip tray 272 is removable from the housing 210 to ease emptying of the collected water. A recess 275 is formed in the front half of the housing 210 above the receptacle stand 271 to accommodate the dimensions of the receptacle.

The cartridge head 250 is located towards the top of the housing 210 above the receptacle stand as shown in Figures 35 and 36. Preferably, the height of the grill 274 relative to the cartridge head 250 can be adjusted to accommodate different sizes of receptacle. It is preferred that the receptacle is as close to the cartridge head 250 as possible, whilst still allowing the receptacle to be inserted and withdrawn from the dispense station 270, so as to minimise the height that the dispensed beverage has to descend before contacting the receptacle. This acts to minimise spraying and splashing of the beverage and minimise loss of entrained air bubbles where these are present. Preferably receptacles of between 70mm and 110 mm in height can be inserted between the grill 274 and cartridge head 250.

The machine user interface 240 is located on the front of the housing 210 and comprises a start/stop button 241, and a plurality of status indicators 243-246.

The status indicators 243-246 preferably include a light emitting diode (LED) 243 to indicate readiness of the machine 201, a LED 244 to indicate if an error has occurred in the machine 201 operation, and one or more LEDs 245-256

to indicate whether the machine 201 is operating in manual or automatic modes. The LEDs 243-246 may be controlled to illuminate at a constant intensity, to flash intermittently, or both depending on the status of the machine 201. The LEDs 243-246 may have a variety of colours including green, red and yellow.

The start/stop button 241 controls commencement of the operating cycle and is a manually operated push-button, switch or similar.

A volume adjustment control may be provided to allow a user of the machine 201 to manually adjust the volume of the delivered beverage without altering the other operating characteristics. Preferably the volume adjustment control allows an adjustment in volume of plus or minus 20%. The volume adjustment control may be a rotary knob, a linear slider, a digital readout with increment and decrement buttons, or similar. More typically, volume is controlled by a user operating the start/stop button 241.

A manual power switch (not shown) may be provided on the machine 201. Alternatively, power supply can be controlled simply by insertion or removal or the power supply plug from the mains power supply.

The water tank 220 is located to the rear of the housing 210 and is connected to the rear half 212 of the housing 210. The water tank 220 comprises a generally cylindrical body 221 which may be right circular or a frustum as desired for aesthetic reasons. The tank comprises an inlet for filling the tank with water which is closed off in use by a manually removable lid 222. An outlet is provided towards a lower end of the tank which communicates with the water pump 230. The water tank 220 may

be made from a transparent or translucent material to allow a consumer to view the quantity of water remaining in the tank. Alternatively, the water tank 220 may be made from an opaque material but have provided a viewing window therein. In addition, or in place of the above, the water tank 220 may be provided with a low level sensor which prevents operation of the water pump 230 and optionally triggers a warning indicator, such as an LED, when the water level in the tank descends to a preselected level. The water tank 220 preferably has an internal capacity of approximately 1.5 litres.

The water pump 230 is operatively connected between the water tank 220 and the water heater 225 as shown schematically in Figure 43 and is controlled by the control processor. The pump provides a maximum flow rate of 900 ml/min of water at a maximum pressure of 2.5 bar. Preferably, in normal use, the pressure will be limited to 2 bar. The flow rate of water through the machine 201 can be controlled by the control processor to be a percentage of the maximum flow rate of the pump by cycle chopping the electrical supply to the pump. Preferably the pump can be driven at any of 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% or 100% of the maximum rated flow rate. The accuracy of the volume of water pumped is preferably + or - 5% leading to a + or - 5% accuracy in the final volume of the dispensed beverage. A suitable pump is the Evolution EP8 pump produced by Ulka S.r.l. (Pavia, Italy). A volumetric flow sensor (not shown) is preferably provided in the flow line either upstream or downstream of the water pump 230. Preferably, the volumetric flow sensor is a rotary sensor.

The water heater 225 is located in the interior of the housing 210. The heater 225 has a power rating of 1550 W and is able to heat water received from the water pump 230 from a starting temperature of approximately 20 °C to an operating temperature of around 85 °C in under 1 minute. Preferably the dwell time between the end of one operating cycle and the heater 225 being able to commence a subsequent operating cycle is less than 10 seconds. The heater maintains the selected temperature to within + or - 2 °C during the operating cycle. As discussed below, the water for the operating cycle may be delivered to the cartridge head 250 at 83 °C or 93 °C. The heater 225 is able to quickly adjust the delivery temperature to either 83 °C or 93 °C from a nominal water temperature of 85 °C. The heater 225 comprises an over-temperature cut-off which shuts off the heater if the temperature exceeds 98 °C. Water output from the heater 225 is fed to the cartridge head 250 and cartridge 1 by means of a three-way valve. If the pressure of the water flow is acceptable the water is passed to the cartridge 1. If the pressure is below or above predetermined limits then the water is diverted by means of the three-way valve into the drip tray recovery receptacle 270.

The air compressor 235 is operatively connected to the cartridge head 250 by means of a one-way valve and controlled by the control processor. The air compressor 235 provides a maximum flow rate of air of 500 ml/min at 1.0 bar. In use a working volume of 35 ml is pressurised to 2.0 bar. Preferably, the air compressor 235 can produce two flow rates: a fast (or maximum) flow rate and a slow flow rate.

The control processor of the beverage preparation machine 201 comprises a processing module and a memory. The

control processor is operatively connected to, and controls operation of, the water heater 225, water pump 230, air compressor 235 and user interface 240.

The memory of the control processor includes one or more variables for one or more operational parameters for the beverage preparation machine 201. In the illustrated embodiment the operational parameters are the temperature of the water passed through the beverage cartridge 1 during the operating stage, the speed of charging the beverage cartridge 1, the presence or otherwise of a soak step, the total dispensed volume of the beverage, the flow rate of the water during the discharge stage, and the flow rate and period of the purge stage.

The variables for the operational parameters are stored in the memory. The cartridge 1 comprises a code provided on or in the cartridge 1 representing the operational parameters required for optimal dispensation of the beverage in that cartridge 1. The code is in binary format and comprises a plurality of data bits corresponding to the variables stored in the control processor memory. Table 3 illustrates how 13 bits of data can be used to represent the necessary variables for the operational parameters described above.

Table 3

Bit	Parameter	Description
0 & 1	Water temperature	00 = cold 01 = warm 10 = 83 °C 11 = 93 °C
2 & 3	Cartridge charge	00 = fast charge with soak 01 = fast charge without soak

		10 = slow charge with soak 11 = slow charge without soak
4, 5, 6 & 7	Beverage volume	0000 = 50 ml 0001 = 60 ml 0010 = 70 ml 0011 = 80 ml 0100 = 90 ml 0101 = 100 ml 0110 = 110 ml 0111 = 130 ml 1000 = 150 ml 1001 = 170 ml 1010 = 190 ml 1011 = 210 ml 1100 = 230 ml 1101 = 250 ml 1110 = 275 ml 1111 = 300 ml
8, 9 & 10	Flow rate	000 = 30% 001 = 40% 010 = 50% 011 = 60% 100 = 70% 101 = 80% 110 = 90% 111 = 100%
11 &12	Purge	00 = slow flow/short period 01 = slow flow/long period 10 = fast flow/short period 11 = fast flow/long period

The code on or in the cartridge 1 will normally comprises one or more extra data bits for error checking. In one example a 16 bit code is provided. For example, using the variables listed in Table 3, a cartridge 1 bearing the

code "1000100011110" would have the following operational parameters:

10	Water temperature of 83 °C
00	Fast charge with soak
1000	Dispensed drink volume of 150ml
111	Flow rate equals 100%
10	Fast air flow purge/short period.

Thus, unlike in previous beverage preparation machines, the memory of the control processor does not store operational instructions for beverage cartridges based on the cartridge type, i.e. instructions for a coffee cartridge, instructions for a chocolate cartridge, instructions for a tea cartridge etc. Instead the memory of the control processor stores variables for adjusting the individual operational parameters of the operating cycle. This has a number of advantages. Firstly, a greater degree of control of the dispensation cycle can be exercised. For example, slightly different operational parameters can be used for different grades or blends of coffee rather than using the same parameters for all types of coffee. Prior coding solutions relying on storing instructions by cartridge type rather than by individual parameters are unsuited to such subtle differences in operating cycles for similar beverage types because they quickly consume the available storage space in the coding medium and control processor. Secondly, the coding method of the present invention allows for new beverage cartridge types to be used in pre-existing beverage preparation machines even where the operational parameters for the operating cycle for the new beverage cartridge 1 are only decided upon after sale of the beverage preparation machine 201. This is because the

control processor of the beverage preparation machine 201 does not need to recognise that the beverage is of a new type. Rather the operational parameters of the operating cycle are set without direct reference to the beverage type. Hence the coding method of the present invention provides excellent backward compatibility of the beverage preparation machines for new beverage types. In contrast, with prior machines, the manufacturer is restricted to dispensing a new beverage type using one of the pre-existing dispensation cycles as determined by the in-market machines.

The cartridge head 250 is shown in Figures 39 to 42. The cartridge holder 251 of the cartridge head 250 comprises a fixed lower part 255, a rotatable upper part 256 and a pivotable cartridge mount 257 positioned inbetween the fixed lower part 255 and the rotatable upper part 256. The upper part 256, lower part 255 and cartridge mount 257 are rotated about a common hinge axis 258. Figures 39 to 42 show the cartridge holder 251 with some components of the machine 201 omitted for clarity.

The rotatable upper part 256 and pivotable cartridge mount 257 are moved relative to the fixed lower part 255 by means of a clamping mechanism 280. The clamping mechanism 280 comprises a clamping lever having first and second members or parts 281 and 282. The first part 281 of the clamping lever comprises a U-shaped arm which is pivotably mounted to the upper part 256 at two first pivot points 283, one on each side of the cartridge holder 251.

The second part of the clamping lever comprises two over-centre arms 282, one on each side of the cartridge holder 251 which are each pivotably mounted to the upper part 256 at a second pivot point 285 located on the hinge

axis 258 coupling the upper part 256 to the fixed lower part 255. Each over-centre arm 282 is a reciprocal member comprising a cylinder 282a, a stem 282b and a resilient sleeve 282c. The cylinder 282a has an internal bore and is rotatably mounted at one end at the hinge axis 258. A first end of the stem 282b is slidingly received in the bore of the cylinder 282a. The opposite end of the stem 282b is rotatably mounted to the U-shaped arm 281 at a third pivot point 286. The third pivot points 286 are unconnected to, and freely moveable relative to, the upper part 256 and lower part 255. The resilient sleeve 282c is mounted externally on the stem 282b and extends, in use, between abutment surfaces on the cylinder 282a and stem 282b. The resilient sleeve 282c accommodates shortening of the over-centre arm 282 but biases the over-centre arm 282 into an extended configuration. Movement of the third pivot points 286 towards and away from the hinge axis 258 is thus possible by relative movement of the stems 282b in the cylinders 282a. The resilient sleeves 282c are preferably formed from silicone.

The U-shaped arm 281 extends around the front of the cartridge holder 251 and comprises two downwardly dependant hook members 287, one on each side of the cartridge holder 251, each comprising a cam surface 288 facing the hinge axis 258. The fixed lower part 255 of the cartridge holder 251 is provided with two bosses 259, or detents, located one on each side of the lower part 255 at or near a front edge 260 thereof aligned generally with the hook members 287.

As shown in Figure 39, the U-shaped arm 281 may be formed from a one piece plastics moulding comprising an

ergonomic hand grip and the hook members 287 integral to the arm.

The cartridge mount 257 is rotatably mounted between the upper and lower parts 255, 256 of the cartridge holder 251. The mount 257 is provided with a substantially circular recess 290 which receives in use the beverage cartridge 1. The recess 290 includes an irregularity 291 for accommodating the handle portion 24 of the beverage cartridge 1 which also acts to prevent rotation of the beverage cartridge 1 in the cartridge holder 251. The cartridge mount 257 is sprung relative to the fixed lower part 255 such that in the open position, as shown in Figure 41, the cartridge mount 257 is biased out of contact with the fixed lower part 255 so that the cartridge mount 257 is moved out of contact with the outlet and inlet piercer members 254, 253. The cartridge mount 257 is provided with an aperture 292 for receiving therethrough the inlet and outlet piercers 253, 254 and a head 300 of the cartridge recognition means 252 when the cartridge mount 257 is moved into the closed position.

The upper part 255 comprises a generally circular body 310 housing a circular viewing window 312 through which a consumer can view the beverage cartridge 1 during an operating cycle and also visually confirm whether a cartridge 1 is loaded in the machine 201. The viewing window 312 is cup-shaped having a downwardly directed rim 311 which engages and grips the flange 35 of the beverage cartridge 1 against the lower part 256 when the cartridge holder 251 is closed. At the same time the window 312 contacts the closed top 11 of the cartridge 1. A wave spring (not shown) is positioned between the viewing window 312 and the circular

body 310 to enable the viewing window 312 to move axially relative to the circular body 310 by a small degree. The pressure exerted by the rim 311 on the flange 35 and by the window 312 on the closed top 11 ensures a fluid tight seal between the cartridge 1 and the cartridge holder 251.

The lower part 255 comprises the inlet and outlet piercers 253, 254 and the head 300 of the cartridge recognition means 252. The inlet piercer 253 comprises a hollow needle-like tube 260 having a sharpened end 261 for perforating the laminate 5 of the beverage cartridge 1 in use. The inlet piercer 253 is in fluid communication with a water conduit 262 as shown in Figure 42 which passes through the lower part 255 and is connected to an outlet conduit 263 of the water heater 225. The outlet piercer 254 is similar in type to the outlet piercer described in the applicant's European patents EP 0 389 141 and EP 0 334 572 and comprises an open ended cylinder 264 of circular or D-shaped cross-section having dimensions larger than the discharge spout 43. An arcuate portion 265 of the upper end of the outlet piercer 254 is serrated to pierce and eventually cut the laminate of the beverage cartridge 1. The remainder of the upper end is cut back longitudinally of the cylinder at least to the base of the teeth 266 of the serrated portion to fold or pull the cut laminate 5 away from the outlet aperture before the beverage is dispensed therethrough. The outlet piercer 254 pierces the laminate 5 externally of the discharge spout 43 and when the cartridge mount 257 is in the closed position, rests in the annulus between the discharge spout 43 and the outer wall 42 of the discharge funnel 40. The outlet piercer 254 folds back the cut laminate 105 into the annulus. Thereby both the outlet

piercer 254 and the cut laminate 105 are held out of the way of the discharged beverage.

The outlet piercer 254 is surrounded by a ledge 254a which is raised relative to its surroundings by 0.5mm.

Advantageously, the outlet piercer 254 is removable from the lower part 255 to enable it to be thoroughly cleaned, for example, in a dishwasher. The removable outlet piercer 254 is received in a recess 267 in the lower part 255 where it is seated. The inlet piercer 253 and/or the outlet piercer 254 may be made of a metal, such as stainless steel, or from a plastics material. Advantageously, the use of plastic cutting elements is enabled by use of a laminate 5 which is able to be punctured and cut by a non-metallic material. Consequently, the piercers 253, 254 can be made less sharp which lowers the risk of injury to the consumer. In addition, plastic piercing elements are not prone to rust. Preferably, the inlet piercer 253 and the outlet piercer 24 are formed as a single, integral unit which is removable from the lower part 255.

In use, the upper part 256 of the cartridge holder 251 is movable from an open position in which it is orientated vertically or towards the vertical as shown in Figure 36, to a closed position in which it is orientated substantially horizontally and in interengagement with the fixed lower part 255 and cartridge mount 257. The upper part 256 is moved from the open to the closed positions by operation of the clamping lever. To close the upper part 256 a user takes hold of the clamping lever by the U-shaped arm 281 and pulls downwards. Consequently, the upper part 256 rotates which first brings the rim 311 of the viewing window 312 into contact with the flange 35 of the beverage cartridge 1 in

the cartridge mount 257 and the window 312 itself into contact with the closed top 11 of the cartridge 1. Continued rotation of the upper part 256 rotates the upper part 256 and cartridge mount 257 down into contact with the lower part 255. Further rotation of the U-shaped arm 281 causes the U-shaped arm 281 to rotate relative to the upper part 256 and the lower part 255 resulting in the hook members 287 of the upper part 256 engaging the bosses 259 of the lower part 255 with the cam surface 288 riding over the bosses 259. During this last stage of rotation the cartridge 1 is compressed between the cartridge mount 257 and the viewing window 312. As a result, the viewing window 312 is moved axially relative to the circular body 310 of the upper part 256 against the bias of the wave spring. This movement allows for a take up of tolerances in the beverage cartridge 1 and beverage preparation machine and ensures that the amount of compressive force applied to the cartridge is kept within an acceptable range. The clamping force of the mechanism as moderated by the action of the wave spring ensures a clamping pressure on the cartridge of between 130 and 280N. Preferably the force is approximately 200N. A force less than about 130N does not provide an adequate seal, whilst a force greater than about 280N leads to plastic failure of the components of the cartridge 1. During closure of the cartridge head the laminate 5 of the cartridge 1 is tensioned as it is brought into contact with the ledge 254a surrounding the outlet piercer 254 which causes the laminate 5 to flex out of plane as the distal end of the outer tube 42 of the cylindrical funnel is moved upwardly by 0.5mm relative to the flange 35. This movement also ensures that the great majority of the compressive

force applied to the cartridge acts through the central region of the cartridge 1 through the load-bearing inner member 3. In the closed position the cartridge 1 is thus clamped around the flange 35 by means of the rim 311 of the viewing window 312 and firmly clamped between the closed top 11 of the cartridge and the outer tube 42 of the inner member 3 by contact with the viewing window 312 and the ledge 254a. These clamping forces help prevent failure of the cartridge 1 during pressurisation and also ensure that the inner member 3 and outer member 2 are fully seated relative to one another and thus that all internal passageways and apertures remain at their intended dimensions even during internal pressurisation.

An imaginary datum line can be drawn between the first and second pivot points 283, 285 of the cartridge holder 251. As can be seen in Figure 41, in the open position the third pivot points 286 are located on the side of the datum line nearest the fixed lower part 255. As the upper part 256 reaches the closed position, the third pivot points 286 of the clamping lever pass through the datum line joining the first and second pivot points 283, 285 to the opposite side of the line, furthest from the fixed lower part 255. Consequently, the U-shaped arm 281 'snaps through' from a first stable position to a second stable position. The snap through action is accommodated by shortening of the over-centre arms 282 and consequential compression of the resilient sleeves 282c. Once the third pivot points 286 are past the imaginary datum line then recovery of the resilient sleeves 282c acts to continue the motion of the third pivot points 286 away from the imaginary datum line. The clamping lever thus has a bi-stable operation in that the lever is

stable in the open or closed positions but unstable at the point when the third pivot points 286 lie on the imaginary datum line joining the first and second pivot points 283, 285. Thus, the snap-through action of the clamping lever provides a positive closure mechanism which leads to a definite closure action wherein in the final stages of the clamping lever's rotation, the snap-through action of the U-shaped arm 281 and second arms 284 forces the hook members 287 firmly into engagement with the bosses 259. In addition, the resilient sleeves 282c provide a resistance to re-opening of the upper part 256 since a minimum force is required to compress the sleeves 282c sufficiently to move the third pivot points 286 back into line with the datum line joining the first and second pivot points 283, 285. Advantageously, the interengagement of the hook members 287 and the bosses 259 prevents separation of the upper and lower parts other than by rotation of the clamping lever. This is useful in preventing opening of the cartridge head 250 during operation when the cartridge head 250 is subject to internal pressurisation.

The purpose of the cartridge recognition means 252 is to allow the machine 201 to recognise the type of beverage cartridge 1 that has been inserted and to adjust one or more operational parameters accordingly. In a typical embodiment, the cartridge recognition means 252 comprises an optical barcode reader which reads a printed barcode 320 provided on the laminate 5 of the beverage cartridge 1 as shown in Figure 45. The barcode 320 is formed from a plurality of bars of contrasting colour. Preferably the bars are black on a white background to maximise the contrast. The barcode 320 is not required to conform to a published standard but a

standard format for barcodes, such as EAN-13, UPC-A, or Interleaf 2 of 5 may be used. The optical barcode reader comprises one or more LEDs 321 to illuminate the barcode 320, a focusing lens 322 to acquire an image of the barcode, a charge coupled device (CCD) 323 for producing an electrical signal representative of the acquired image and support circuitry for the LEDs and CCD. The space in the lower part for accommodating the barcode reader is limited. A mirror or mirrors 324 may be used to reflect the light from the LEDs 321 to a focussing lens which is not located in the lower part 255. Schematic arrangements are shown in Figures 44a and 44b. The lower part 255 comprises an aperture 326 which is the same size as the barcode 320 on the beverage cartridge 1. In use the electrical signals produced are decoded by signal processing software and the results forwarded to the control processor. The software can recognise whether the read of the barcode contained errors. The barcode 320 may be rescanned a number of times before an error message is presented to the consumer. If the machine 201 is unable to read the barcode the consumer is able to use the beverage cartridge 1 to dispense a beverage using a manual mode of operation.

The cartridge head 250 also includes a cartridge sensor for detecting whether a cartridge is present in the cartridge holder 251.

The cartridge head 250 also includes a lock sensor which detects whether the cartridge holder 251 is properly closed. Preferably the lock sensor comprises a micro-switch which is triggered when the cartridge holder 251 is closed and locked. Preferably the cartridge sensor and lock sensor are connected in series such that the output of both sensors

must be satisfactory, i.e. cartridge present and mechanism locked, before the operating cycle can be commenced.

Operation of the machine 201 comprises insertion of a beverage cartridge 1 into the cartridge head 250, carrying out an operating cycle in which the beverage is dispensed and removal of the cartridge 1 from the machine.

The operational behaviour of the machine 201 is determined by software embedded in the control processor. Operation of the machine can be described in terms of 'States', wherein the machine 201 will normally exist in a particular State until an event occurs to change the State, a step called a State transition.

Table 4 shows a State Transition Table which illustrates the States and State transitions for one embodiment of the beverage preparation machine 201.

Table 4

State	State Description	Temperature	Lock Sensor	Cartridge Sensor variable (OK, NOK, CLR)	Water level indicator	Water flow rate	StartStop
1	WATER HEATING	> or = 85 goto 2	Closed: [Cartridge Sensor= readpod()] Open: [Cartridge Sensor =CLR]	N/A	Low goto 10	N/A	No Action
2	WATER READY If timeout 10mins goto 9	< 85 goto 2	Closed: [Cartridge Sensor = readpod()] Open: [Cartridge Sensor =CLR]	Cartridge Sensor =OK goto 4 Cartridge Sensor =NOK goto 3	Low goto 10	N/A	No Action
3	READY TO BREW AUTO	N/A [temperature controlled in background]	Open: [Cartridge Sensor =CLR] goto 2	N/A	Low goto 10	N/A	Goto 5
4	BREW IN PROGRESS AUTO [Run Brew State] goto 7	N/A [temperature controlled in background]	Open: [Cartridge Sensor =CLR] goto 10	N/A	Low goto 10	No flow goto 10	Water off goto 6
5	BREW SUSPENDED	N/A [temperature controlled in background]	Open: [Cartridge Sensor =CLR] goto 10	N/A	Low goto 10	N/A	Goto 5
6	READY TO BREW MANUAL	N/A [temperature controlled in background]	Open: [Cartridge Sensor =CLR] goto 2	N/A	Low goto 10	N/A	[Water On] Goto 8

7	BREW IN PROGRESS MANUAL	N/A [temperature controlled in background]	Open: [Cartridge Sensor =CLR] goto 10	N/A	Low goto 10	No flow goto 10	Released goto 7
8	PURGE [Water off; air on, timeout n sec then goto 9]	N/A [temperature controlled in background]	Open: [Cartridge Sensor =CLR] goto 10	N/A	No action	N/A	No Action
9	BREW DONE [air purge] [Cartridge Sensor =CLR] if timeout 10s goto 2	N/A [temperature controlled in background]	Open goto 2	N/A	Low goto 10	N/A	Goto 9
10	STANDBY	N/A [heater off]	Open: [Cartridge Sensor =CLR] goto 1 Closed: [Cartridge Sensor = readpod()]	N/A	Low goto 10	N/A	Goto 1
11	ERROR Power off/on required to clear	N/A	N/A	N/A	N/A	N/A	N/A
12	WATER LOW				Low goto 10		

The following example illustrates an operating cycle to exemplify the use of the State Transitions by the control processor.

It is assumed that the machine 201 is initially switched off and with no cartridge 1 inserted in the cartridge head 250. When the machine 201 is switched on the control processor is in State 1. The water heater 225 is switched on. Once the temperature reaches 85 °C the control

processor transits to State 2. If at any time during State 1 or 2 the cartridge holder 251 is closed the lock sensor will be triggered to send a signal to the control processor indicating that the cartridge holder 251 is properly closed. The control processor then interrogates the cartridge sensor by sending a 'readpod' instruction. The cartridge sensor returns a signal to the control processor indicating whether a cartridge is in place in the cartridge holder 251. If no cartridge is present the control processor transits to State 3 where it remains in a readiness state until the cartridge holder 251 is reopened at which point the control processor transits back to State 2. If a cartridge is present in State 2 then the control processor transits to State 4 and operation is commenced automatically. During States 4 to 9 the water temperature is controlled in the background to remain within the required tolerance range of the desired temperature as set by the operational parameters set by the barcode on the beverage cartridge 1. Once the discharge stage of dispense is completed an air purge is commenced in State 8. Once the air purge is completed the operating cycle is completed and the machine enters to standby mode in State 10. If, during operation, an error occurs then the processor transits to State 11. If a low water level is detected then the processor transits to State 12.

To insert the cartridge 1 the cartridge holder 251 is opened as described above to expose the cartridge mount 257. The cartridge 1 is then placed on the cartridge mount 257 received within the recess 290 such that the handle 24 of the cartridge is located in the irregularity 291. The optical or magnetic barcode 320 of the cartridge 1 is orientated directly above the aperture 326 in the cartridge

mount 257. The cartridge holder 251 is then closed by operation of the clamping lever as described above. During closure the inlet and outlet piercers 253, 254 pierce the laminate 5 of the cartridge 1 to form the cartridge inlet 121 and outlet 122. As described above the laminate 5 cut by the outlet piercer 254 is folded up into the annulus surrounding the discharge spout 43. When closed the cartridge holder 251 grips the cartridge 1 around the rim 35 between the cartridge mount 257 and the upper part 256 and between the window 311 and the top 11 of the cartridge 1 to form a fluid tight seal of sufficient integrity to withstand the pressures developed during the operating cycle.

To commence the operating cycle the consumer operates the start/stop button 241.

The operating cycle comprises the steps of cartridge recognition and the discharge cycle.

Cartridge recognition is performed by the optical cartridge recognition means 252 as described above assuming that the outputs from the cartridge sensor and lock sensor are satisfactory. Once the barcode 320 has been decoded the operational parameters of the machine 201 are adjusted by the control processor. The discharge cycle is then automatically commenced.

The discharge cycle has four main stages, not all of which are used for all beverage types:

(i) Pre-wet

(ii) Pause

(iii) Brew/Mixing

(iv) Purge

In the pre-wet stage the cartridge 1 is charged with water from the water storage tank 220 by means of the water

pump 230. The charging with water causes the beverage ingredients 200 in the filtration chamber 130 to be wetted. The charging may take place at a "fast" flow rate of 600 ml/min or a "slow" flow rate of 325 ml/min. The slow charging rate is particularly useful for cartridges containing viscous liquid beverage ingredients where the ingredients require some dilution before they are able to be pumped at a higher volume flow rate. The volume of water injected into the cartridge 1 is selected to ensure that water or beverage does not drip out of the cartridge outlet 122 during this stage.

The pause stage allows the beverage ingredients 200 to soak in the water injected during the pre-wet stage for a predetermined period of time. Both the pre-wetting and soaking stages are known to increase the yield of the extractibles from the beverage ingredients 200 and to improve the end flavour of the beverage. Pre-wetting and soaking are particularly used where the beverage ingredients are roast and ground coffee.

In the brew/mixing stage water is passed through the cartridge 1 in order to produce the beverage from the beverage ingredients 200. The temperature of the water is determined by the control processor which sends instructions to the water heater 225 to heat the water passing from the water tank 220 to the cartridge head 250. Water enters the lower part 255 of the cartridge holder 251 through the conduit 262 via the inlet valve and the inlet piercer 253 into the inlet chamber 126 of the beverage cartridge 1. Brewing and/or mixing and subsequent dispensing of the beverage from the beverage cartridge 1 is as described above with reference to the versions of the beverage cartridge 1.

The air purge comprises the blowing of pressurised air through the beverage preparation machine and the beverage cartridge 1 to ensure that all beverage is dispensed and that the flow path is cleared ready for dispensing another beverage. The air purge does not commence immediately on cessation of the brew/mixing stage to allow for the majority of the fluid to clear the flow path. This prevents an unacceptable spike in internal pressure on commencement of the air purge.

In normal operation a user manually stops the machine 201 by operating the start/stop button 241.

Once the operating cycle has been completed the consumer removes the cartridge 1 by opening the cartridge holder 251 and manually removing and disposing of the cartridge. Alternatively, the machine 201 may be provided with an automatic ejection mechanism for removing the cartridge automatically on opening the cartridge holder 251.

As described above, two or more of the beverage cartridges are used in combination according to the present invention to produce a wide variety of beverages including incorporating the advantage of dispensing a liquid dairy-based beverage portion from a cartridge of the same overall size as the cartridges used to prepare the remainder of the beverage. Thus a single beverage preparation machine may be used with all types of cartridges since the interface between the cartridges and the machine are the same irrespective of the beverage ingredients contained in the cartridges.

The delivery times for beverages using the machine 201 and cartridges 1 are typically between 10 and 120 seconds, preferably 30 to 40 seconds for roast and ground coffee,

between 5 and 120 seconds, preferably 10 to 20 seconds for chocolate and between 5 and 120 seconds, preferably 10 to 20 seconds for milk.

The machine 201 may also advantageously comprise a memory in operative communication with the control processor that stores information on the type of beverage dispensed by a user. The operating cycle of the machine 201 may then be adjusted for the next cartridge 1. This is especially advantageous where two or more beverage cartridges 1 are used sequentially to form a beverage. For example a coffee cartridge may be dispensed followed by a milk cartridge to form a cappuccino beverage. Alternatively a chocolate cartridge could be used followed by a milk cartridge to produce a creamy hot chocolate beverage. By using a memory that stores information on the first beverage dispensed, the manner of dispensing the second cartridge, say a milk cartridge, may be altered to achieve an optimum beverage. In the above example the milk dispensed for hot chocolate may, typically, be diluted less than the milk added to the coffee. In addition, the milk dispensed for chocolate may be dispensed at a slower flow rate to lessen the degree of foaming of the beverage. Many combinations of cartridges are possible and operating parameters as will be obvious to the skilled person. In addition, the memory may be used to allow the machine 201 to 'predict' the type of beverage that a user will next want to dispense. For example, if a user predominantly drinks one beverage type then the machine can instruct the water heater to remain at the optimum temperature for that beverage type.

Claims:

1. A cartridge (1) containing one or more liquid beverage ingredients (200) and being formed from substantially air- and water-impermeable materials, the cartridge comprising an inlet (121) for the introduction of an aqueous medium into the cartridge, a compartment (134) containing the one or more liquid beverage ingredients and an outlet (122) for a beverage produced by dilution of the one or more liquid beverage ingredients by the aqueous medium, characterised in that the compartment includes means for controlling dilution of at least a proportion of the one or more liquid beverage ingredients on introduction of the aqueous medium into the compartment.

2. A cartridge (1) as claimed in claim 1 wherein the means for controlling dilution delays dilution of at least a proportion of the one or more liquid beverage ingredients on introduction of the aqueous medium into the compartment.

3. A cartridge (1) as claimed in claim 1 or claim 2 wherein, in use, an aqueous medium flow path is established from the inlet to the outlet, the means for delaying dilution comprising a partition (100) which hinders entry of at least a proportion of the one or more liquid beverage ingredients into the aqueous medium flow path.

4. A cartridge (1) as claimed in claim 3 wherein the partition (100) comprises one or more apertures (103) for controllably releasing the at least a proportion of the one or more liquid beverage ingredients into the aqueous medium flow path.

5. A cartridge (1) as claimed in claim 4 wherein four apertures (103) are provided.

6. A cartridge (1) as claimed in any of claims 3 to 5 wherein the partition comprises a cup-shaped member having an open mouth (104) directed away from the aqueous medium flow path.

7. A cartridge (1) as claimed in claim 6 wherein the cup-shaped member is annular.

8. A cartridge (1) as claimed in claim 6 or claim 7 wherein one or more apertures (103) are provided at or near a base of the cup-shaped member.

9. A cartridge (1) as claimed in claim 8 wherein the at least a proportion of the liquid beverage ingredients in the cup-shaped member (100) drain by gravity through the one or more apertures (103) in use.

10. A cartridge (1) as claimed in claim 9 wherein the cup-shaped member is spaced from a bottom of the cartridge, such that the aqueous medium flow path passes between the cup-shaped member and the bottom of the cartridge.

11. A cartridge (1) as claimed in claim 10 wherein the at least a proportion of the liquid beverage ingredients in the cup-shaped member (100) drain by gravity through the one or more apertures (103) in use vertically downwards into the aqueous medium flow path.

12. A cartridge (1) as claimed in any of claims 6 to 11 comprising an inner member (3) and an outer member (2), wherein the inner member comprises the cup-shaped member.

13. A cartridge as claimed in any of claims 3 to 12 further comprising means for producing a jet of the beverage, wherein said means for producing the jet of the beverage comprises an aperture (128) in the aqueous medium flow path.

14. A cartridge as claimed in claim 13 as dependent on claim 11 wherein the aperture (128) is delimited by an interface between the inner member and the outer member.

15. A cartridge as claimed in claim 13 or claim 14 further comprising at least one inlet (71) for air and means for generating a pressure reduction of the jet of beverage, whereby, in use, air from the at least one air inlet is incorporated into the beverage as a plurality of small bubbles.

16. A cartridge (1) as claimed in claim 15 wherein the at least one air inlet (71) is provided in the inner member downstream of the aperture (128).

17. A cartridge (1) as claimed in claim 16 wherein the at least one air inlet (71) and means for producing a pressure reduction in the jet of beverage produces a foaming of the one or more liquid beverage ingredients of greater than 40%.

18. A cartridge (1) as claimed in claim 17 wherein the foaming is greater than 70%.

19. A cartridge (1) as claimed in any preceding claim wherein the cartridge is disc-shaped.

20. A cartridge (1) as claimed in any preceding claim wherein the outer member and/or inner member are formed from polypropylene.

21. A cartridge (1) as claimed in any preceding claim wherein the outer member and/or inner member is formed by injection moulding.

22. A cartridge (1) as claimed in any preceding claim wherein the liquid beverage ingredient is a concentrated liquid milk composition.

23. A cartridge (1) as claimed in claim 22 wherein the concentrated liquid milk contains between 25 and 40% total solids.

24. A cartridge (1) as claimed in claim 23 wherein the concentrated liquid milk contains 30% total solids.

25. A cartridge (1) as claimed in any of claims 22 to 24 wherein the concentrated liquid milk contains between 0.1 and 12% fat.

26. A cartridge (1) as claimed in any of claims 1 to 21 wherein the one or more liquid beverage ingredients are selected from the group of cocoa solids, coffee, tea, sweeteners, cordials, flavourings, alcoholic beverages, flavoured milk, fruit juices, squashes, sauces and desserts.

27. A method of dispensing a beverage from a cartridge (1) containing one or more liquid beverage ingredients (200) during an operating cycle, comprising the steps of passing an aqueous medium through the cartridge to form a beverage by dilution of said one or more beverage ingredients, and dispensing the beverage into a receptacle, wherein the one or more liquid ingredients as dispensed has a concentration at the start of the operating cycle of between 30 and 70% total solids and a concentration at the end of the operating cycle of between 1 and 15% total solids.

28. A method as claimed in claim 27 wherein the concentration at the start of the operating cycle is between 30 and 35% total solids.

29. A method as claimed in claim 28 wherein the concentration at the end of the operating cycle is approximately 10% total solids.

30. A method as claimed in claim 28 or claim 29 wherein the liquid ingredient is concentrated milk.

31. A method as claimed in claim 27 wherein the concentration at the start of the operating cycle is between 60 and 70% total solids.

32. A method as claimed in claim 31 wherein the concentration at the end of the operating cycle is between 12 and 15% total solids.

33. A method as claimed in claim 31 or claim 32 wherein the liquid ingredient contains cocoa solids.

34. A method as claimed in claim 27 wherein the concentration at the start of the operating cycle is between 40 and 70% total solids.

35. A method as claimed in claim 34 wherein the concentration at the end of the operating cycle is between 1 and 2% total solids.

36. A method as claimed in claim 34 or claim 35 wherein the liquid ingredient is contains coffee.

37. A method of dispensing a beverage from a cartridge (1) containing one or more liquid beverage ingredients

(200) during an operating cycle, comprising the steps of passing an aqueous medium through the cartridge to form a beverage by dilution of said one or more beverage ingredients, and dispensing the beverage into a receptacle, wherein the one or more liquid beverage ingredients is foamed on dispense to a ratio of between 20 and 150%.

38. A method as claimed in claim 37 wherein the one or more liquid beverage ingredients are foamed to a ratio between 70 and 100%.

39. A method as claimed in claim 37 or claim 38 wherein the one or more liquid beverage ingredients includes one or more of concentrated milk, coffee and cocoa solids.

40. A beverage as produced by the method of any of claims 27 to 39.

41. A method of manufacturing a cartridge (1) for dispensation of a beverage comprising the steps of:

a. manufacturing a plurality of outer members (2) comprising at least a first type of outer member and a second type of outer member having differing shape or configurations;

b. manufacturing a plurality of inner members (3) comprising at least a first type of inner member and a second type of inner member having differing shape or configurations;

c. storing said plurality of outer members and said inner members;

d. selecting one of the first type of outer member or the second type of outer member from the plurality of outer members;

e. selecting one of the first type of inner member or the second type of inner member from the plurality of inner members;

f. conjoining the selected inner member to the selected outer member such the inner member is within the outer member;

g. filling the outer member with one or more beverage ingredients (200) selected from a plurality of beverage ingredients; and

h. sealing the outer member with a lid (5) to form the cartridge.

42. A method as claimed in claim 41 further comprising in step b. of joining a filter member (4) to the first type and/or second type of inner member (3).

43. A method as claimed in claim 41 or claim 42 wherein the first type of outer member (2) is suitable for containing roast and ground beverage ingredients or the like.

44. A method as claimed in any of claims 41 to 43 wherein the second type of outer member (2) is suitable for containing soluble or liquid beverage ingredients or the like.

45. A method as claimed in any of claims 41 to 44 wherein the first type of inner member (3) is suitable for

filtering roast and ground beverage ingredients and the like.

46. A method as claimed in any of claims 41 to 45 wherein the second type of inner member (3) is suitable for filtering roast and ground beverage ingredients and the like and for entraining a plurality of air bubbles in the dispensed beverage.

47. A method as claimed in claim 45 or claim 46 wherein the first and second type of inner member (3) comprise a frame (41) having a filter (4) disposed thereupon, and wherein a peripheral rim (51) of the frame is conjoined to the selected type of outer member by welding.

48. A method as claimed in claim 47 wherein the second type of inner member (3) comprises means (70) for producing a jet of the beverage, which means comprises an aperture in a beverage flow path between an inlet and an outlet of the cartridge.

49. A method as claimed in any of claims 41 to 48 further comprising manufacturing and storing a third type of inner member (3).

50. A method as claimed in claim 49 wherein the third type of inner member is suitable for dispensing soluble beverage ingredients and the like.

51. A method as claimed in any of claims 41 to 50 further comprising manufacturing and storing a fourth type of inner member (3).

52. A method as claimed in claim 51 wherein the fourth type of inner member (3) is suitable for dispensing a liquid beverage ingredients and the like.

53. A method as claimed in any of claims 49 to 52 wherein the third or fourth type of inner member (3) comprises a skirt (80) surrounding an outlet, the skirt comprising an upper extension (81) having an upper rim (91) which engages, on assembly of the cartridge, a co-operating formation (19) of the selected type of outer member (2) to form a snap-fit arrangement for conjoining the third or fourth type of inner member to the selected type of outer member.

54. A cartridge system for dispensing a plurality of beverages comprising:

a. a plurality of outer members (3) comprising at least a first type of outer member and a second type of outer member having differing shape or configurations;
b. a plurality of inner members (2) comprising at least a first type of inner member and a second type of inner member having differing shape or configurations;
c. a plurality of beverage ingredients (200); and
d. at least one lid (5) to seal the cartridge;

wherein each cartridge comprises an outer member, an inner member, one or more beverage ingredients and a lid.

55. A cartridge system as claimed in claim 54 wherein each cartridge further comprises a filter (4).

56. A cartridge system as claimed in claim 54 or claim 55 wherein the first type of outer member (3) is suitable for containing roast and ground beverage ingredients or the like.

57. A cartridge system as claimed in any of claims 54 to 56 wherein the second type of outer member (3) is suitable for containing soluble or liquid beverage ingredients or the like.

58. A cartridge system as claimed in any of claims 54 to 57 wherein the first type of inner member (3) is suitable for filtering roast and ground beverage ingredients and the like.

59. A cartridge system as claimed in any of claims 54 to 58 wherein the second type of inner member (3) is suitable for filtering roast and ground beverage ingredients and the like and comprises means entraining a plurality of air bubbles in the dispensed beverage.

60. A cartridge system as claimed in any of claims 54 to 59 wherein the first and second type of inner member (3) comprise a frame (41) having a filter (4) disposed

thereupon, and wherein a peripheral rim (51) of the frame is conjoined to the selected type of outer member by welding.

61. A cartridge system as claimed in claim 59 or claim 60 wherein the second type of inner member (3) comprises means (70) for producing a jet of the beverage, which means comprises an aperture in a beverage flow path between an inlet and an outlet of the cartridge.

62. A cartridge system as claimed in any of claims 54 to 61 further comprising a third type of inner member (3).

63. A cartridge system as claimed in claim 62 wherein the third type of inner member (3) is suitable for dispensing soluble beverage ingredients and the like.

64. A cartridge system as claimed in any of claims 54 to 63 further comprising a fourth type of inner member (3).

65. A cartridge system as claimed in claim 64 wherein the fourth type of inner member (3) is suitable for dispensing a liquid beverage ingredients and the like.

66. A cartridge system as claimed in any of claims 62 to 65 wherein the third or fourth type of inner member (3) comprises a skirt (80) surrounding an outlet, the skirt comprising an upper extension (81) having an upper rim (91) which engages, on assembly of the cartridge, a co-operating formation (19) of the selected type of outer member to form a snap-fit arrangement for conjoining

the third or fourth type of inner member to the selected type of outer member.

67. A method of preparing a beverage comprising the steps of:

a) inserting a first beverage cartridge (1) containing one or more beverage ingredients (200) into a beverage preparation machine (201);

b) operating said beverage preparation machine to pass an aqueous medium through the first beverage cartridge to dispense a first portion of said beverage into a receptacle;

c) inserting a second beverage cartridge (1) containing one or more beverage ingredients (200) into the beverage preparation machine; and

d) operating the beverage preparation machine to pass an aqueous medium through the second beverage cartridge to dispense a second portion of said beverage into the receptacle;

characterised in that one of the first or second beverage cartridges contains a liquid dairy-based ingredient.

68. A method as claimed in claim 67 wherein one of the first or second beverage cartridges (1) contains an ingredient for forming a brewed portion of a beverage.

69. A method as claimed in claim 67 or claim 68 further comprising the step of removing the first beverage

cartridge (1) before inserting the second beverage cartridge (1).

70. A method as claimed in any of claims 67 to 69 wherein the beverage ingredient in the first or second beverage cartridge is roast and ground coffee.

71. A method as claimed in any of claims 67 to 69 wherein the beverage ingredient in the first or second beverage cartridge is leaf-based tea.

72. A method as claimed in any of claims 67 to 69 wherein the beverage ingredient in the first or second beverage cartridge is a liquid coffee ingredient.

73. A method as claimed in any of claims 67 to 69 wherein the liquid dairy-based ingredient is a concentrated dairy-based product.

74. A method as claimed in claim 73 wherein the concentrated dairy-based product is concentrated liquid milk.

75. A method as claimed in claim 74 wherein the concentrated liquid milk contains between 25 and 40% total solids.

76. A method as claimed in claim 75 wherein the concentrated liquid milk contains 30% total solids.

77. A method as claimed in any of claims 73 to 76 wherein the concentrated liquid milk contains between 0.1 and 12% fat.

78. A method as claimed in any of claims 73 to 77 further comprising the step of foaming the one or more liquid dairy-based ingredients during dispensation.

79. A beverage preparation system comprising a beverage preparation machine (201) having means for receiving a range of beverage cartridges (1) and means for passing an aqueous medium through said beverage cartridges, a first beverage cartridge (1) containing one or more beverage ingredients (200) for preparing a first portion of said beverage, and a second beverage cartridge (1) containing one or more beverage ingredients (200) for preparing a second portion of said beverage, characterised in that one of the first or second beverage cartridges contains a liquid dairy-based ingredient.

FIG. 1.

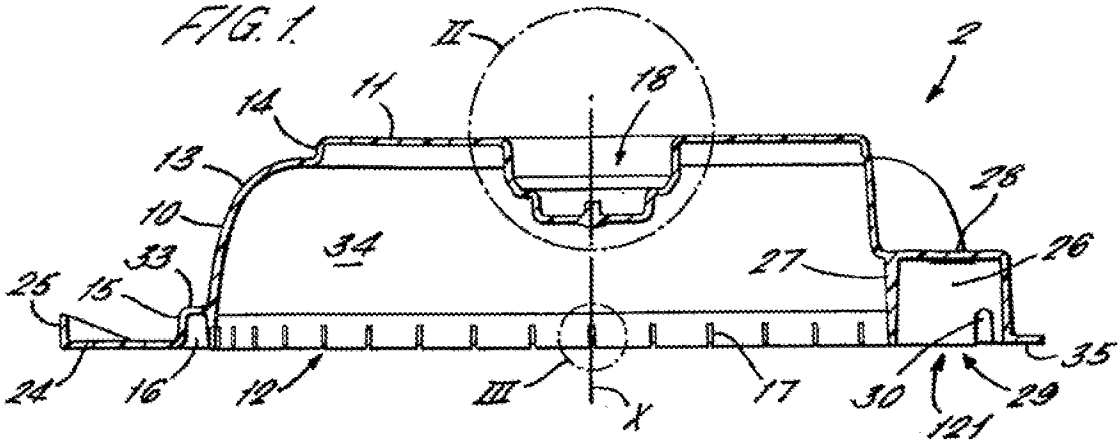


FIG. 2.

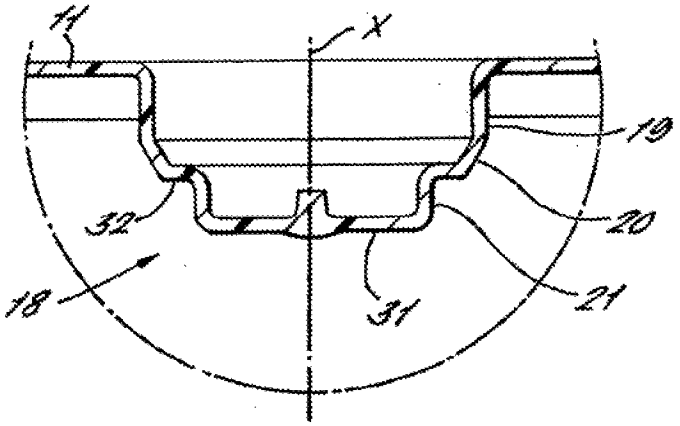


FIG. 3.

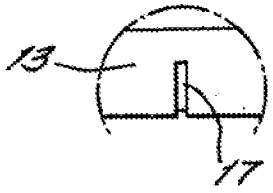


FIG. 4.

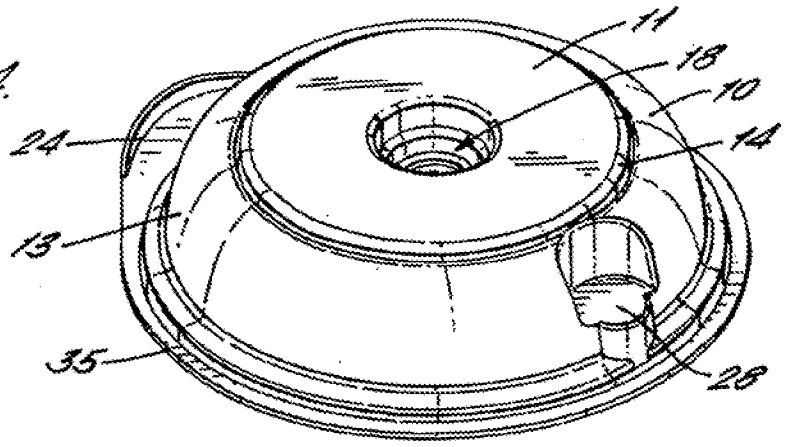


FIG. 5.

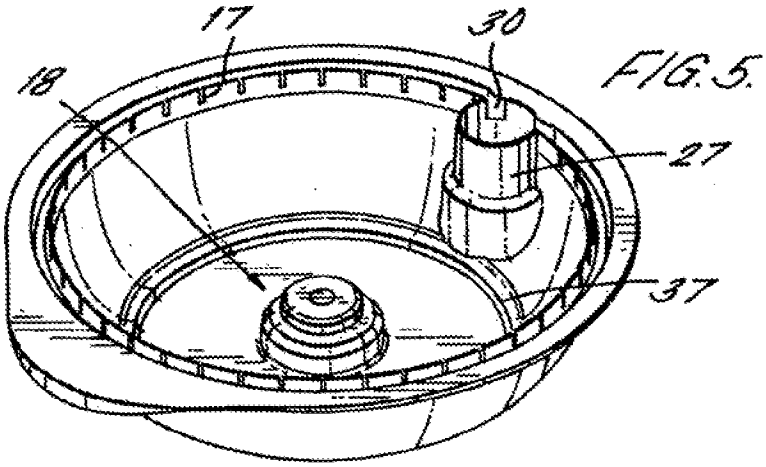
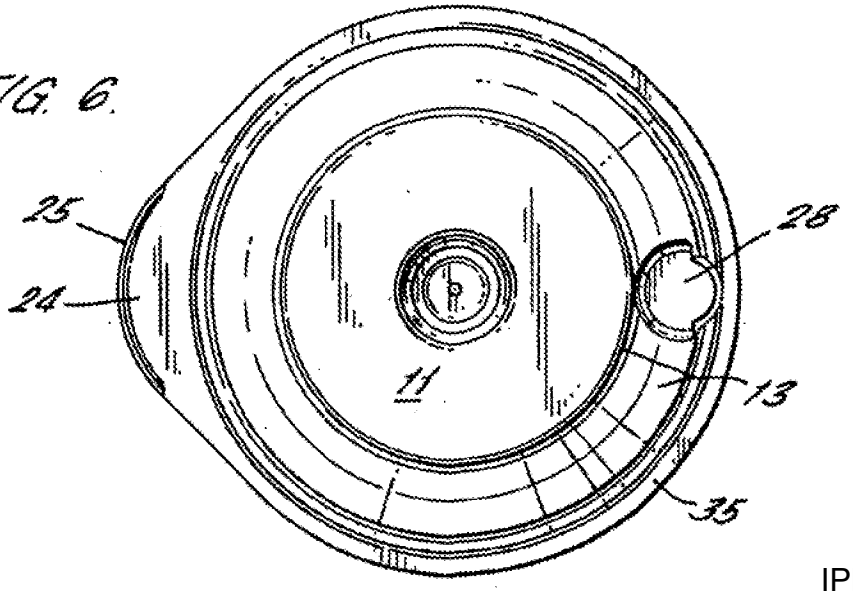


FIG. 6.



3/25

FIG. 7.

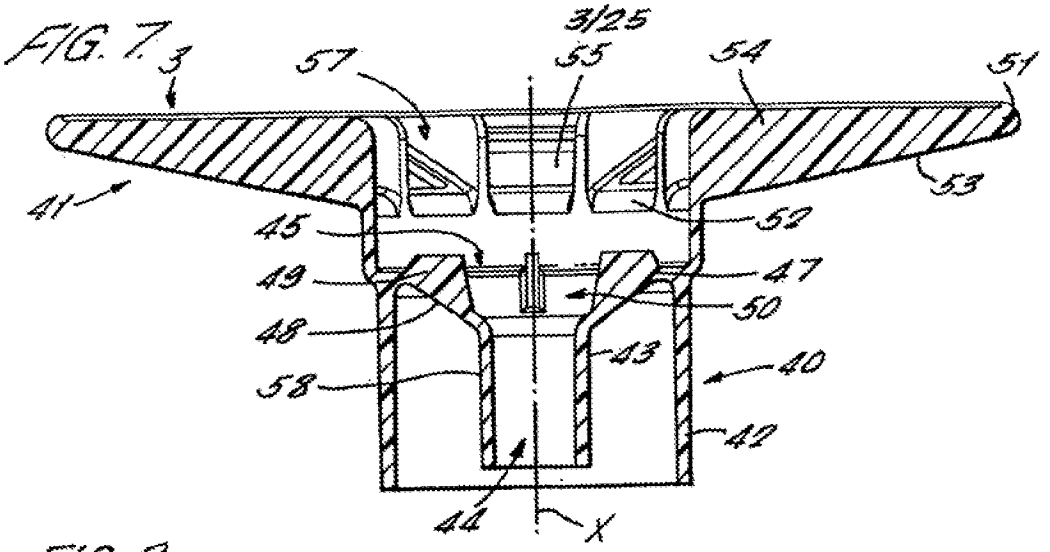


FIG. 8.

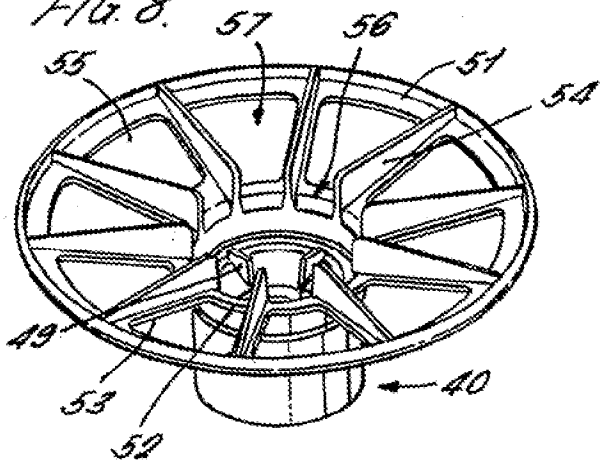


FIG. 9.

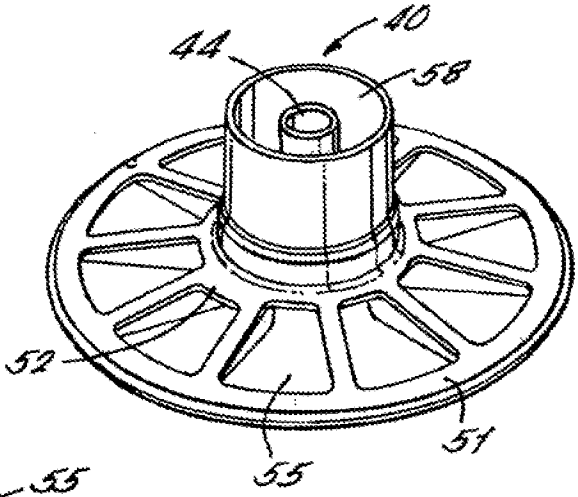
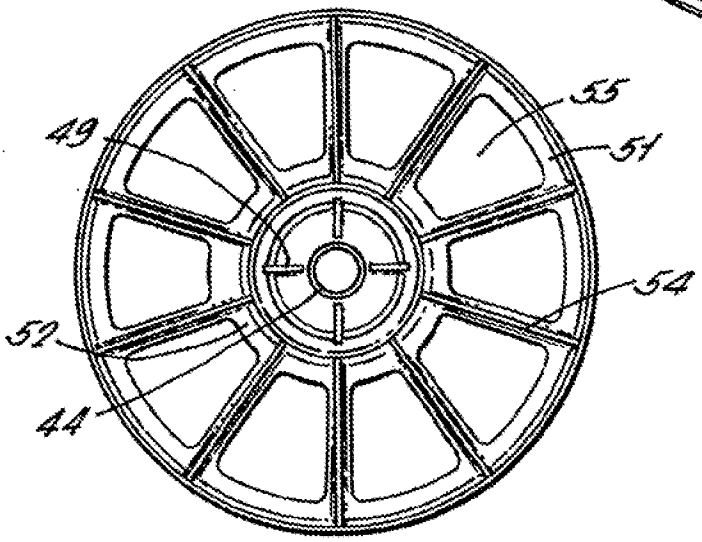


FIG. 10.



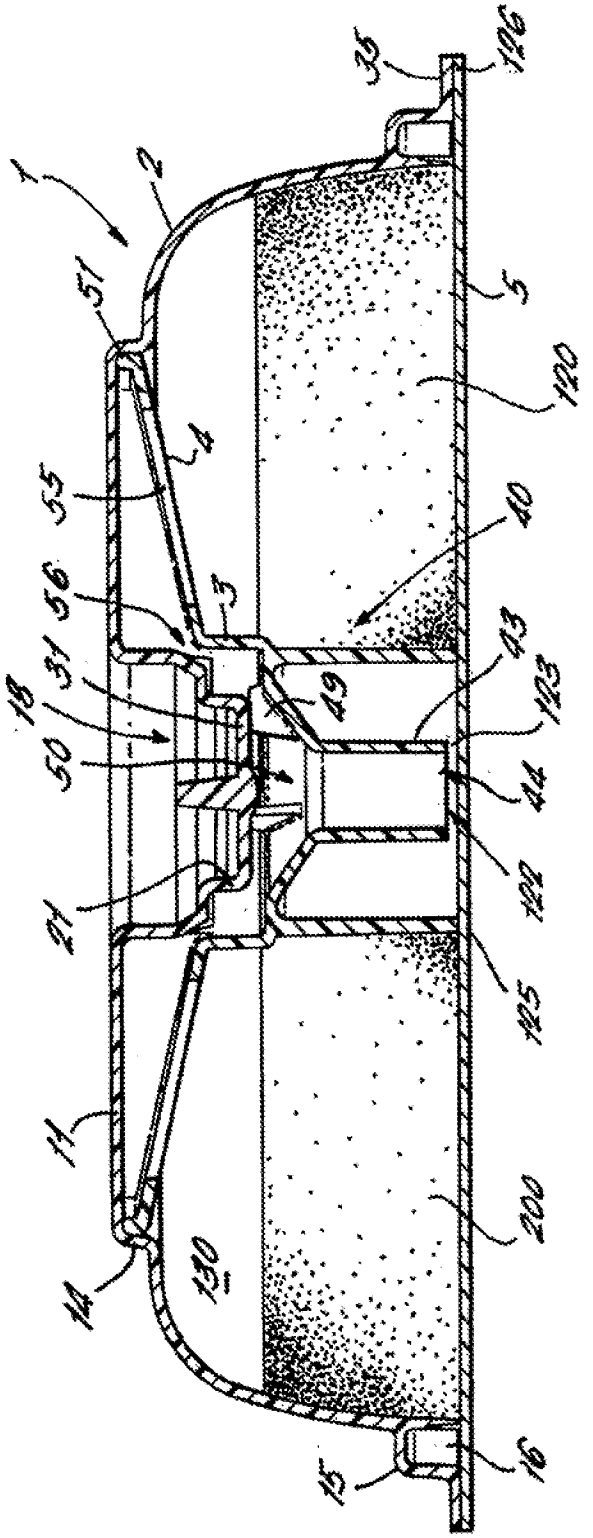

1
2
51
4
55
56
3
18
51
50
21
11
14
130
15
16
35
106
5
120
40
43
19
103
44
102
125
200

FIG. 11.

FIG. 12.

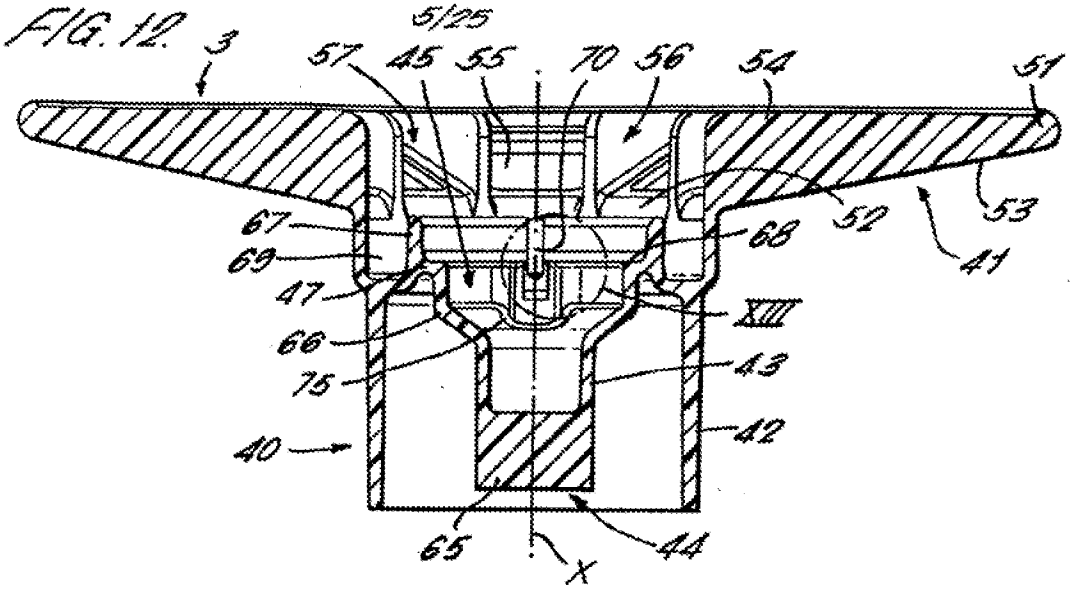


FIG. 13.

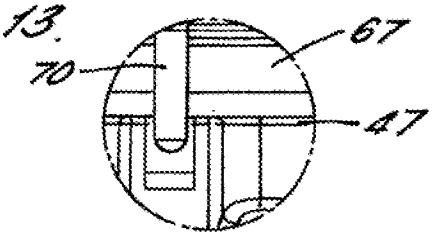


FIG. 14.

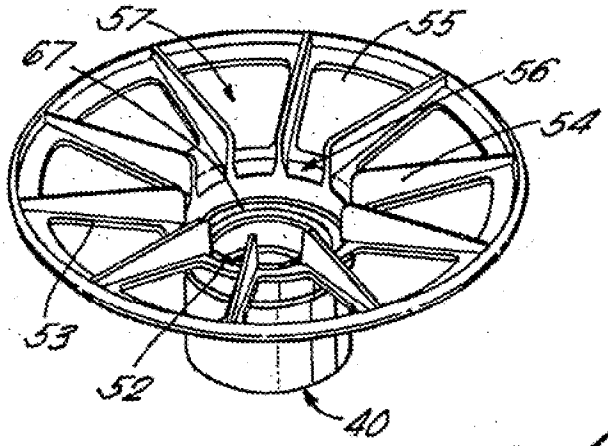


FIG. 15.

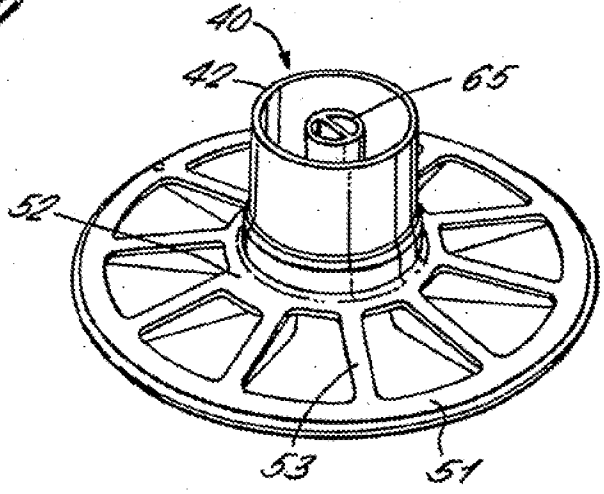


FIG. 16.

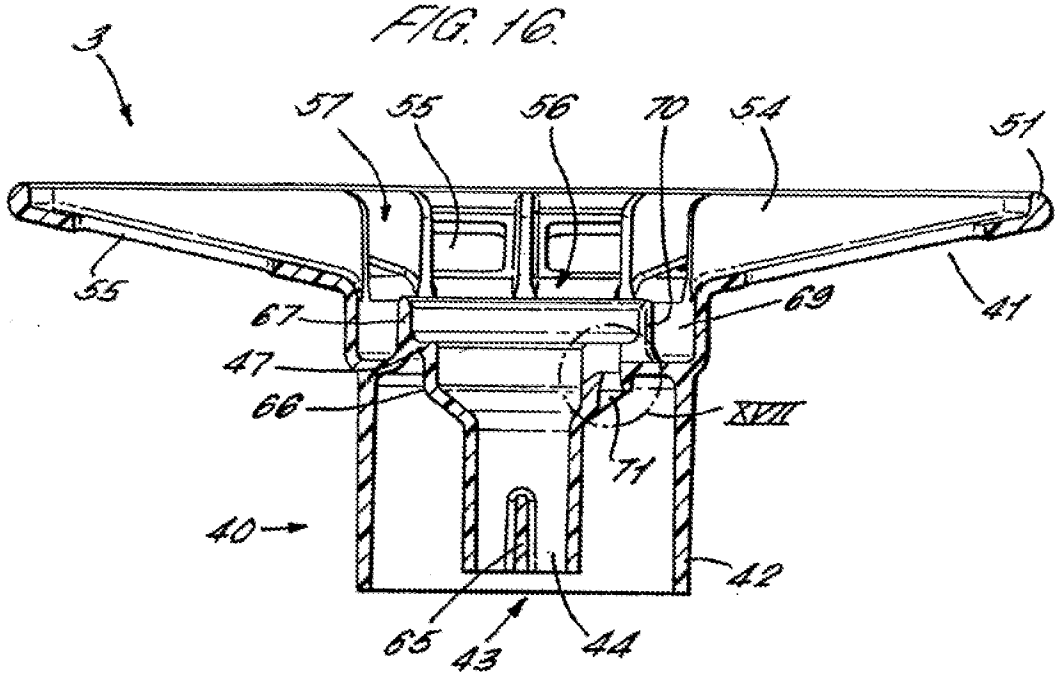
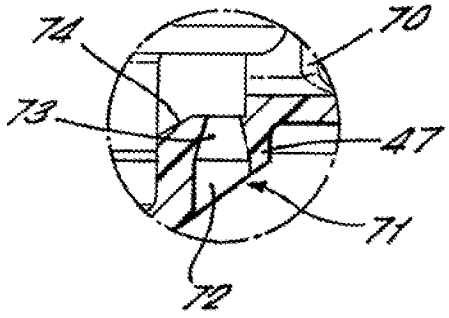

3
57
55
56
70
54
51
55
67
69
41
47
66
XVII
71
40
42
65
43
44

FIG. 17.


74
70
73
47
71
72

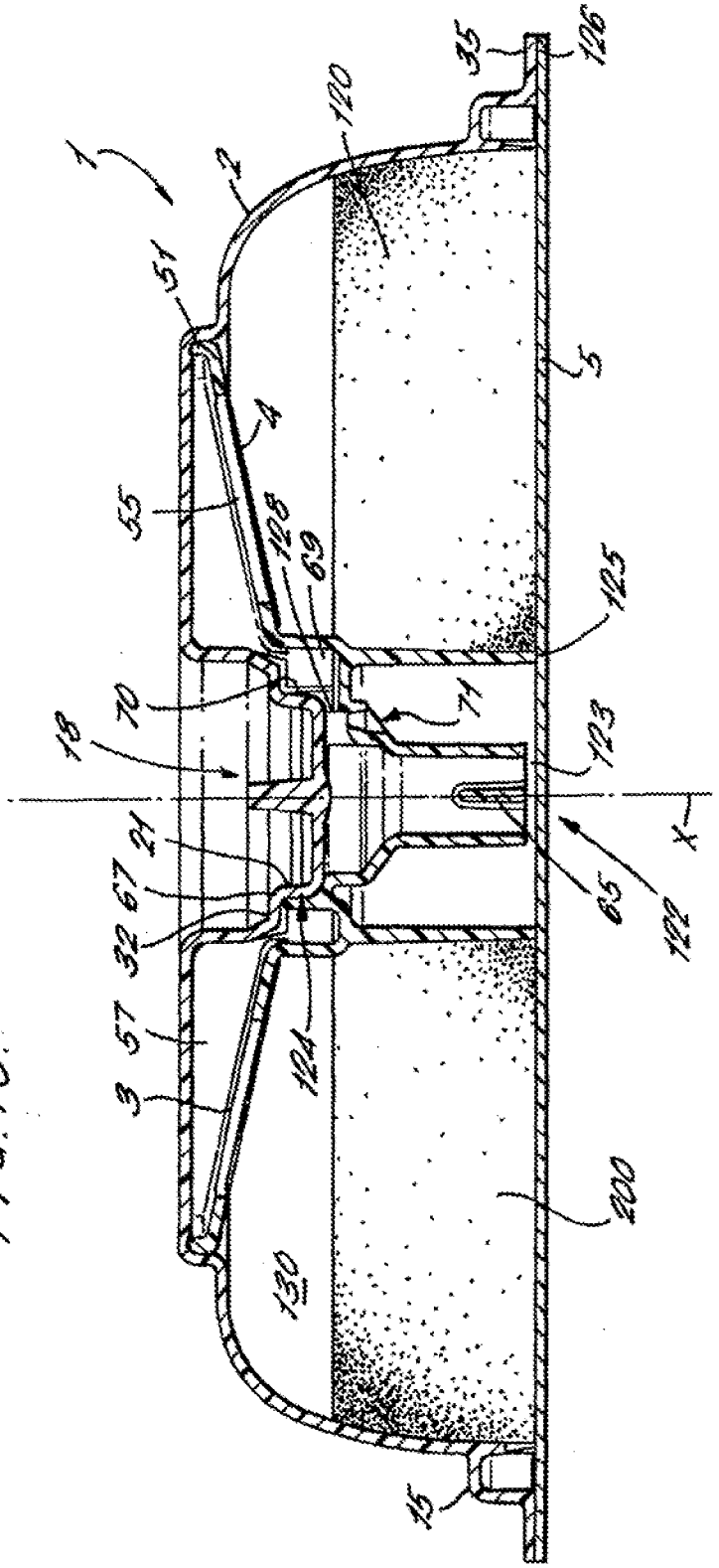

1
2
120
35
126
51
5
4
55
108
69
125
70
71
18
123
21
67
65
122
32
57
3
124
100
130
15
X

FIG. 18.

FIG. 19.

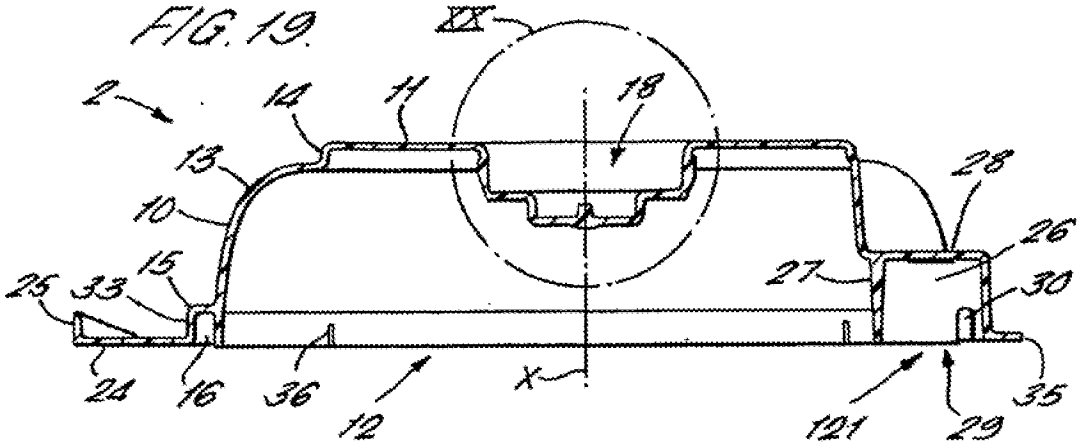

XX
2
14
11
18
13
28
10
26
15
27
30
25
33
24
16
36
12
X
121
29
35

FIG. 20.

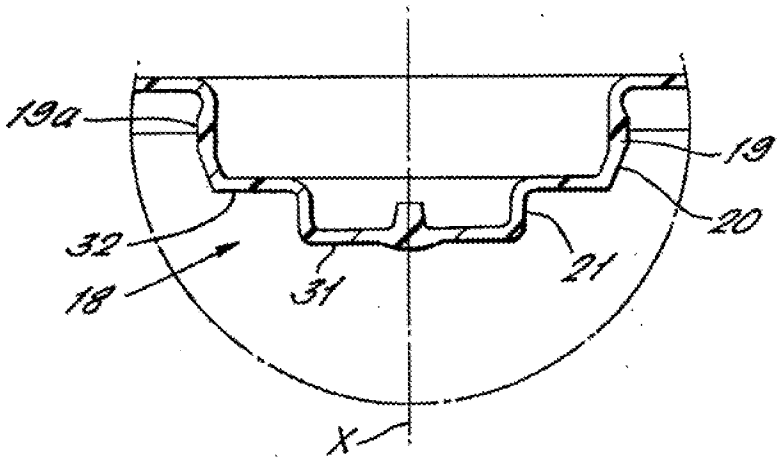

19a
19
20
32
21
31
18
X

FIG. 21.

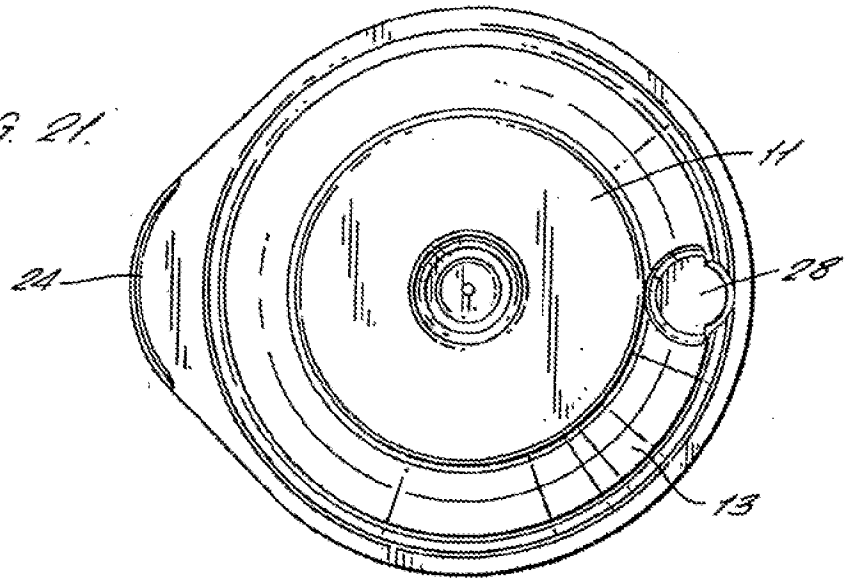


FIG. 22.

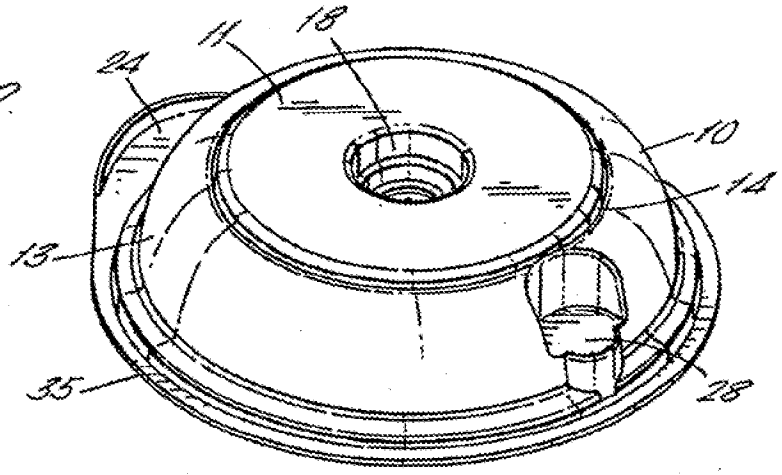


FIG. 23.

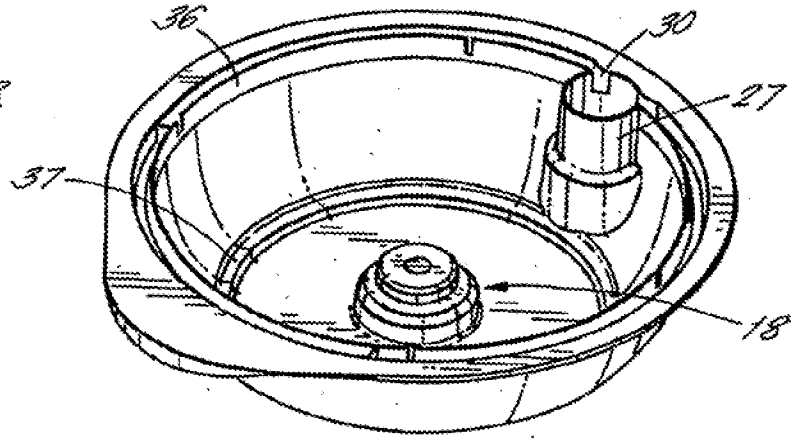


FIG. 24.

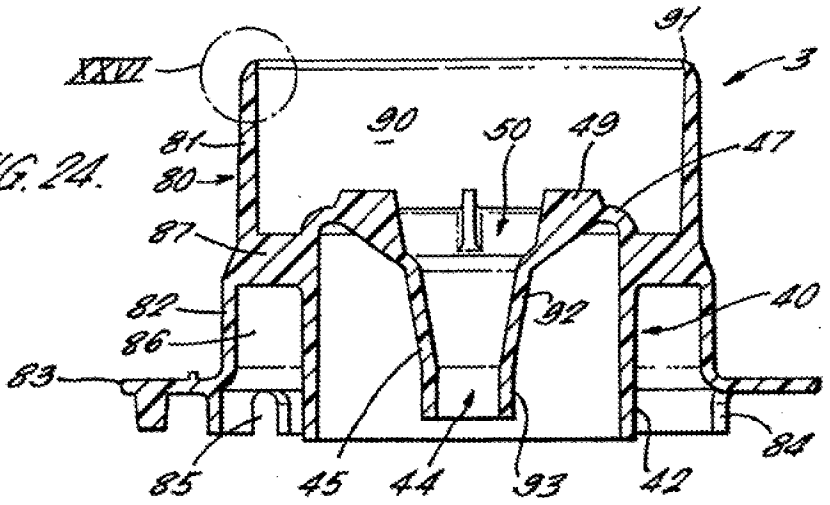


FIG. 25.

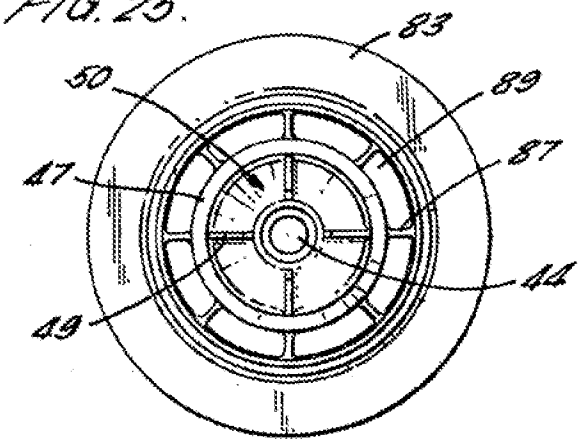


FIG. 26.

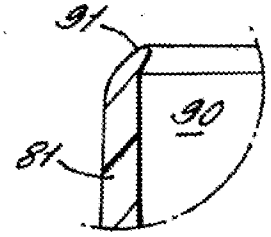


FIG. 27.

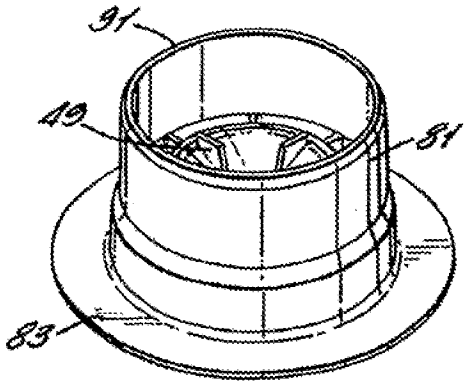
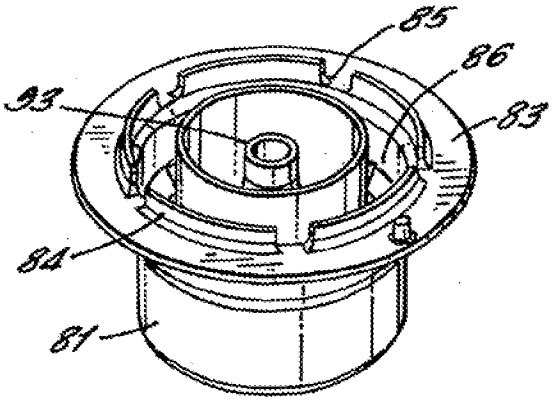


FIG. 28.



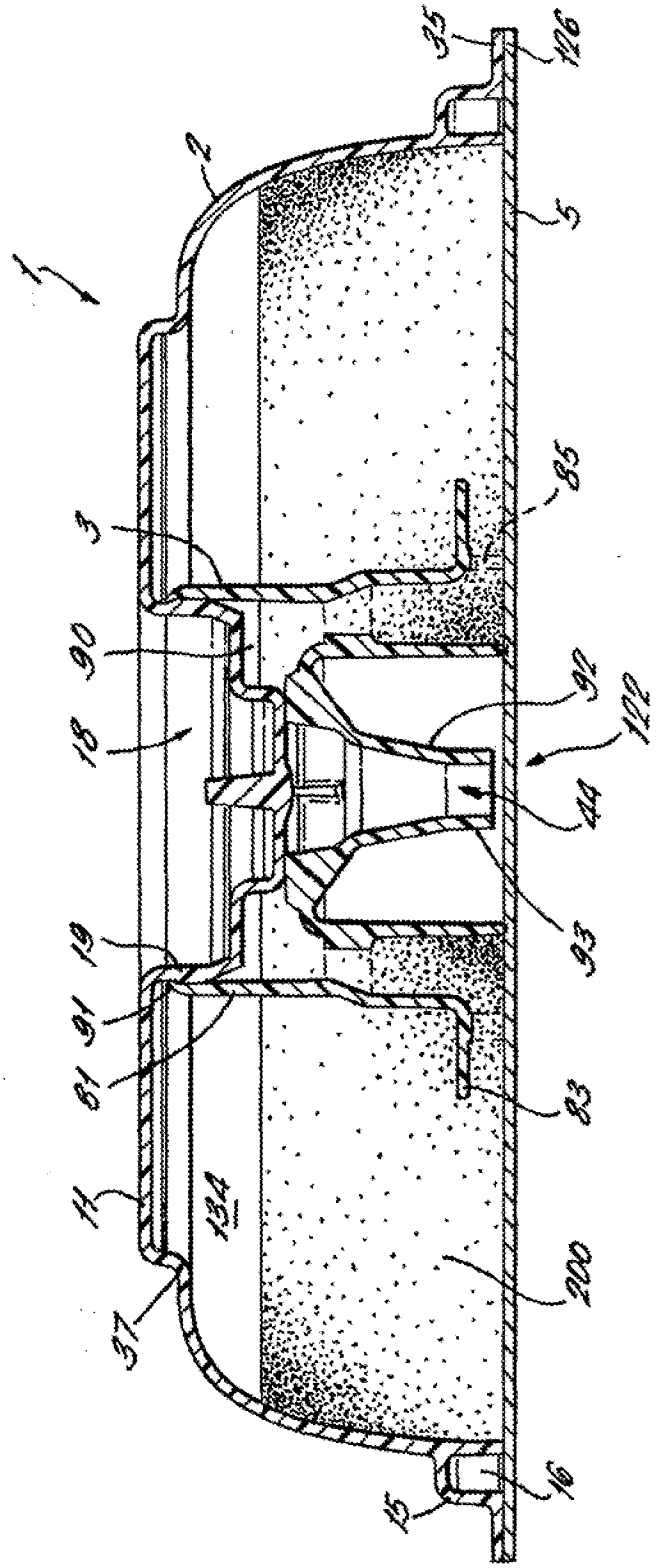


FIG. 29.

FIG. 30.

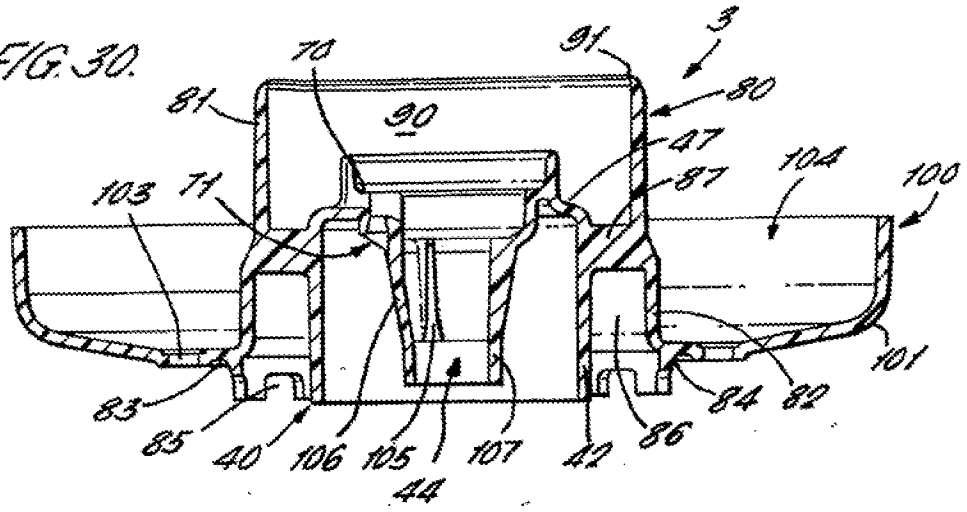


FIG. 32.

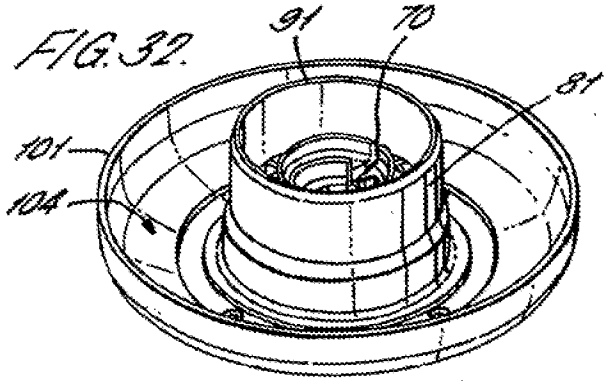


FIG. 31.

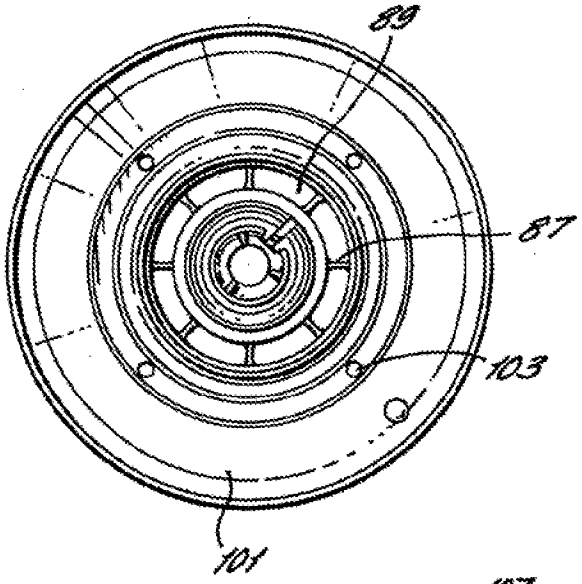
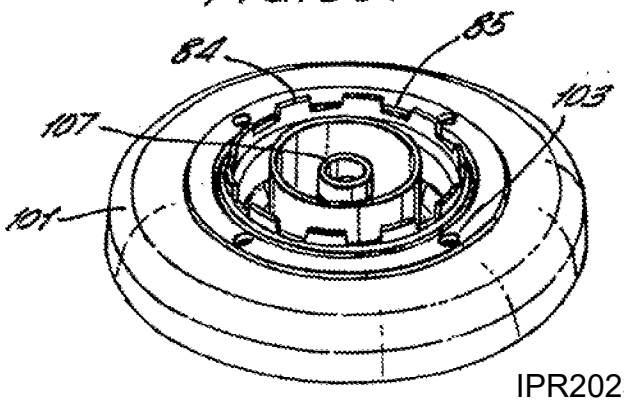


FIG. 33.



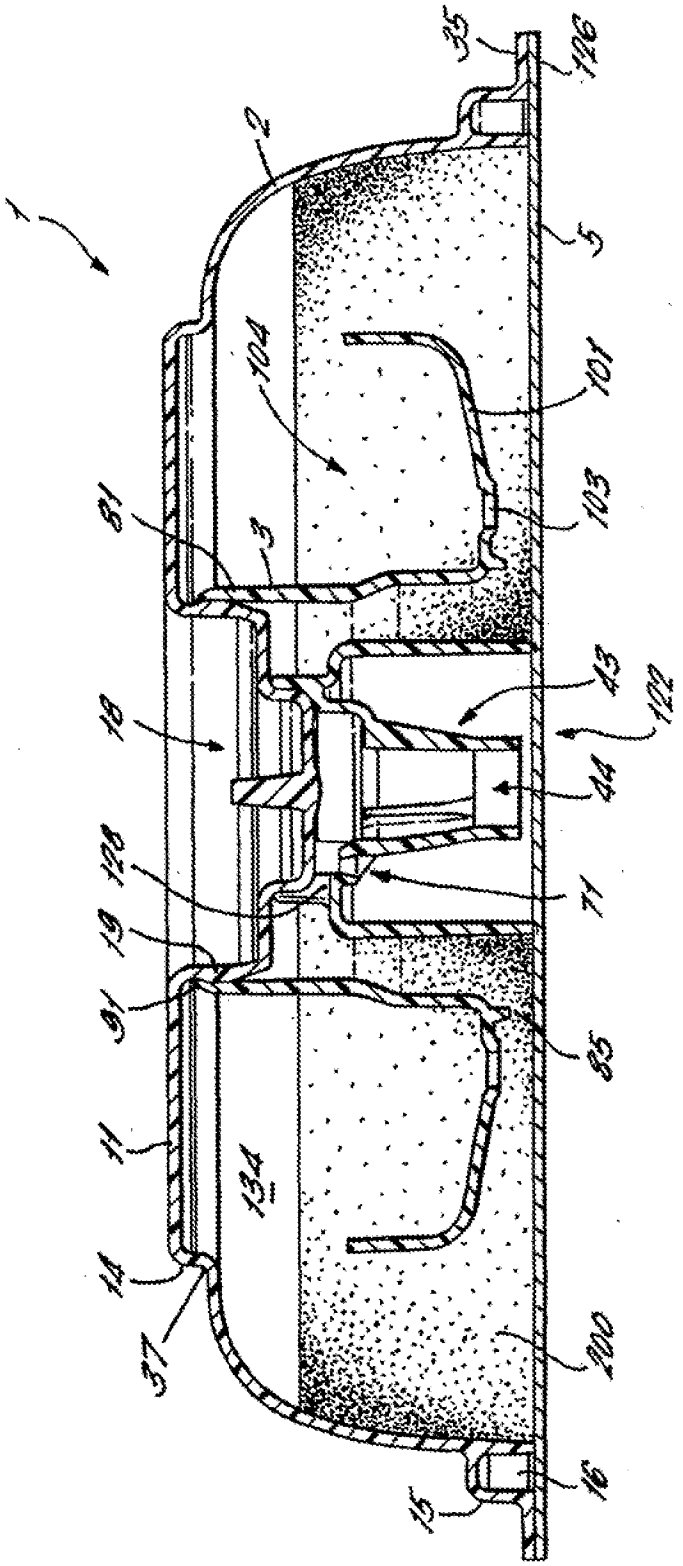

1
2
35
116
5
104
101
61
3
103
43
122
18
44
128
71
19
91
65
11
134
14
37
100
16
15

FIG. 34.

FIG.35.

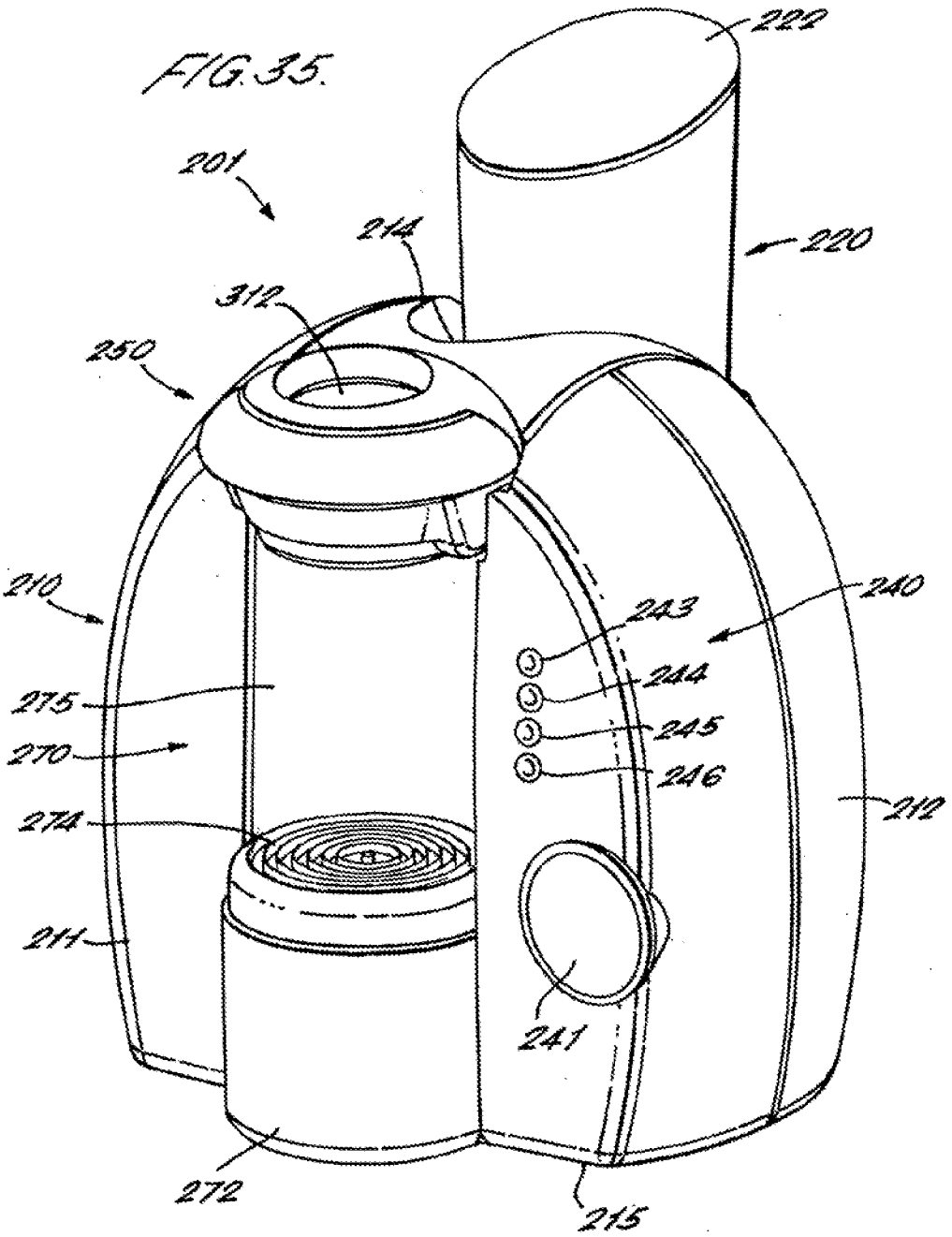

222
201
214
220
312
250
210
240
223
244
275
245
270
246
212
274
211
241
272
215

FIG. 36.

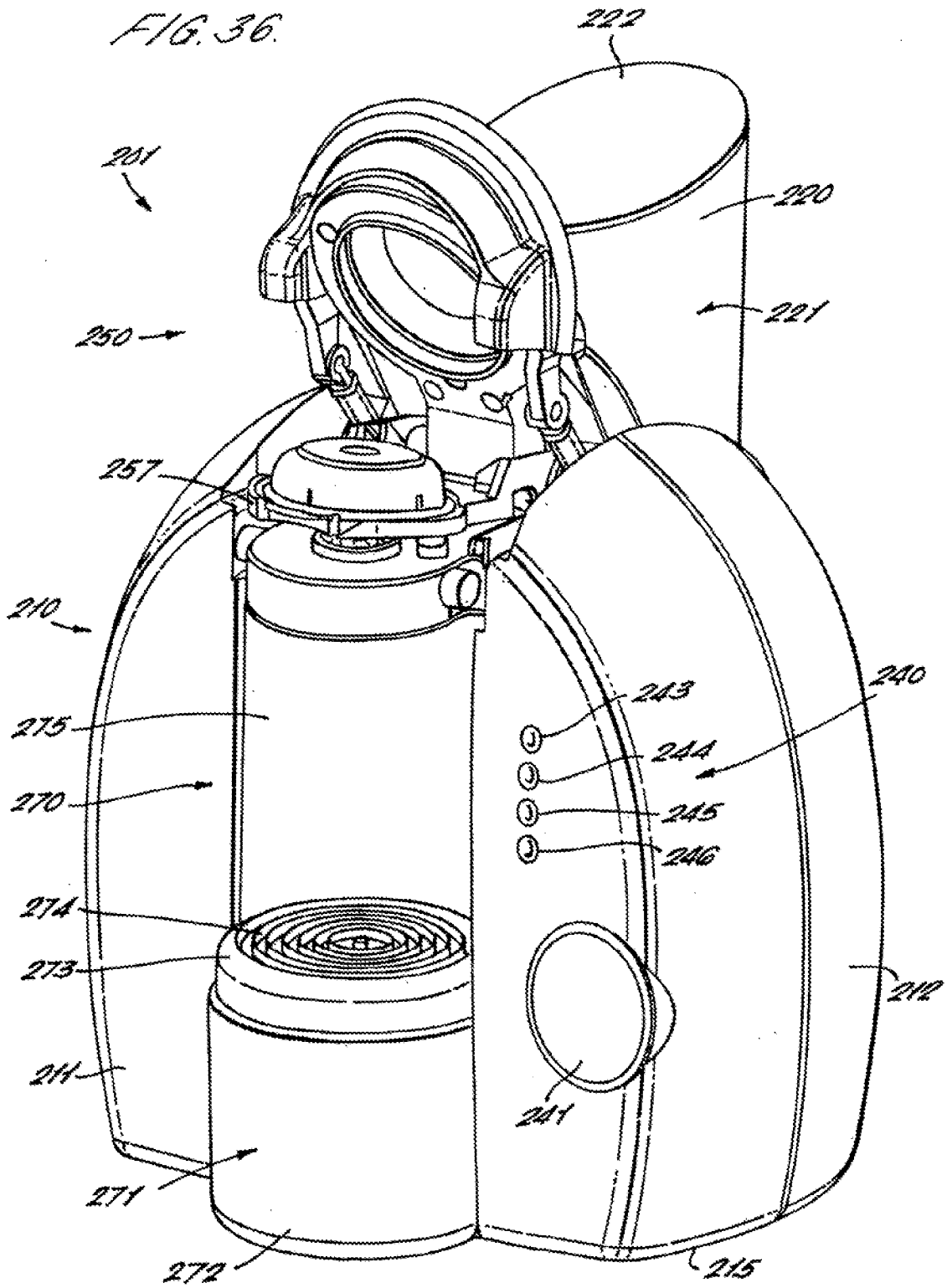

222
201
220
221
250
257
210
240
243
275
244
270
245
246
274
273
212
214
241
271
272
215

FIG. 37.

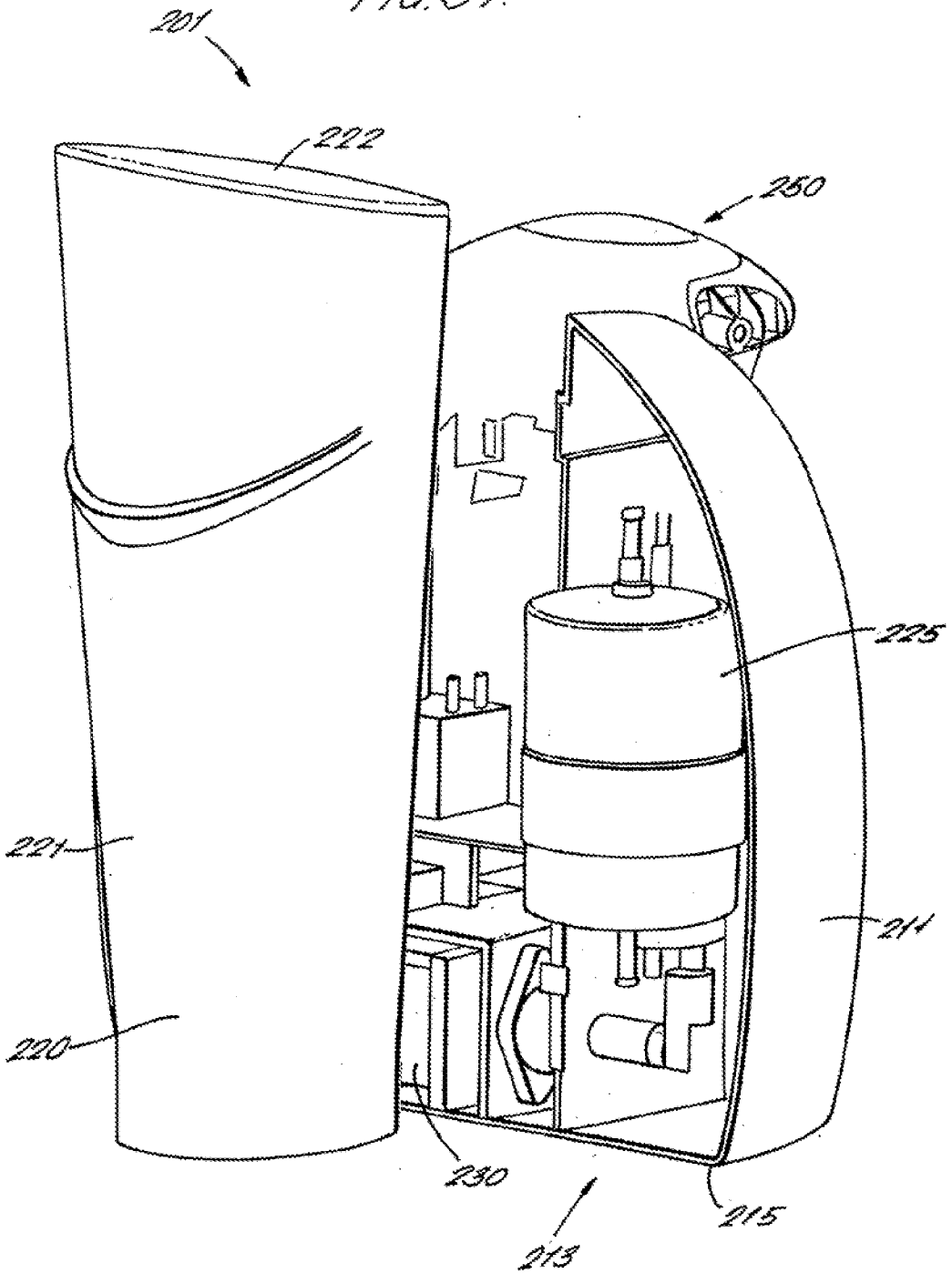
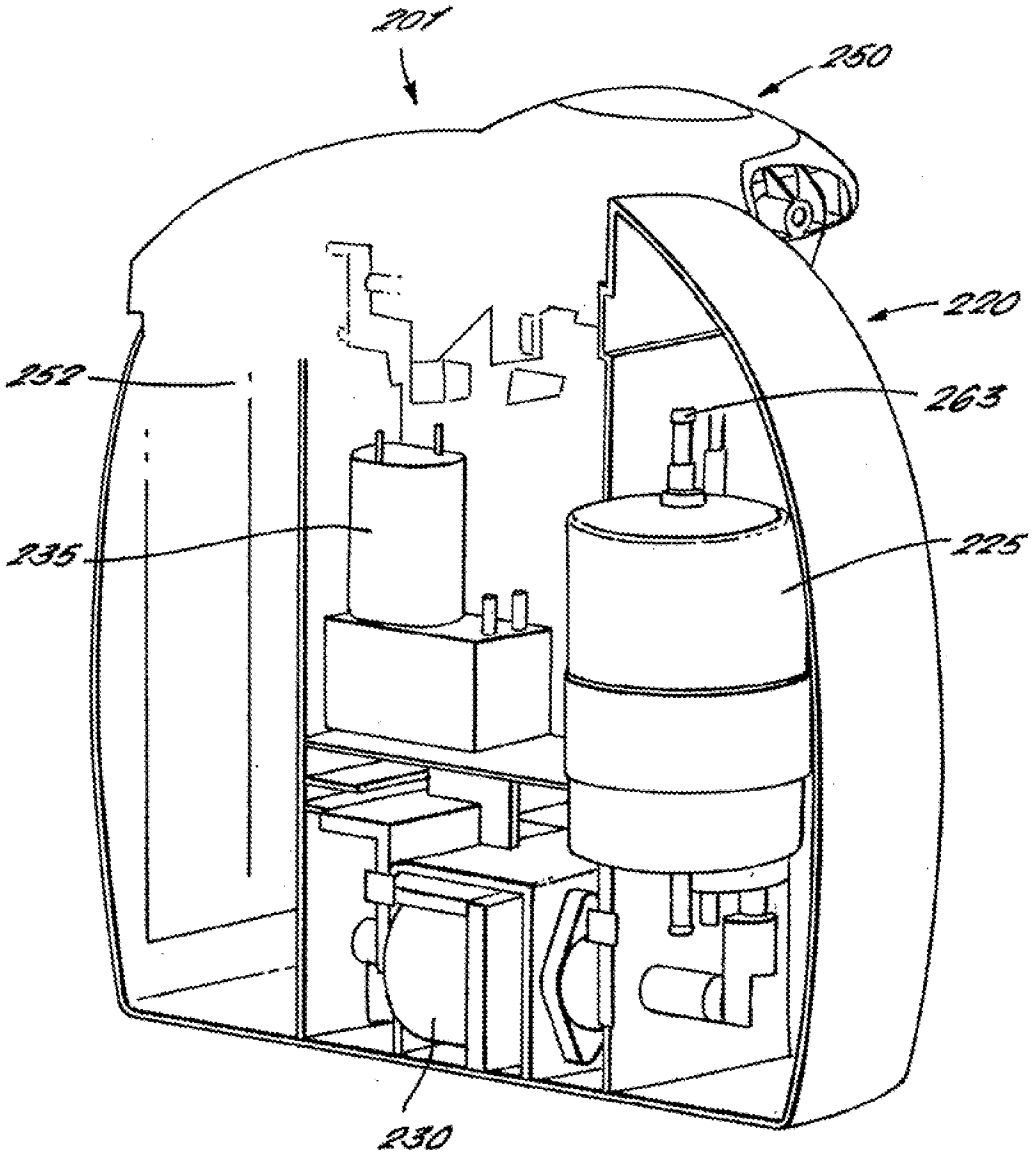


FIG. 38.



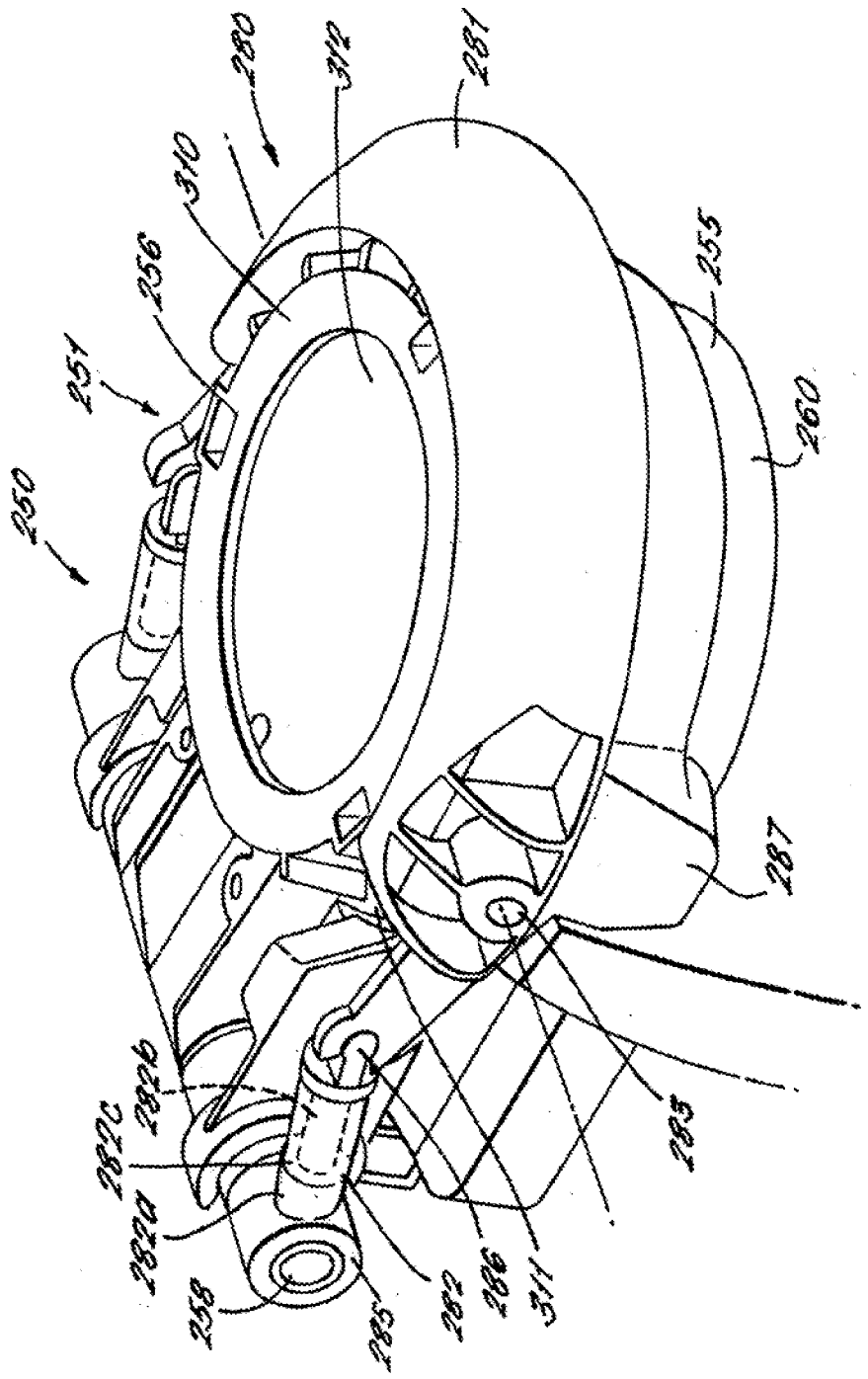
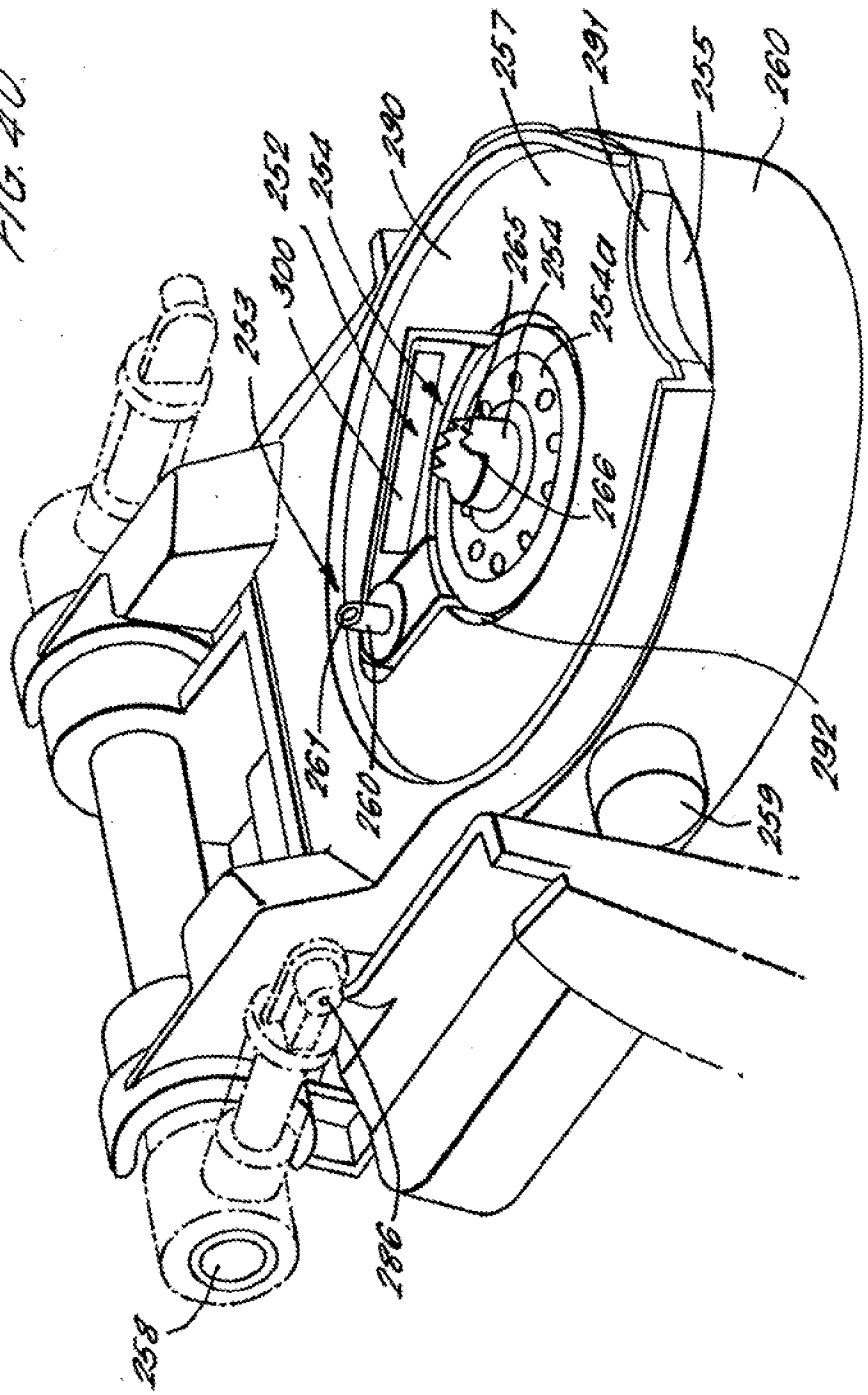

280
310
281
310
256
255
251
260
250
287
283
282c
282a
282b
258
282
286
311

FIG. 39.

FIG 40


257
291
255
260
252
254
250
253
300
265
254
254a
166
161
160
259
292
258
286

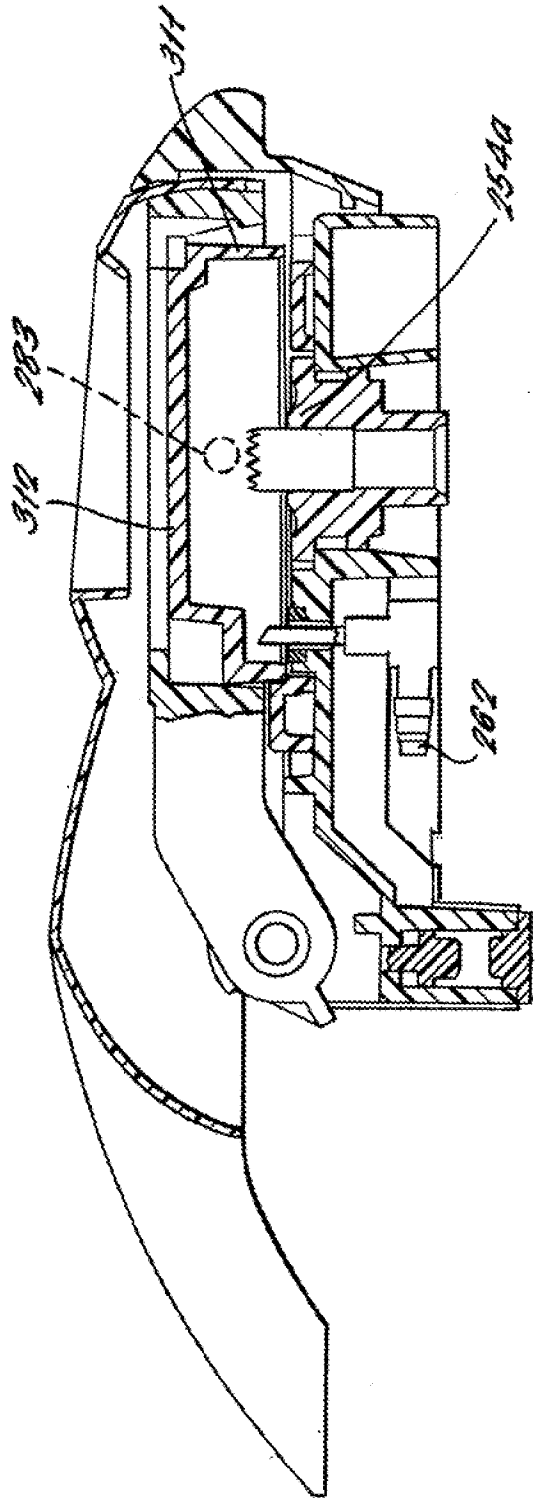
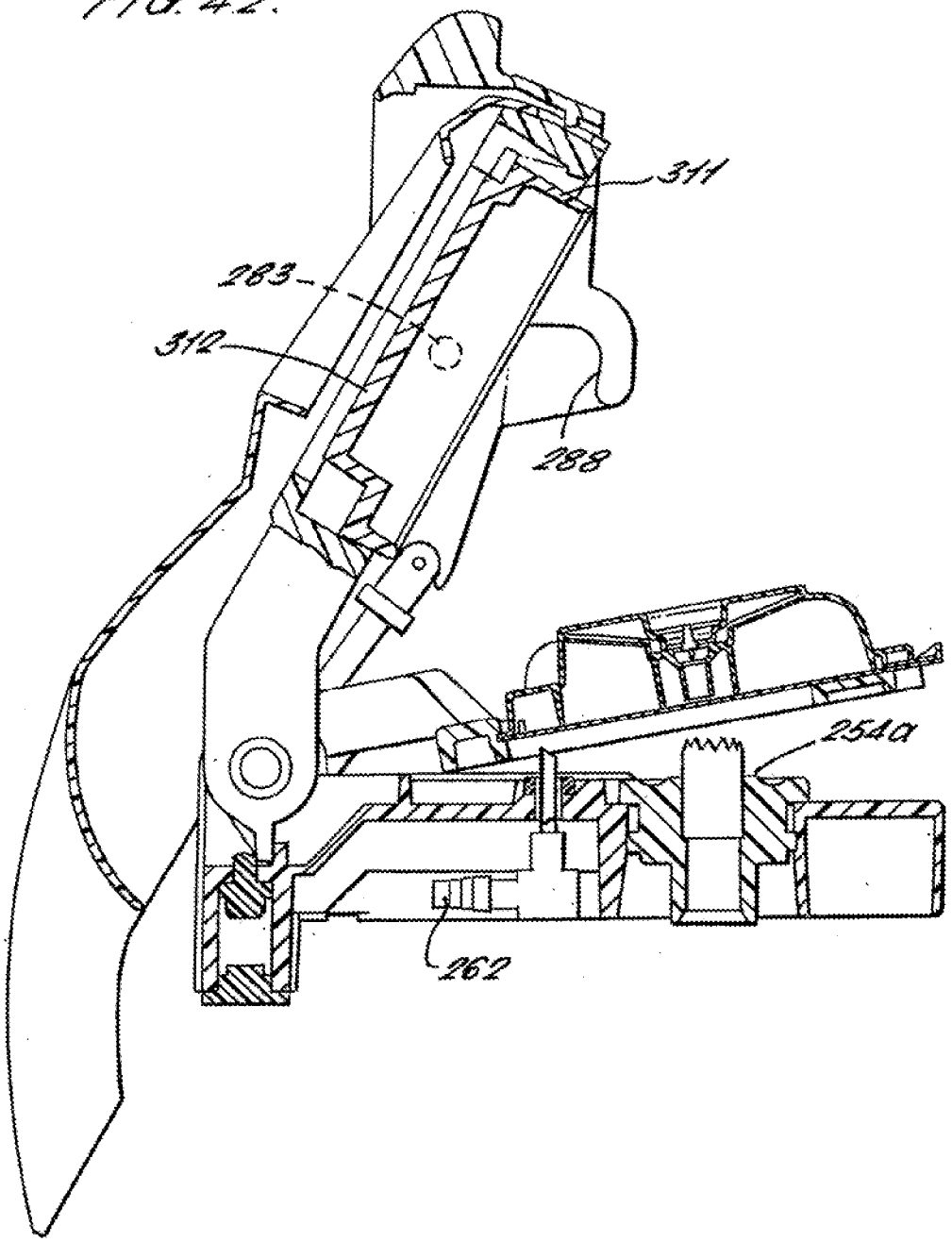


FIG. 41.

FIG. 42.



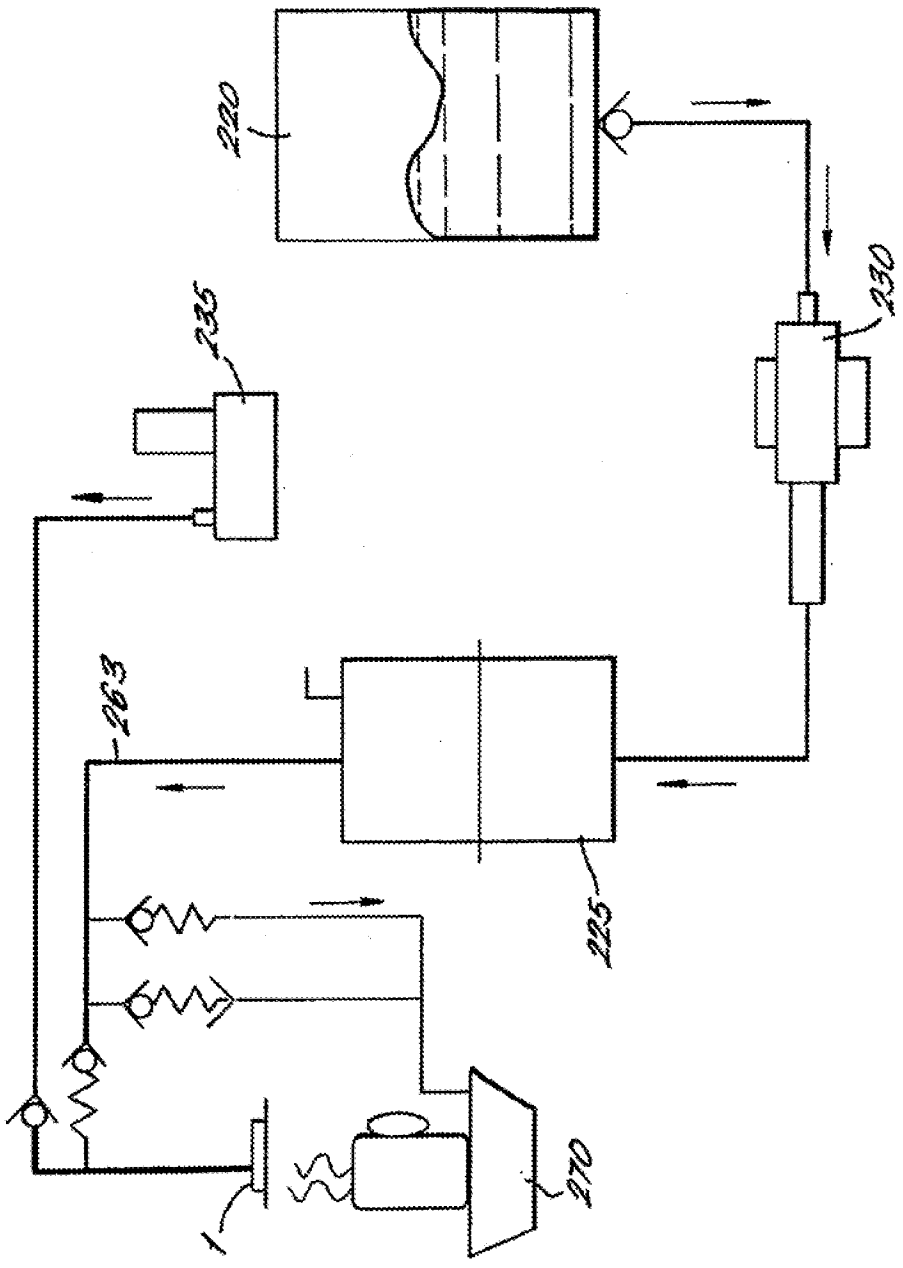


FIG. 43.

FIG. 44a.

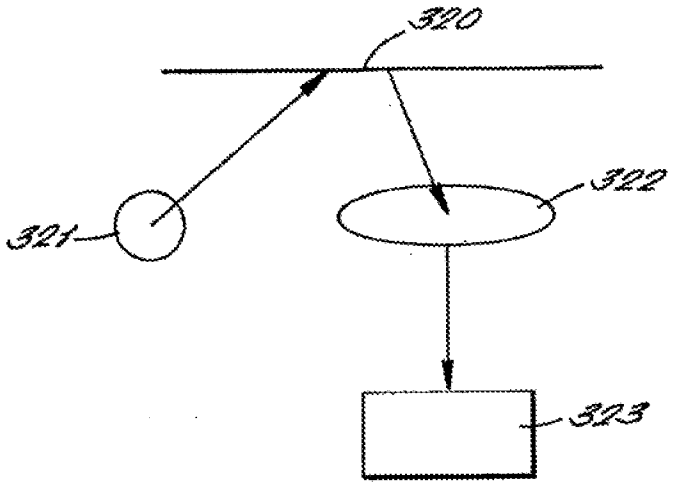


FIG. 44b.

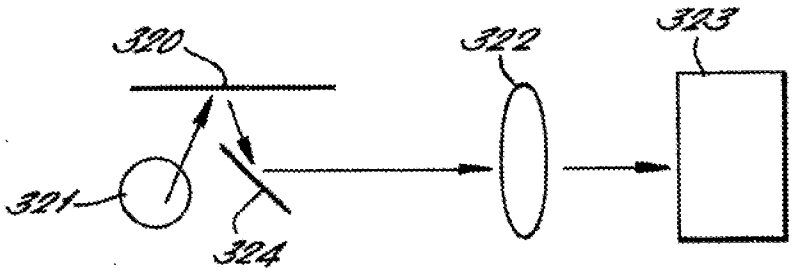


FIG. 45.

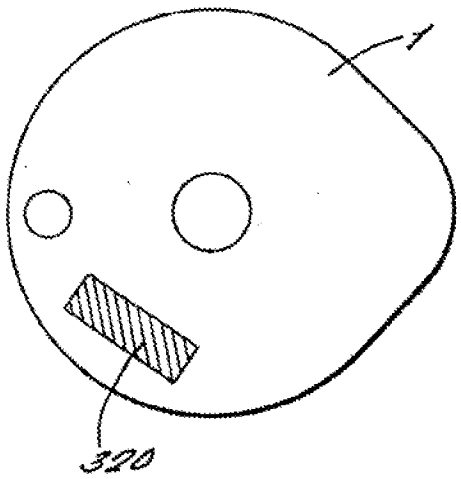


FIG. 46a.

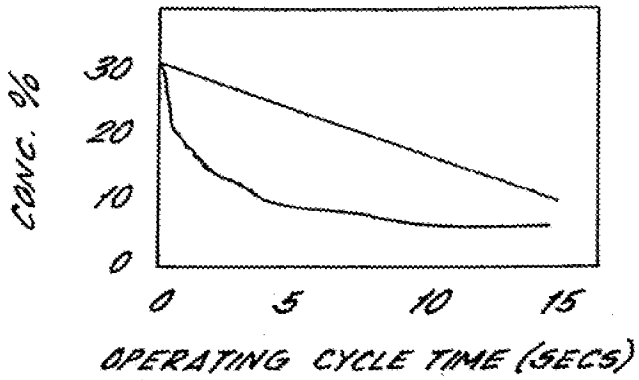


FIG. 46b.

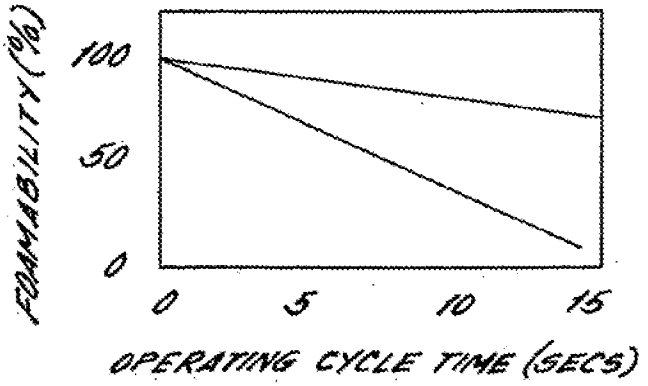
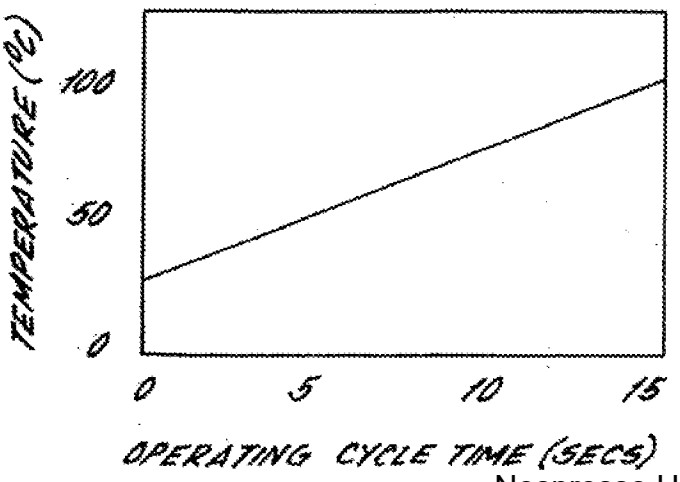


FIG. 46c.



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

PCT

(43) International Publication Date
11 October 2007 (11.10.2007)

(10) International Publication Number
WO 2007/114685 A1

(51) International Patent Classification:
B65D 85/804 (2006.01)

(21) International Application Number:
PCT/NL2007/000046

(22) International Filing Date:
16 February 2007 (16.02.2007)

(25) Filing Language: Dutch

(26) Publication Language: English

(30) Priority Data:
1031177 17 February 2006 (17.02.2006) NL

(71) Applicant *(for all designated States except US)*: **MECCANO ASIA LTD.**; 22/F One Capital Place, 18 Luard Road, Wanchai, Hong Kong (CN).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **VERBEEK, Roland Waldemar** [NL/NL]; 4, Het Domein, 1216-JP Blaricum (NL).

(74) Agent: **BROOKHUIS, H.J.A.**; Exter Polak & Charlouis B.V., P.O. Box 3241, 2280-GE Rijswijk (NL).

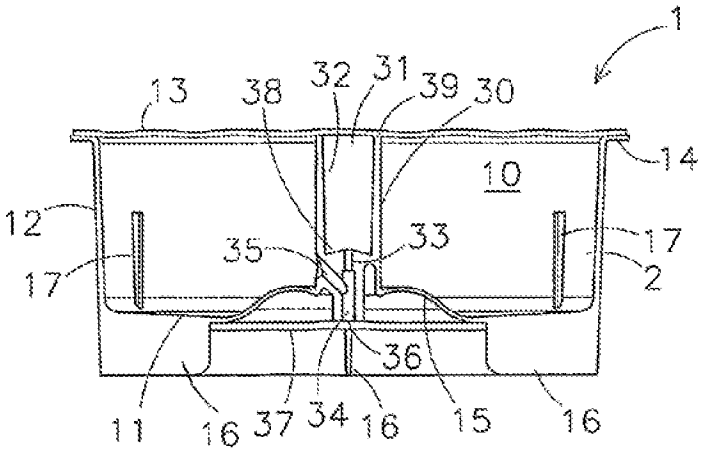
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, 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, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: PACKAGE AND DEVICE FOR PREPARATION OF A FOOD PRODUCT SUCH AS A BEVERAGE



(57) Abstract: A package for a portion of liquid foodstuff dilutable with a diluent, which package comprises a reservoir (10) for containing a portion of liquid foodstuff dilutable with a diluent, which reservoir has a filling aperture, a reservoir seal (13) for closing the reservoir, a mixing element (30) for mixing the dilutable liquid foodstuff with the diluent, which mixing element comprises a mixing chamber (34), which mixing chamber has an outflow aperture (36) for dispensing liquid foodstuff diluted with the diluent, a liquid passage for feeding dilutable liquid foodstuff from the reservoir to the mixing chamber, a feed channel (31) for feeding diluent to the mixing chamber, which feed channel has a first portion (32) and a second portion (33), the second portion having an outflow aperture which opens into the mixing chamber, and the cross section of the second portion being smaller than the cross section of the first portion and the cross section of the mixing chamber to such an extent that when diluent is fed to the mixing chamber a venturi effect occurs in the mixing chamber.

WO 2007/114685 A1

PACKAGE AND DEVICE FOR THE PREPARATION OF A FOOD PRODUCT SUCH AS A BEVERAGE

The invention relates to the preparation of a food product suitable for human consumption. In a preferred embodiment the invention relates to the preparation of a beverage or component of a beverage, in particular the preparation of milk froth. The invention is suitable in particular for the preparation of milk froth for a cappuccino.

In the invention use is made of a package, which is preferably disposable, filled with a portion of dilutable liquid foodstuff or a liquid ingredient to be mixed with a base liquid.

The invention also proposes a device which can be used in combination with the package.

A disposable package with a reservoir filled with a portion of dilutable liquid foodstuff or liquid ingredient is known. In a known embodiment a separate mixing element, provided with a mixing chamber, is fixed on the reservoir made of plastic. A vacuum is produced in the mixing chamber by creating a venturi effect, so that the dilutable liquid foodstuff or the liquid ingredient is drawn out of the reservoir. This known package is complex and consequently expensive to produce. In addition, the known package requires many assembly steps during its production, which increases the cost even further.

One object of the invention is to provide an improved package.

Another object is to provide a package which can be mass-produced at relatively low cost.

Another object is to provide a package which can be handled in an attractive manner on a filling unit for filling the package, for example with a milk ingredient.

Another object is to provide a package which is reliable when it is a matter of food safety.

Another object is to provide a package which is easy for the user to use, particularly for use by a consumer in the home.

In order to achieve one or more of the abovementioned objects, the invention according to a first aspect thereof provides a package as described in claim 1. In accordance with that first aspect, the

invention also provides a package as described in claim 17.

In the package according to the first aspect of the invention the plastic body is produced in one piece by means of injection moulding. This means that a separate assembly step is no longer necessary in the production. Making the body of one piece also means that the shape of the mixing element or column can be kept relatively simple because no assembly is required. Furthermore, sealing problems do not occur in such a monolithic construction.

In an advantageous embodiment the body has a bottom, and the mixing element or column is connected directly to the bottom. The mixing element or column then in fact stands in the reservoir.

The bottom preferably has a flexible portion. The mixing element or column can consequently be moved, preferably particularly in the vertical direction, relative to a non-flexible portion of the bottom and/or relative to the circumferential wall. This possibility of movement can be used for opening or otherwise activating the package, as will be explained further.

In a possible embodiment the flexible bottom portion is provided in the form of a protuberance.

Provision can also be made for the flexible bottom portion to be of a bistable design. The mixing element or column in that case has a first stable position and a second stable position, which is preferably lower than the first stable position.

For example, the protuberance projects upwards in the reservoir in the first stable position and downwards relative to the reservoir in the second stable position. The protuberance of the portion of the bottom concerned makes it possible to move the mixing element or column connected to said protuberance into another, lower position relative to the remainder of the reservoir. This possibility of movement can be used for opening or otherwise activating the package and assists with the emptying of the reservoir.

The movable arrangement of the mixing element or column is used in an advantageous embodiment for opening the package, notably for opening a seal on the underside of the package in that way.

In an advantageous embodiment a breakable or removable seal, for example with a plastic film or plasticized aluminium foil, is provided at the outlet aperture situated on the underside of the package. Said seal is, for example, connected to a rigid portion of the bottom, in other words a portion of the bottom lying around the

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 209 of 387

flexible portion. In the initial position, which can correspond to the first stable position if a bistable protuberance has been provided, the protuberance projects inwards in the reservoir. Pressing the mixing element or column down now causes the protuberance to be moved downwards. In the case of a bistable protuberance the latter is preferably taken into its second stable position as a result, in which case the protuberance points outwards. The underside of the mixing element or column is also moved down in the process, and in doing so pierces the bottom seal, which is applicable particularly if a sealing film or foil is provided. In another embodiment of this seal it is, for example, the case that the downward movement causes the seal to be pushed away to the side. For example, a sealing element with a hinged arm is fixed on the underside of the package, in such a way that during downward movement said sealing element swings away out of the path of the dispensed jet.

In an advantageous embodiment the mixing element or column is placed substantially in the centre of the reservoir. It has been found in practice that a good discharge out of the package can be achieved in this way.

In one embodiment the circumferential wall forms a filling aperture on the upper side and a reservoir seal or top seal which protects the contents of the package from the atmosphere is provided there. In this way the reservoir can be filled through a relatively large filling aperture, after which a top seal can be placed in a simple manner, for example with known equipment for placing a film or foil seal over an aperture on the upper side of a plastic package.

It is advantageous if the reservoir seal or top seal is breakable at the position of the channel, notably can be pierced or removed by a lance.

It is not necessary for a seal also to be present between the reservoir and the channel. The absence of such a seal leads to a simpler production of the package.

The package according to the first aspect of the invention, through its simple production and possible low cost, is suitable for mass production and as a disposable package for a single use.

According to a second aspect of the invention, a package according to claim 47 is provided. In the case of this package provision is made for the column - through the engagement of a base

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 210 of 387

liquid feed lance on to the column - to be moved from a higher initial position higher to a lower dispensing position.

This movability of the column has already been described and explained above with reference to the preferred embodiments of the package according to the first aspect of the invention. In that first aspect of the invention the body of the package is made monolithically of plastic material. That construction detail is an advantageous embodiment, but is not essential in the case of the package according to the second aspect of the invention. In particular, a package according to the second aspect of the invention could be made of several components which are assembled. For example, in the case of the package according to the second aspect of the invention the column is made separately and fitted later on the component forming the circumferential wall and bottom of the package.

For example, the package according to the second aspect of the invention is designed specifically for multiple use. For example, this package is dishwasher-safe.

For example, the circumferential wall and an annular part of the bottom are made of metal, such as stainless steel, the flexible portion of the bottom being formed by a suitable elastomeric component, and the column being also of stainless steel or another suitable material. Such a package can have a large filling aperture on the upper side, for example just as explained in the case of suitable embodiments of the package according to the first aspect of the invention, but the filling aperture can also be smaller or can be in a different place. For example, the package can have a cover (preferably removable or hinged) with a hole above the column, so that a lance can act upon the column. When the cover has been removed or is open the user can then fill the package and put on or close the cover, and can then place the package in a suitable device.

The invention furthermore relates to a system according to claim 50 and a system according to claim 81.

The invention also relates to a device for preparation of a beverage according to claim 13.

The invention also relates to a device according to claim 70 and to a device according to claim 71.

The device has a holder for accommodation of a package according to the invention.

The device can also be provided with several holders for

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 211 of 387

simultaneous accommodation of several packages according to the invention or of several types of holders, for example one for accommodation of a package according to the invention and one for another type of package, for example a coffee pad.

The invention also relates to such a device which does not accommodate a package according to the invention, but two different packages, preferably single-portion disposable packages, the device having, for example, a lance which connects to a channel in one of said packages and then, on the basis of some suction effect or other, draws a liquid ingredient out of the reservoir of said package and subsequently mixes it with liquid, such as (hot) water, supplied through the lance. A package according to the invention is preferred here. The first and second package can preferably be placed by the user in a common holder.

The device preferably has a water feed means which connects to a feed lance for the diluent or base liquid. The lance and the holder for the package(s) are preferably movable relative to each other by means of suitably designed controllable movement means of the device.

The lance and the package(s) can be moved relative to each other, for example when the user closes the device after placing the package in the device. In that case the operable displacement means are operated by closing the system. It is, however, also possible for the lance and the package(s) to move relative to each other when the user actuates the system, for example by means of a push button. In that case the operable displacement means are operated by activating the system.

In an advantageous embodiment the lance is adapted to break or remove a seal provided over the channel of a package. During insertion of the lance into the inlet of the channel the lance can pierce and/or push away the seal.

In a further advantageous embodiment the lance is equipped to act upon the mixing element or column in order to deform the flexible portion of the bottom of a package and thus take the mixing element or column into a different position, preferably downwards relative to the initial position.

For instance, during use of a package with a protuberance, bistable or otherwise, in the bottom said protuberance can be taken from the first position into the second position by the lance. During this process any seal which may be present over the outflow aperture

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 212 of 387

of the package can be broken or removed.

Apart from that, it is also possible to realize a reusable package on the basis of the package according to the first aspect of the invention.

The package can be used, for example, for preparing coffee, cappuccino, drinking chocolate, broth, fruit juice or soft drinks.

It is advantageous if the package is sterilizable, because in that case the contents of the package do not have to be subjected to a high temperature for a long time. If the package is filled with, for example, concentrated milk or concentrated orange juice, this is beneficial for the quality and the taste of the contents.

Packages according to the invention and also devices and systems are described further in the claims and will be described below in a non-limitative way with reference to the appended drawing.

The drawing shows in:

Fig. 1: a first embodiment of a package according to the invention, in cross section;

Fig. 2: the embodiment of the package according to Fig. 1 in a device according to the invention, in a first phase of use;

Fig. 3: the embodiment of the package according to Fig. 1 in a device according to the invention, in a second phase of use;

Fig. 4: the embodiment of the package according to Fig. 1 in a device according to the invention, in a third phase of use;

Fig. 5: the body of a second embodiment of the package according to the invention, in a view from the top in perspective;

Fig. 6: the body of Figure 5 in a view from the bottom in perspective;

Fig. 6a: the illustration of Figure 6 with bottom sealing film;

Fig. 7: the body of Figure 5 in vertical section with the column in the initial position;

Fig. 8: the body of Figure 5 in another vertical section;

Fig. 9: a detail of the body of Figure 5 on a larger scale in the initial position of the column;

Fig. 10: a part of the body of Figure 5 with the column in the dispensing position;

Fig. 11: diagrammatically an example of a device suitable for combination with a package according to the invention;

Fig. 12: diagrammatically an example of a holder for the system according to the invention;

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 213 of 387

Fig. 13: diagrammatically in section the holder of Figure 12 and corresponding parts of the device of the system according to the invention;

Fig. 14: diagrammatically an example of an alternative device suitable for combination with a package according to the invention;

Fig. 15: diagrammatically a part of an example of an alternative system according to the invention.

Fig. 1 shows a first embodiment of a package 1 according to the invention. The package 1 comprises a reservoir 10 and a mixing element or column 30. The reservoir 10 is intended for the accommodation of a dilutable liquid foodstuff or liquid ingredient for a foodstuff suitable for human consumption. The package can be filled with, for example, a portion of concentrated milk, concentrated fruit juice or concentrated broth.

The reservoir 10 is preferably filled approximately 2/3 full, preferably through the aperture formed by the circumferential wall on the upper side of the package 1. The reservoir 10 is then closed by a reservoir seal 13.

The reservoir seal 13 is preferably a suitable film, for example a plastic film and/or metal foil (possibly multi-layer).

The reservoir seal is preferably slightly elastic, for example through the use of a PE film. The sealing film 13 is preferably fixed by means of a fusion weld on the upper edge of the circumferential wall of the package 1. On a closed package the reservoir seal 13 is fixed on the reservoir by means of the sealing edge 14.

The reservoir 10 has a bottom 11 and a circumferential wall 12. The circumferential wall 12 is preferably of a slightly tapered design, the remaining shape of the package preferably being such that the empty packages 1 which are not yet filled and provided with a sealing film are nestable.

For making, for example, milk froth for the preparation of cappuccino the package has a circumferential wall with a diameter of 55 millimetres and a height of 23 millimetres.

The package can be made of food-grade plastic, for example PP or PE.

It is not necessary also to provide a seal between the reservoir 10 and feed channel 31, for example by connecting the reservoir seal 13 also to the upper edge 39. If such a seal is not present, liquid foodstuff can run into the feed channel 31, for

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 214 of 387

example during conveyance of the package, but during use it is flushed out again by the diluent or base liquid. The absence of a seal between the reservoir 10 and the feed channel 31 makes production of the package according to the invention considerably simpler.

The bottom 11 of the reservoir 10 in this example is stiffened by means of stiffening ribs 16. A number of stacking lugs 17, for example three, are provided on the inside of the circumferential wall 12. The stacking lugs 17 ensure that damage is not caused to the mixing element 30 during the nesting of empty packages 1.

In the example shown the package 1 is substantially disc-shaped. A circular symmetrical shape such as a disc has the advantage that the package can be placed in any desired orientation in a holder. If a particular orientation is still desired, the circular symmetrical shape can be departed from, so that the package can be placed in only one way in the holder.

It can be seen clearly in Figure 1 that a protuberance 15 is provided in the bottom 11 of the package 1. The mixing element 30 is present on said protuberance 15.

The feed channel 31, with inlet on the upper side of the mixing element, is formed in the mixing element 30 during the injection moulding, and a mixing chamber 34 is also co-moulded during the injection moulding. Liquid foodstuff or ingredient from the reservoir 10 can be mixed with a diluent in said mixing chamber 34. The liquid foodstuff or ingredient from the reservoir is fed to the mixing chamber 34 through one or more ducts or passages 35, here a single passage 35, formed in the mixing element during the injection moulding. The diluent or base liquid is fed to the mixing chamber 34 through the feed channel 31.

The feed channel 31 has a first portion 32 and a second portion 33. As can be seen clearly in Fig. 1, the second portion 33 of the feed channel 31 has a cross section which is significantly smaller than the cross section of the first portion 32 of the feed channel 31 and of the mixing chamber 34. The ratio between the cross sections of the two portions 32, 33 and the mixing chamber 34 is selected in such a way that when diluent, for example water, is fed in through the feed channel 31 to the mixing chamber 34 a venturi effect occurs in the mixing chamber 34. Said venturi effect creates a vacuum in the mixing chamber 34, with the result that liquid foodstuff flows out of

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 215 of 387

the reservoir 10 through passage 35 into the mixing chamber 34. The turbulence as a result of the venturi effect also ensures good mixing of the liquid foodstuff or ingredient from the reservoir 10 with the diluent or base liquid.

The selection of the cross section of the passage 35 in relation to the cross section of the second portion 33 of the feed channel 31 partly determines the mixing ratio between the liquid foodstuff or ingredient, on the one hand, and the diluent or base fluid, on the other hand. Making the parts of the injection mould that determine the respective cross sections removable from the mould means that these cross sections are relatively easy to change.

The mixture leaves the mixing chamber 34 through the outflow aperture 36 on the underside of the package 1. When the package is closed said outflow aperture 36 is sealed by a suitable seal 37. Said seal 37 can be in various forms. An example is a cap or a sealing film or foil, which is removed by the user before use. The seal can also be removed or broken automatically when the package is placed in a suitable device according to the invention and the device is then activated.

It can be seen in Figure 1 that the second portion 33 of the feed channel 31 in this illustrated embodiment does not connect up to the lowest point of the first portion 32 of the feed channel 31. This means that a dead space 38 is produced. Any sediment from the liquid foodstuff to be diluted can settle in said dead space 38 without the second portion 33 of feed channel 31 becoming blocked.

Figure 2 shows the embodiment of the package 1 according to Figure 1 in a device 50 according to the invention, in a first phase of use.

The device 50 according to the invention comprises a holder 55, in which a package 1 according to the invention can be placed. Figure 2 shows a package 1 placed in the holder 55. The holder 55 is situated in a low position, so that there is still some distance between a lance 52 of the device which is connected to a suitable water supply 51, on the one hand, and the feed channel 31 of the package 1, on the other hand.

The protuberance 15 in the bottom 11 of the reservoir is raised and therefore facing inwards in this phase. The bistable protuberance 15 is now situated in its first stable position.

Figure 3 shows the embodiment of the package 1 according to

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 216 of 387

Figure 1 in a device 50 according to the invention, in a second phase of use.

The holder 55 has now moved upwards in the direction of the lance 52. The free end of the lance 52 is now projecting into the first part 32 of the feed channel 31. The slanting side 57 of the lance 52 has broken through the part of the reservoir seal 13 which sealed the feed channel 31. The water feed means 51 can now feed water to the mixing chamber 34 through the feed channel 31.

The major part of the reservoir seal 13 is still intact. This prevents splashing and consequently soiling of the device 50. It is otherwise conceivable for one or more small holes also to be pierced in the reservoir seal 13 when the holder 55 is moved upwards. This prevents undesired pressures, for example in that the package draws vacuum during emptying of the reservoir 10. A suitable projection can be provided on the lance 52 for this purpose, if desired.

Instead of the holder 55 moving upwards to the lance 52, it is also possible for the lance 52 to move downwards.

Figure 4 shows the embodiment of the package 1 according to Figure 1 in a device 50 according to the invention, in a third phase of use.

The holder 55 has now moved slightly further upwards, in the direction of the lance 52. In this embodiment the lance 52 has a collar 53, which is preferably provided with a rubber ring 54. The collar 53 exerts a downwardly directed force by way of ring 54 upon the mixing element 30. The result is that the protuberance 15 is deformed and springs into its second stable position, in which the protuberance 15 is directed outwards. The mixing element 30 is moved downwards as a result. During this process the underside of the mixing element 30 pierces the sealing film 37 extending along the bottom of the outflow aperture 36 of the mixing chamber 34.

The holder 55 has a dispensing aperture 56 through which the mixture of liquid foodstuff or ingredient from the reservoir 10 and diluent or base liquid can leave the device 50. The dispensing aperture 56 is preferably so wide that the mixture does not come into contact with the device 50. Soiling of the device 50 is prevented in that way.

Through the elasticity of the material of the reservoir seal 13, the upper side of the reservoir 10 remains substantially closed in the embodiment shown, except for the hole for the lance 52. This

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 217 of 387

prevents soiling of the device 50.

In an alternative embodiment the protuberance 15 can also be of a non-bistable design. This means that a force remains upon the mixing element 30 and upon the lance 52 during emptying of the reservoir.

The invention furthermore also provides an embodiment in which, in addition to at least one recess for the accommodation of a package according to the invention, the holder 55 also has at least one recess for the accommodation of a coffee pad. In that situation when a package filled with concentrated milk and a coffee pad are placed in the holder a cup of cappuccino can be prepared.

A second exemplary embodiment of the package according to the invention will now be explained with reference to Figures 5 - 10.

These Figures 5 - 10 show a plastic body of a disposable package 100, which can be filled with a portion of a liquid ingredient intended for mixing with a base liquid for a food product suitable for human consumption, notably a beverage which can be cold or hot as desired.

Before filling, the package is preferably sterilized, and the filling is preferably performed under aseptic conditions. In that case the package is also sealed under aseptic conditions, so that the ingredient is protected from the atmosphere.

A particularly interesting application is when the package is filled with a milk ingredient, which is mixed with hot water, preferably at a temperature of at least 70 degrees Celsius, preferably not boiling, as the base liquid, so that milk froth on top of a cup of coffee, for example such as cappuccino, or for example on hot chocolate, can be obtained.

For example, the package is filled with a milk concentrate that remains stable when stored at room temperature, for example milk that is sterilized for 1 to 5 seconds at 116 - 122 degrees.

It will be clear that the package can also contain another liquid beverage preparation ingredient or an ingredient for preparing another food product, such as a soup. As already mentioned, the food product to be prepared can also be cold, for example if the ingredient is mixed with cold or even chilled water, possibly even carbonated water.

The food product to be prepared with the package does not have to be in a frothed form, as appears, for example, from examples

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 218 of 387

mentioned earlier such as the preparation of fruit juice.

If it is desired that little or no froth should be formed on the dispensed mixture, the geometry of the venturi portion and/or of the passages connecting to it can be adapted. Of course, the ingredient itself also has an influence on any froth formation, and the froth formation or absence of froth formation can also be influenced by adapting the recipe of the ingredient.

It appears, for example in the case of milk froth, that the distance of the outflow aperture of the package from the bottom of a mug or the like into which the mixture is dispensed can also play a role in the froth formation. For instance, experiments seem to demonstrate that a relatively great distance leads to a large quantity of froth with fairly large bubbles and consequently limited stability. Reduction of that distance can then produce a more stable froth with finer bubbles.

For example, milk froth with bubbles which are substantially less than 1.5 millimetres is obtained.

In particular, the package according to the invention and a suitable device can be used first to prepare a relatively thick milk froth layer, preferably over 1 centimetre thick, in a cup or the like to be used by the consumer, and then (preferably with the same device or possibly with another device) to prepare coffee, preferably on the basis of a coffee pad or another single-portion coffee ingredient package, which goes in a jet or stream from above onto the milk froth layer and sinks down through said froth layer. A thick, firm layer of milk froth is ultimately obtained on the top of the coffee, so that a cappuccino is prepared. The device is possibly equipped for the preparation of a café crème with a thin, fine-frothed creamy layer, on top of which the thick, firm froth layer obtained with the package according to the invention then lies.

It is for example a possibility that the package contains a quantity of ingredient which is mixed with a certain quantity of base liquid, and that, if all of the ingredient in the package has been discharged, base liquid is still supplied by the device to the channel of the package. The effect is then that a relatively strong jet of base liquid goes onto the mixture already dispensed into a cup or the like, so that the mixture can be made to froth well. This was found, for example, during the preparation of milk froth described earlier, in the case of which, for example, 15 - 30 ml of milk

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 219 of 387

ingredient is present in the package. When hot water is supplied the milk ingredient is drawn from the package in a few seconds, and said mixture can then be brought into vigorous agitation with the jet of hot water still spouting out of the channel of the package. The narrow passage of the venturi portion then causes the fast jet of water. This process appears to be influenced by the thickness of the layer in the bottom of the holder into which the mixture is dispensed, into which layer the fast jet is then squirted.

The package 100 here has a monolithic plastic body 101, produced by injection moulding, with a bottom 102 and a circumferential wall 103, in which the upper edge 104 of the circumferential wall 103 bounds an aperture. As already mentioned, the reservoir of the package 100 is preferably filled with the ingredient through said aperture, so that known filling techniques can in principle be used.

After filling, said aperture is hermetically sealed by a top sealing film (not shown), which is fixed on the upper edge 104 on its circumference, here to an outwardly directed circumferential flange 104a, preferably by means of a fusion weld. Such fusion welding technology and also sealing film for this purpose are generally known in the field of plastic holders for food products, such as, for example, for packages of individual evaporated milk portions, desserts etc., to be sealed with film.

The package 100 is preferably filled and sealed under aseptic conditions on a suitable filling machine.

The monolithic plastic body 101 has a central column 110, which is integral with a central portion of the bottom 102, which column 110 has a portion 110a that projects upwards from the bottom to an upper side of the column, and in the example shown here also has a portion 110b that projects below the bottom 102.

A channel 115 extends through the column 110 from an inlet 116 on the upper side of the column 110 to an outflow aperture 120 on the underside of the column 110, and therefore on the underside of the package.

The top sealing film is breakable, preferably piercable, so that a base liquid feed lance can be taken through said sealing film and can then be connected to the inlet 116 of the channel 115 in the column 110, so that the base liquid can be fed through the channel 115 to the outflow aperture 120.

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 220 of 387

A venturi portion 130 (visible in detail in Figure 9) is present in the channel 115, to which venturi portion one or more passages 131 for the ingredient formed in the column 110 are connected, in such a way that when base liquid is passed through the channel 115 a venturi effect occurs and the ingredient goes through the one or more passages 131 into the venturi portion 130 and mixes there with the base liquid, which mixture is dispensed at the outflow aperture 120 of the column 110.

The channel 115, the venturi portion 130, and the passages 131 are - as is preferable - all fully formed during the injection moulding of the body, so that no further operations were necessary to make those parts or to finish them.

The bottom 102 here has an annular flexible portion 140 around the column 110, so that the column 110 is movable downwards relative to the upper edge of the body 101 and back up again here in an elastically shape-recovering manner.

The column 110 is therefore movable here between a higher initial position (Figures 5 - 9) and a lower dispensing position (Figure 10) relative to the upper edge of the body, preferably with a height difference of at least 3 millimetres.

It can be seen that the flexible portion 140, viewed in cross section, is in the form of one or more undulations, formed here by coaxial annular parts, which in this example are in each case at a higher level from the outside towards the inside (in the initial position of the column 110).

It can be seen that here in the initial position the upper side of the column 110 lies in the plane of the upper edge 104, so that when the top sealing film is present the upper side of the column goes against the underside of said sealing film. This makes it easier to pierce the sealing film, since the column forms a sort of counter-support here on the underside of the film.

As explained earlier, the presence of a "seal" between the upper side of the column and the top sealing film is not critical, but in this simple manner the inlet 116 is nevertheless more or less sealed relative to the reservoir with the ingredient.

It is preferable for the package to be filled with the liquid ingredient to a level at a distance below the upper side of the central column. For the filling technique it is also advantageous if the level of the ingredient lies at a distance below the upper edge

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 221 of 387

of the package.

It is conceivable for liquid ingredient to be present in the column after the filling and/or for the column to be relatively short with its upper side lying at a distance below the sealing film, possibly even below the level of the ingredient.

In this example it can also be seen that in the initial position the underside of the column 110 lies in the plane of the underside of the bottom 102.

As is preferred, a bottom sealing film is provided, which sealing film is placed along the bottom of the outflow aperture 120 on the underside of the bottom of the package. Said sealing film 141 is visible in Figure 6a.

The underside of the column 110 in the initial position preferably lies against the bottom sealing film 141.

Said bottom sealing film 141 is fixed on the underside of the bottom in a region 142 around the flexible portion 140 of the bottom. Said film 141 is preferably placed already before the filling (and possibly sterilizing) of the package.

The person skilled in the art will understand that when the column 110 is pressed down to the dispensing position the bottom portion 110b of the column 110 goes with force against said bottom film 141 and breaks, in this case pierces, said film 141, so that the outflow aperture 120 is opened. The bottom film 141 here remains adhering to the bottom 102 in the annular region 142.

In this example it can also be seen that the circumferential wall 103 projects below the bottom 102 and has a lower edge 105 which defines an imaginary flat supporting surface of the package 100, so that the package can be placed with the lower edge of the circumferential wall stably on a surface. In that case the bottom sealing film 141 is lying higher up than said lower edge 105, so that undesirable damage to said film 141 is avoided, for example during handling/conveyance of the package when it is being filled on a filling machine.

For the stability of the body 110, co-moulded ribs 107 are provided here between the bottom 102 and the part of the circumferential wall 103 that projects downwards.

The venturi portion 130 shown has a narrow passage 132, in this example, which is adapted for milk froth, having a diameter of 0.8 millimetres, followed by a chamber 133 with a larger diameter, here

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 222 of 387

of 1.2 millimetres. It will be clear to the person skilled in the art that for other ingredients and/or base liquid the dimensions and shape of the venturi portion can be selected differently.

As regards the venturi portion 130, it can furthermore be seen in this example that from the chamber 133 of the venturi portion 130 to the outflow aperture 120 the channel has a substantially uniform cross section, which in any case is greater than the diameter of the narrow passage 132. That has the advantage, inter alia, that, if the package has been emptied and liquid is still being fed to the channel, a fast jet is dispensed through said passage 132 and remains clear of the surrounding wall until it reaches the outflow aperture 120, so that it is not disturbed. Said fast jet can then be used to froth, or further froth, the mixture dispensed earlier.

The venturi portion 130 here lies substantially at the level of the surrounding portion of the bottom 102, so that no "upward conveyance" of the ingredient is necessary and the reservoir can be emptied well and quickly. For the purpose of good emptying of the package provision is made here for the passages 131 in the column 110 each to have an inflow aperture close to the surrounding region of the bottom.

Furthermore, one or more passages 131, in this example two disposed diametrically opposite each other, are provided in the column 110 with a corresponding inflow aperture on the outer circumference of the column, for the feeding of the ingredient to the venturi portion. The passages 131 are funnel-shaped here, viewed from the inflow aperture to the venturi portion. Furthermore, the passages 131 here are placed at an angle slanting downwards, viewed from an inflow aperture to the venturi portion.

It is pointed out that in the package illustrated only the one or more passages 131 for the liquid ingredient connect to the venturi portion 130, and not any additional passages in the column for the suction of air to the venturi portion. That has not been found to be necessary for the quality of the frothing, and it produces a simple construction.

Figure 10 shows diagrammatically a lance 170 acting upon the column 110 and thereby pressing the column 110 downwards to its dispensing position.

It can be seen that the flexible portion of the bottom 140 now forms a downward-facing funnel, so that all liquid ingredient passes

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 223 of 387

through the inflow apertures, which are now low down, into the passages 131.

When the lance 170 is removed again (or the package is removed from the lance), the shape-recovering flexible portion 140 of the bottom will ensure that the column 110 and the surrounding flexible portion of the bottom move back again to, or at least in the direction of, the initial position. In the process the inflow apertures now reach a position higher up than the surrounding bottom, so that any residue of ingredient does not leak out of the package through the outflow aperture 120.

For ease of placing the package in a device, provision is made for the circumferential wall 102 to be cylindrical and for the column 110 to be disposed on the axis of the cylindrical circumferential wall, the inlet 116 of the channel 115 likewise being disposed on said axis, and the outflow aperture 120 preferably also being disposed on said axis. This concentric arrangement of the components also makes it easier to handle on a filling machine.

A system for preparation of a food product suitable for human consumption, notably a beverage or component of a beverage, in particular for preparation of milk froth for a cappuccino, will now be explained with reference to Figure 11.

Figure 11 shows a device 200, in this example intended for domestic use. Said device 200 has a housing 201 with a base 202, an erect housing part 203 and an overhanging housing part 204. Of course, other embodiments are also conceivable.

A holder 210 for accommodating and retaining a package according to the invention (here, as an example, package 100) is present in the device at a dispensing position in the device. The holder 210 accommodates the package 100 in the normal position, with the bottom down and the top sealing film up. In particular, the package 100 rests here on its lower edge 105 on the holder. There is an aperture 211 in the holder 210 in line with the outflow aperture 120, so that the jet of mixture or base liquid can squirt in a downward direction out of the package and then through the aperture 211 into the mug 300 or other beverage holder. Said aperture 211 is so large here that the mixture does not make contact with the holder 210, so that soiling is prevented.

As mentioned earlier, the preparation of milk froth, in which the package 100 is filled with a milk ingredient, will be explained

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 224 of 387

here as an example.

Facilities indicated in general by base liquid feed means are present in the device 200, here for the preparation and feeding of hot water to the package 100.

A supply tank 220 for a supply of water can be seen, here a tank 220 which can be removed by the user and refilled under the tap, and which has a self-closing valve 221 which closes when the supply tank is disconnected from the device.

A water circuit is present in the housing of the device, said water circuit having a system of one or more pipes, and furthermore having an electric pump 225 and a heating assembly for heating the base liquid, here an flow-through electric water heater 230, for supplying hot, preferably not boiling base liquid, preferably hotter than 70 degrees, to the lance. If desired, one or more valves, preferably electrically controllable valves, can be provided in the water circuit. Instead of being an flow-through water heater, the water heater could also be a hot-water boiler, or a combination of the two.

The water circuit connects to a lance 240, which is mounted, in a stationary position here, on the underside of the overhanging part 204 of the housing 201, said lance being situated at the dispensing position.

As explained earlier, the lance 240 is adapted to pierce the top sealing film of the package 100 and to connect to the channel 115 in the column 110, so that water can be fed through the lance 240 to the channel 115 and thereby, on the basis of the venturi effect, the ingredient flows through the one or more passages 131 to the venturi portion and is mixed there with the water, and the mixture is dispensed through the outflow aperture 120, here to the mug 300 disposed on the base 202.

As described, provision is made for the lance 240 to act upon the column 110 in order to press said column downwards and therewith also to break through the bottom film 141. That requires a relative movement between holder 210 and the lance 240, which can be achieved in many different ways.

The device 200 is preferably provided with operable (manually, electrically or the like) displacement means which are adapted to produce a relative movement of the holder 210 for the package 100 relative to the lance 240, so that when the displacement means are

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 225 of 387

operated the lance 240 pierces the top sealing film of the package, and the bottom sealing film 141 is also broken in the process.

In a simple embodiment the displacement means are a manually controllable lever mechanism 270, for example with a handle 271 on the front side of the overhanging part 204 of the housing.

In this example provision is made for the holder 210 to be removed by the user, and it can then be filled with the package, after which the holder can be replaced in a carrier 250 belonging to the device.

The carrier 250 is connected to the lever mechanism 270 and can be moved up and down by operation of said mechanism.

One or more vertical guides are preferably provided in the device, which guides guide the carrier 250 substantially in the vertical direction relative to the housing 201.

The holder 210 can preferably be pushed from the front side into the carrier 250, so that the consumer can first remove the holder 210, can place the package 100 in it, and can then slide holder 210 back into the carrier 250. Operating the handle 271 then causes the carrier 250 to move upwards with holder 210 and package 100. The lance 240 then goes against the top film and pierces said film, and the column 110 is then pressed downwards relative to the package 100 which is moving upwards. In this way the package 100 reaches the position of Figure 10.

Putting into operation the feed of hot water to the lance 240 now leads first to a mixture of ingredient, in this example milk, and the hot water being dispensed into the mug 300. When the package is empty, a jet of hot water is squirted at high speed, notably because of the narrow passage of the venturi portion, through the package 100 into the mug, and onto the milk and water mixture dispensed earlier, which jet is thereby formed into a stable milk froth of high quality.

After dispensing, the carrier 250 can be moved down again by operating the mechanism 270, and the holder 210 can be removed and the empty package 100 thrown away.

During the dispensing there has been no contact here between the jet of mixture and the device, so that no soiling occurs. The channel 115 of the package has been flushed out by the stream of water, so that no milk can drip out there either. Furthermore, when the carrier 250 moves down the column 110 is moved up again by the shape-recovering portion 140, so that any residue in the package does

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 226 of 387

not reach the passages 131 if the package is kept more or less straight.

As mentioned earlier, it is furthermore conceivable to arrange an additional preparation and dispensing assembly in the housing of the device for the purpose of preparing, on the basis of a second ingredient, which differs from the ingredient in the abovementioned package according to the invention, a second, different food product suitable for human consumption, for example a beverage or component of a beverage, for example for coffee.

The additional preparation and dispensing assembly preferably has a corresponding dispensing orifice for dispensing the food product prepared on the basis of the second ingredient, which dispensing orifice is preferably situated near the outflow aperture of the first package, in the dispensing position of said package, (or can be taken into that position if the dispensing orifice is movable), in such a way that a mug or other holder into which the streams from the first package and the dispensing orifice are dispensed does not need to be moved, and can then receive both streams (in succession, simultaneously or with a certain overlap in time). This mutual distance is preferably no more than 5 centimetres.

An appropriate embodiment of the device is for preparing coffee with said additional preparation and dispensing assembly. With the first package, which is preferably designed according to the invention, milk froth can then be made, and the coffee can be prepared subsequently with the additional station, which coffee can then flow through the froth, so that a layer of milk froth is produced on the coffee, as in the case of a cappuccino.

The additional preparation and dispensing assembly can be adapted, for example, for preparing coffee based on coffee beans, in which case a grinding device for the beans is provided.

The additional preparation and dispensing assembly is preferably adapted for accommodating and retaining a second package filled with the second ingredient, for example a coffee preparation ingredient.

The second ingredient is preferably intended for combination with the same liquid as the ingredient in the first package, for example with water (hot water), in which case the additional preparation and dispensing assembly is connected to the liquid feed means and is equipped to dispense the second ingredient combined with

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 227 of 387

the liquid.

The second package is preferably a disposable package filled with a single portion of the second ingredient, for example a coffee pad or a metal cup filled with a coffee ingredient, or a cartridge or the like. The second ingredient does not, of course, have to be liquid, depending on the ingredient and the second package, and may, if desired, be in powder form or in another form.

The second package is, for example, a package already available on the market, examples of which are the coffee pad, a plastic cartridge, a metal capsule, a flexible sachet etc. Such packages clearly differ from the package according to the invention. It is also conceivable for a package according to the invention likewise to be filled with the second ingredient, in which case it is then preferable to make at least the dimensions of that package different, so that the user does not make a mistake.

As will be explained below in detail with reference to an example, the second package can be a coffee pad, in which case the system furthermore comprises a coffee pad holder part, the device having a corresponding part which forms a chamber with the coffee pad holder part when contiguity has been achieved, said chamber having an inlet for feeding hot water to it and an outlet for coffee, possibly an outlet adapted for creating coffee with a relatively thin, fine-frothed creamy layer.

It is preferable to provide a common carrier, which forms the holder for a first package with a first ingredient, preferably the package according to the invention, and for a second package containing a second ingredient. In that case both packages are preferably disposable packages. For example, the second package is a single-portion coffee preparation package, for example a coffee pad. In that case it is preferable for the common carrier to be equipped to accommodate a coffee pad holder part containing a coffee pad.

In a possible embodiment the additional dispensing assembly of the device is adapted for the preparation and dispensing of a beverage, such as coffee, or another food product, on the basis of a second ingredient with which a second package is filled, which second package is in the form of a storage package, i.e. contains second ingredient for a number of preparations. This can be, for example, for coffee machines for use in businesses etc. For example, the beverage, such as coffee, is made on the basis of a second package

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 228 of 387

with a supply of an extract for mixing with water, stored in a suitable package (bag-in-box or the like).

In a possible embodiment provision is made for the device, with or without additional preparation and dispensing assembly, to contain a magazine for accommodating in it a number of packages according to the invention, as well as an automatic feed mechanism for removing one package at a time from the magazine and feeding it to the dispensing position in the device if preparation of a food product on the basis of said package is desired. Such magazines and feed mechanisms are known in the field of beverage preparation machines and can be adapted to the package according to the invention by the person skilled in the art.

Figure 12 shows diagrammatically a variant of the holder 210, which here has an accommodation recess 213 for a package according to the invention, for example package 100, and an accommodation recess 214 for a coffee pad, in this example for a removable coffee pad holder part in which or on which the coffee pad (or a number of coffee pads stacked) can be placed.

Making coffee on the basis of a coffee pad and the technical components of the device to be used for this purpose are generally known, for example from EP 904 717 and WO 03/026470, in which it is attempted to prepare a beverage similar to cappuccino.

In addition to the lance 240, the device 200 also has a part 320 which together with the holder 210 forms a chamber (when the carrier 250 has been moved up) around the coffee pad(s), which chamber is connected to the water circuit. In this way hot water can be fed under limited pressure to said chamber, and coffee can be prepared. Said coffee then flows through a pipe 215 to one or more dispensing orifices 216, 217 of the holder 210.

It can be seen that the one or more dispensing orifices 216, 217 are situated so close to the aperture 211 that all streams out of or through them open into the mug 300 or the like.

Figure 13 shows very diagrammatically the holder 210 of Figure 12 with package 100 and with a coffee pad 310 placed on a part 311 which the user places in the holder 210 (in accommodation recess 214). Furthermore, the lance 240 is shown, as is the part 320, which together with part 311 forms a chamber around the pad 310 when the carrier 250 in which the holder has been placed has been moved upwards. As pointed out, much is known in the field of coffee

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 229 of 387

preparation with a pad and corresponding parts, inter alia from the patent literature. The inclusion of one or more details in the device according to the invention will be achievable for the person skilled in the art.

The water circuit now comprises one or more electrically controllable valves 235, here between the heater 230, on the one hand, and the lance 240 and part 320, on the other hand. Said one or more valves 235 make it possible first to feed hot water to the lance 240 and after a milk froth layer has been formed in the mug 300 to make coffee by feeding said water to the chamber containing the pad 310. Said coffee then goes onto the froth and sinks through it.

The holder 210 is preferably made of plastic and is dishwasher-safe.

The holder 210 here is provided with one or more positioning elements, holes 218 in this case, which can interact with complementary positioning elements of the housing of the device in order in this way to ensure the correct position of the holder relative to the lance 240 and any chamber-forming part 320 (this being, for example, in connection with the seal at the chamber for the coffee pad).

It will be clear that the displacement means for the carrier 250 can also be of an electrical type.

It will be clear that the carrier 250 could also be dispensed with, and the holder 210 could be connected directly to a suitable displacement mechanism of the device.

In a variant of the device shown diagrammatically in Figure 14 provision is made for the lance 240 to be disposed so as to be movable, movable up and down here, preferably connected to a flexible hose 241, and to be movable by means of corresponding first displacement means 242 of the device. The holder 210 for the package 100 (and any other package in the holder) here is likewise movable, movable up and down here, by means of corresponding second displacement means of the device, in this example already explained with reference to Figure 11. For use of the system the user first operates the second displacement means, so that the holder and the package in it and retained by it move to the dispensing position in the device. In the version also having a coffee pad holder part that movement causes the chamber to close around the coffee pad. The user then operates the first displacement means 241, which move the lance

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 230 of 387

240 in such a way that the lance connects to the channel. The first displacement means can be electrically driven here, so that operating a button puts said means into operation, suitably followed by switching on of the pump and the water heater. It is also conceivable for the hydraulic pressure of the water, when the pump 225 is switched on, to put a suitable actuator, for example a bellows, into operation to move the lance.

It will be clear to the person skilled in the art that instead of a coffee pad, the system and the device can also be equipped to accommodate another portion package with a suitable ingredient, such as a beverage preparation ingredient, for example a flexible sachet or a plastic cartridge made up of several components, for example of the type being put on the market under the brand name Tassimo or, for example, a metal capsule, for example of the type being put on the market under the brand name Nespresso. As is known, Tassimo cartridges, made up of several components, are available not only filled with a coffee ingredient, but also with a chocolate ingredient for preparing hot chocolate. The invention can then be used to make milk froth.

It is also conceivable for a device which accommodates only the package according to the invention to be produced, for example in order first to make a quantity of milk froth in a mug at home. Coffee or another beverage can then be made using a separate device, for example a coffee pad device or another device of the type mentioned here, and the coffee or other beverage is then dispensed into said mug. Such a device according to the invention could then have a small supply tank for water, for example with a capacity of no more than 250 ml, so that the device can be made small and takes up little space.

Figure 15 shows an alternative package 1000 according to the invention, which works together with a lance 2400 of a device (not shown in any further detail) and together with that device forms an alternative system according to the invention of the type described in claim 79.

It will be clear that all kinds of details of the package have already been explained, which details can be used separately or in combinations if desired on the package described in claim 79. The device can in principle be designed largely in accordance with devices described earlier, as will be clear to the person skilled in

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 231 of 387

the art.

The package 1000 shown is filled or can be filled with a portion of a liquid ingredient which is intended for mixing with a base liquid for the preparation of the food product. A top sealing film, which is pierced by the lance 2400, is preferably provided.

The package 1000 has a body with a bottom and a circumferential wall, the body furthermore having a column 1100, which is connected to a preferably centrally situated portion 140 of the bottom, which column 1100 has a portion which projects upwards from the bottom to an upper side of the column.

In the version shown the portion 140 of the bottom is flexible, in such a way that the column is movable, preferably elastically movable, downwards and possibly back up again.

A channel extends through the column 1100 from an inlet on the upper side of the column to an outflow aperture 120 on the underside of the column.

Unlike preferred embodiments shown earlier, the column 1100 in this case is not provided with a complete venturi portion, but provision is made for said venturi portion to be fully formed in the lance (not shown), or for the venturi portion (and possibly also the one or more passages connecting to it) to be formed by the interaction of the bottom portion of the lance with the adjacent portion of the column (see Figure 15).

The device (not shown in any further detail) furthermore comprises a holder for accommodating and retaining the package at a dispensing position in the device and base liquid feed means, of which the lance 2400 disposed at the dispensing position forms part.

As can be seen, the lance 2400 can be placed in the inlet of the channel in the column 1100, so that the base liquid can be fed through the channel.

It can be seen that the underside of the lance 2400 together with an adjacent part of the column 1100 forms a venturi portion to which one or more passages 130, formed in the column here, connect in such a way that, when base liquid is fed through, a venturi effect occurs and the ingredient passes through the one or more passages into the venturi portion and mixes there with the base liquid, which mixture is dispensed at the outflow aperture 120 of the column.

It will be clear that this makes a simple design of the package possible.

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 232 of 387

C L A I M S

1. Package for a portion of liquid foodstuff dilutable with a diluent, which package comprises:
   - a reservoir for containing a portion of liquid foodstuff dilutable with a diluent, which reservoir has a filling aperture,
   - a reservoir seal for closing the reservoir,
   - a mixing element for mixing the dilutable liquid foodstuff with the diluent, which mixing element comprises:
     - a mixing chamber, which mixing chamber has an outflow aperture for dispensing liquid foodstuff diluted with the diluent,
     - a liquid feed device for feeding dilutable liquid foodstuff from the reservoir to the mixing chamber,
     - a feed channel for feeding diluent to the mixing chamber, which feed channel has a first portion and a second portion, the second portion having an outflow aperture which opens into the mixing chamber, and the cross section of the second portion being smaller than the cross section of the first portion and the cross section of the mixing chamber to such an extent that when diluent is fed to the mixing chamber a venturi effect occurs in the mixing chamber,

characterized in that the reservoir and the mixing element are produced monolithically by injection moulding.

2. Package according to claim 1, in which the reservoir has a bottom and at the position of the bottom the mixing element is connected so as to be integral with the reservoir.

3. Package according to claim 2, in which at the position of the mixing element the bottom has a flexible portion.

4. Package according to claim 3, in which the flexible portion is in the form of a protuberance, which protuberance has a bistable form with a first and a second stable position.

5. Package according to one or more of the preceding claims, in which the outflow aperture of the mixing chamber is provided with a breakable or removable seal.

6. Package according to claims 4 and 5, in which the seal of the outflow aperture of the mixing chamber can be removed or broken by taking the protuberance in the bottom of the reservoir from the first

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 233 of 387

stable position into the second stable position.

7. Package according to one or more of the preceding claims, in which the mixing element is placed substantially in the centre of the reservoir.

8. Package according to claim 7, in which the reservoir seal also seals the feed channel for the diluent.

9. Package according to claim 8, in which the reservoir seal is breakable or removable at the position of the feed channel.

10. Package according to one or more of the preceding claims, in which the package is a disposable package for a single use.

11. Package according to one or more of the preceding claims, in which the package is sterilizable.

12. Package according to one of the preceding claims, in which the second portion of the feed channel connects to the first portion of the feed channel in a place other than the lowest point of the first portion of the feed channel.

13. Device for the preparation of a beverage, which device comprises:

- a holder for a package according to one or more of the preceding claims, which holder has an aperture through which the mixture of dilutable liquid foodstuff and diluent passes, preferably without contact with the holder,
- water feed means for feeding water, preferably heated water, to the feed channel of the mixing element of the package,

characterized in that the water feed means comprise a lance which is equipped to connect to the feed channel of the mixing element of the package in order to feed in water as a diluent to the mixing chamber, the lance and the holder being movable relative to each other.

14. Device according to claim 13, in which the lance is adapted to break or to remove a seal placed over the feed channel.

15. Device according to claim 13 or 14, suitable for use of a package according to at least claim 4, in which the lance is adapted to take the protuberance in the bottom of the reservoir from the first stable position into the second stable position.

16. Device according to one or more of claims 13 - 15, in which the device also comprises a holder for accommodation of a coffee pad.

17. Disposable package filled with a portion of a liquid ingredient intended for mixing with a base liquid for the preparation of a food product suitable for human consumption, which package has an

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 234 of 387

injection moulded monolithic plastic body with a bottom and a circumferential wall, the upper edge of the circumferential wall bounding an aperture, which aperture of the filled package is hermetically sealed by a top sealing film which is fixed on its circumference on the upper edge, the monolithic plastic body furthermore having a central column which is integral with a central portion of the bottom, which column has a portion that projects upwards from the bottom to an upper side of the column, through which column a channel extends from an inlet on the upper side of the column to an outflow aperture on the underside of the column, the top sealing film being breakable, preferably piercable, so that a base liquid feed lance can be passed through the sealing film and can then be connected to the inlet of the channel in the column, with the result that the base liquid can be fed through the channel, which channel has a venturi portion to which are connected one or more passages formed in the column for the ingredient, in such a way that when base liquid is fed through the channel a venturi effect occurs and the ingredient goes through the one or more passages into the venturi portion and mixes there with the base liquid, which mixture is dispensed at the outflow aperture of the column.

18. Package according to claim 17, in which the bottom has a flexible portion, such that the column is movable, preferably elastically movable, downwards and back up again relative to the upper edge of the body if desired.

19. Package according to claim 18, in which the bottom has an annular flexible portion around the column.

20. Package according to claim 17 or 18, in which the column is movable between a higher initial position and a lower dispensing position relative to the upper edge of the body, preferably with a height difference of at least 3 millimetres.

21. Package according to one or more of claims 17 - 20, in which the bottom has a flexible portion with a bistable design, so that the column has a stable position both in an initial position and in a dispensing position.

22. Package according to one or more of claims 17 - 21, in which the bottom has a flexible portion around the column, said flexible portion, viewed in each vertical section, being in the form of one or more undulations.

23. Package according to one or more of claims 17 - 22, in which

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 235 of 387

the upper side of the column rests against the underside of the top sealing film when the package is closed.

24. Package according to one or more of claims 17 - 23, in which the channel from the venturi portion to the outflow aperture has a substantially uniform cross section.

25. Package according to one or more of claims 17 - 24, in which the package is provided with a bottom seal which seals the outflow aperture and can be opened or removed at the time of use.

26. Package according to one or more of claims 17 - 25, in which the package has a bottom sealing film, which is placed along the bottom of the outflow aperture on the underside of the bottom of the package.

27. Package according to claim 26, in which a portion of the bottom is flexible, so that the column is movable downwards relative to the upper edge of the body, and the bottom sealing film is breakable along the bottom of the outflow aperture by moving the column downwards from a higher initial position to a lower dispensing position.

28. Package according to claim 26 or 27, in which the body of the package is designed such that it forms a supporting surface of the package, which supporting surface lies at a distance below the bottom sealing film, so that the bottom sealing film lies higher up than any bearing surface when the package is placed on it.

29. Package according to one or more of claims 17 - 27, in which the circumferential wall projects below the bottom and has a lower edge which forms a supporting surface of the package, so that the package can be placed with the lower edge of the circumferential wall in a stable position on a bearing surface and the bottom sealing film in this case lies higher up than said bearing surface.

30. Package according to one or more of claims 17 - 29, in which the column furthermore has a portion which projects below the bottom, in an embodiment according to claim 28 or 29 preferably ending at a distance above the supporting surface of the package.

31. Package according to one or more of claims 17 - 29, in which the one or more passages, preferably two placed diametrically opposite each other, in the column each have an inflow aperture on the outer circumference of the column for the feeding of ingredient to the venturi portion.

32. Package according to one or more of claims 17 - 31, in which

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 236 of 387

the one or more passages in the column are funnel-shaped, viewed from a corresponding inflow aperture on the outer circumference of the column towards the venturi portion.

33. Package according to one or more of claims 17 - 32, in which the one or more passages in the column are placed at an angle slanting downwards, viewed from an inflow aperture on the outer circumference of the column towards the venturi portion.

34. Package according to one or more of claims 17 - 33, in which the one or more passages in the column have an inflow aperture close to the top of the region surrounding the bottom.

35. Package according to one or more of claims 17 - 34, in which the body has on the upper edge of the circumferential wall an outwardly directed circumferential flange on which the top sealing film is fixed.

36. Package according to one or more of claims 17 - 35, in which the bottom has an elastically shape-recovering flexible portion around the column, so that the column is movable downwards relative to the upper edge of the circumferential wall from an initial position to a dispensing position, and after dispensing of the mixture is movable back up again in a shape-recovering manner.

37. Package according to one or more of claims 18 - 22, 27, 36, in which in the initial position the inflow apertures of the one or more passages lie higher up than the region of the bottom lying outside the flexible portion.

38. Package according to claims 18 - 22, 27, 36, 37, in which the connection of the flexible portion of the bottom to the column in an initial position of the column lies higher up than the portion of the bottom lying around the flexible portion.

39. Package according to claim 38, in which the connection of the flexible portion of the bottom to the column in a dispensing position of the column lies lower down than the portion of the bottom lying around the flexible portion.

40. Package according to one or more of claims 17 - 39, in which the circumferential wall, the column and the inlet aperture of the channel are concentric relative to an axis of the package, the outflow aperture also preferably being concentric relative to said axis.

41. Package according to one or more of claims 17 - 40, in which the package contains a liquid beverage preparation ingredient.

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 237 of 387

42. Package according to one or more of claims 17 - 41, in which the package is sterilized before filling, and contains, for example, a liquid milk ingredient, for example a milk concentrate, for example milk which has been heated to 116 - 122°C for 1 to 5 seconds.

43. Package according to one or more of claims 17 - 42, in which the venturi portion has a narrow passage with a diameter of 0.8 millimetres, and between said narrow passage and the outflow aperture has a chamber with a diameter of 1.2 millimetres.

44. Package according to claim 26, 27 or 28, in which the bottom sealing film is fixed on the underside of the bottom in an annular region around the flexible portion of the bottom.

45. Package according to claim 26, 27, 28 or 44, in which the underside of the central column in the initial position rests against the bottom sealing film.

46. Package according to one or more of claims 17 - 45, in which the package is filled with the liquid ingredient to a level at a distance below the upper edge of the central column.

47. Package filled or to be filled with a portion of a liquid ingredient which is intended for mixing with a base liquid for preparation of a food product suitable for human consumption, which package has a body with a bottom and a circumferential wall,
in which the body furthermore has a column which is connected to a portion of the bottom which is preferably situated centrally, which column has a portion that projects upwards from the bottom to an upper side of the column,
in which a portion of the bottom is flexible, such that the column is movable, preferably elastically movable, downwards and back up again if desired,
through which column a channel extends from an inlet on the upper side of the column to an outflow aperture on the underside of the column,
in which a base liquid feed lance can be brought into engagement with the column, with the result that the column moves from an initial position situated higher up to a dispensing position situated lower down, through which feed lance the base liquid can be fed through the channel, which channel has a venturi portion to which one or more passages formed in the column for the ingredient connect, in such a way that when base liquid is fed through the channel a venturi effect occurs and the ingredient goes through the one or more passages into

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 238 of 387

the venturi portion and mixes there with the base liquid, which mixture is dispensed at the outflow aperture of the column.

48. Package according to claim 47, in which the package is a disposable package which is filled with the ingredient through a filling aperture, preferably bounded by the upper edge of the circumferential wall and preferably closed by a top sealing film.

49. Package according to claim 47, in which the package is reusable and the column is movable several times, preferably at least 100 times, between the initial position and the dispensing position.

50. System for the preparation of a food product suitable for human consumption, for example a beverage or a component of a beverage, for example milk froth, for example for cappuccino, which system comprises a first package according to one of the preceding claims, and also a device, the device being at least provided with:

- a holder for accommodating and retaining the first package at a dispensing position in the device,
- liquid feed means with a lance disposed at the dispensing position, which lance is equipped to pass through the top reservoir seal or sealing film which may be present on the first package, for example by piercing the sealing film, and to connect to the channel of the first package, so that liquid can be fed to the channel through the lance and therewith on the basis of the venturi effect the foodstuff or the ingredient in the first package is drawn to the venturi portion and is mixed with the liquid, and the mixture is dispensed through the outflow aperture of the first package.

51. System according to claim 50, in which the device has operable displacement means which are adapted to produce a movement of the holder for the first package and the lance relative to each other, so that when the displacement means are operated the lance connects to the channel by, for example, piercing the reservoir seal or top sealing film of the first package.

52. System according to claim 51, in which the first package has a bottom sealing film along the bottom of the outflow aperture, and a portion of the bottom of the first package is flexible, in such a way that the lance presses the mixing element or the column downwards when the displacement means are operated, with the result that the bottom sealing film is broken.

53. System according to one or more of claims 50 - 52, in which the liquid feed means are equipped for feeding in water as the liquid.

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 239 of 387

54. System according to one or more of claims 50 - 53, in which the liquid feed means comprise a heating assembly for heating the liquid, preferably an electric heating assembly for supplying hot, not boiling liquid, preferably water, preferably hotter than 70°C.

55. System according to one or more of claims 50 - 54, in which the liquid feed means comprise a pump for the liquid.

56. System according to one or more of claims 50 - 55, in which the liquid feed means comprise a supply tank for a supply of the liquid.

57. System according to claim 56, in which the supply tank can be removed from the device by a user in order to fill the supply tank, the supply tank preferably having a self-closing valve which closes when the supply tank is disconnected from the device.

58. System according to one or more of claims 50 - 57, in which the lance and the inlet of the channel of the package are such that the lance ultimately projects into the inlet of the channel of the package.

59. System according to claim 51, in which the lance is stationary, and in which the displacement means are equipped to move the holder towards the lance and away from it, in such a way that in the process the lance connects to the channel of the package.

60. System according to claim 51, in which the lance is disposed so as to be movable and is movable by means of corresponding first displacement means of the device, and in which the holder for the first package is likewise movable by means of corresponding second displacement means of the device, in which during use of the system when the second displacement means are operated the holder and the package accommodated and retained in it move to the dispensing position in the device, and in which when subsequently operated, preferably on the basis of a specific operation instruction from the user, the first displacement means move the lance in such a way that the lance connects to the channel.

61. System according to one or more of claims 50 - 60, in which the holder for the first package is equipped to accommodate and retain the first package in a substantially horizontal position with the bottom downwards, the holder having an aperture below the outflow aperture of the first package in such a way that during dispensing of the mixture said mixture remains clear of the holder.

62. System according to one or more of claims 50 - 61, in which at a distance below the dispensing position of the holder the device has

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 240 of 387

a standing place for a beverage holder, for example a mug.

63. System according to one or more of claims 50 - 62, in which the device is furthermore provided with an additional preparation and dispensing assembly for preparing, on the basis of a second ingredient, which differs from the ingredient in the first package, a second, different food product suitable for human consumption, for example a beverage or component of a beverage, for example for coffee.

64. System according to claim 63, in which the additional preparation and dispensing assembly is adapted for accommodating and retaining a second package filled with the second ingredient, for example a coffee preparation ingredient.

65. System according to claim 64, in which the second package differs from the first package, at least as regards its dimensions.

66. System according to one or more of claims 63 - 65, in which the second ingredient is intended for combination with the same liquid as the ingredient in the first package, for example with water (hot water), in which case the additional preparation and dispensing assembly is connected to the liquid feed means and is adapted to dispense the second ingredient combined with the liquid.

67. System according to one or more of claims 64 - 66, in which the second package is a disposable package filled with a single portion of the second ingredient, for example a coffee pad or a metal cup filled with a coffee ingredient.

68. System according to claim 67, in which the second package is a coffee pad, and in which the system furthermore comprises a coffee pad holder part, the device having a corresponding part which forms a chamber with the coffee pad holder part when contiguity has been achieved, said chamber having an inlet for feeding hot water to it and an outlet for coffee, possibly an outlet adapted for creating coffee with a relatively thin, fine-frothed creamy layer.

69. System according to one or more of claims 64 - 68, in which a common carrier is provided, which carrier forms the holder for the first package and for the second package, for example for the first package and for a coffee pad holder part containing a coffee pad.

70. Device for the preparation of a food product suitable for human consumption, for example a beverage or a component of a beverage, for example milk froth, for example for cappuccino, as described in one or more of claims 50 - 69.

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 241 of 387

71. Device for the preparation of a food product suitable for human consumption, for example a beverage or a component of a beverage, for example milk froth, for example for cappuccino, which device comprises:

- a holder for accommodating and retaining a first disposable package at a dispensing position in the device, which package has a reservoir which is filled with a portion of a first ingredient, and also an inlet and an outflow aperture,
- liquid feed means with a lance disposed at the dispensing position, which lance is adapted to connect to the channel of the first package, so that liquid can be fed to the channel through the lance and therewith the first ingredient can be mixed with the liquid, so that the mixture is dispensed through the outflow aperture of the first package, which first ingredient is, for example, a milk ingredient for the preparation of milk froth,

in which the device furthermore comprises:

- an additional preparation and dispensing assembly for preparing, on the basis of a second ingredient, which differs from the ingredient in the first package, a second, different food product suitable for human consumption, for example a beverage or component of a beverage, the additional preparation and dispensing assembly being adapted for accommodating and retaining a disposable second package filled with a portion of the second ingredient, for example a coffee preparation ingredient, which second package differs from the first package, at least as regards its dimensions.

72. Device according to claim 71, in which the first package comprises a venturi portion in the channel, so that on the basis of the venturi effect the first ingredient is drawn to the channel when liquid is fed to the channel, and is mixed with the liquid.

73. Device according to claim 71 or 72, in which the first package has a sealing film, and the lance is equipped to pierce the sealing film and then to connect to the channel.

74. Device according to one or more of claims 71 - 73, in which the second ingredient is intended for combination with the same liquid as the ingredient in the first package, for example with water (hot water), in which case the additional preparation and dispensing assembly is connected to the liquid feed means and is equipped to dispense the second ingredient combined with the liquid.

75. Device according to one or more of claims 71 - 74, in which

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 242 of 387

provision is made for a common carrier, which forms the holder for the first package and for the second package, for example for the first package and for a coffee pad, possibly for a removable coffee pad holder part in which a coffee pad can be placed.

76. Device according to claim 75, in which the device has operable displacement means which are adapted to produce a movement relative to each other of the common holder for the first package and the second holder and the lance working with the first package, so that when the displacement means are operated the lance connects to the channel of the first package, for example by piercing the reservoir seal or top sealing film of the first package in the process.

77. Device according to claim 76, in which the first package has a bottom sealing film along the bottom of the outflow aperture, and a portion of the bottom of the first package is flexible, such that the lance presses the mixing element or the column downwards when the movement means are operated, with the result that the bottom sealing film is broken.

78. Device according to one or more of claims 71 ~ 77, in which the liquid feed means are equipped to feed in water as the liquid.

79. Device according to claim 76, in which the lance is disposed so as to be movable and is movable by means of corresponding first displacement means of the device, and in which the holder for the first package is likewise movable by means of corresponding second displacement means of the device, in which during use of the system operation of the second displacement means causes the holder and the package accommodated and retained in it to move to the dispensing position in the device, and in which when subsequently operated, preferably on the basis of a specific operation instruction from the user, the first displacement means move the lance in such a way that the lance connects to the channel.

80. Device according to one or more of claims 71 ~ 79, in which the second package is a coffee pad, and in which the device furthermore comprises a coffee pad holder part to be held in the hand, the device having a corresponding part which forms a chamber with the coffee pad holder part when contiguity has been achieved, said chamber having an inlet for feeding hot water to it and an outlet for coffee, possibly an outlet equipped for providing coffee with a relatively thin, fine-frothed creamy layer.

81. System for preparation of a food product suitable for human

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 243 of 387

consumption, for example a beverage or a component of a beverage, for example milk froth, for example for cappuccino, which system comprises a package filled or to be filled with a portion of a liquid ingredient which is intended for mixing with a base liquid for the preparation of the food product,

which package has a body with a bottom and a circumferential wall, in which the body has a column which is connected to a portion of the bottom which is preferably situated centrally, which column has a portion that projects upwards from the bottom to an upper side of the column,

in which a portion of the bottom may be flexible, in such a way that the column is movable, preferably elastically movable, downwards and back up again if desired, through which column a channel extends from an inlet on the upper side of the column to an outflow aperture on the underside of the column,

which device comprises:

- a holder for accommodating and retaining the first package at a dispensing position in the device,
- base liquid feed means with a lance disposed near the dispensing position, which lance can be placed in the inlet of the column, so that the base liquid can be fed through the channel by way of the column, in which:

a) the lance is provided with a venturi portion to which one or more passages formed in the lance for the ingredient are connected, which passages through one or more passages in the column come into contact with the ingredient, in such a way that when base liquid is fed through the channel a venturi effect occurs and the ingredient passes through the one or more passages into the venturi portion and mixes there with the base liquid, which mixture is dispensed at the outflow aperture of the column,

or in which:

b) a bottom portion of the lance interacting with an adjacent portion of the column forms a venturi portion and one or more passages for the ingredient connecting to it, in such a way that when base liquid is fed through the channel a venturi effect occurs and the ingredient passes through the one or more passages into the venturi portion and mixes there with the base liquid, which mixture is dispensed at the outflow aperture of the column.

82. Package specifically adapted for the system of claim 81.

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 244 of 387

83. Device specifically adapted for the system of claim 81.

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 245 of 387

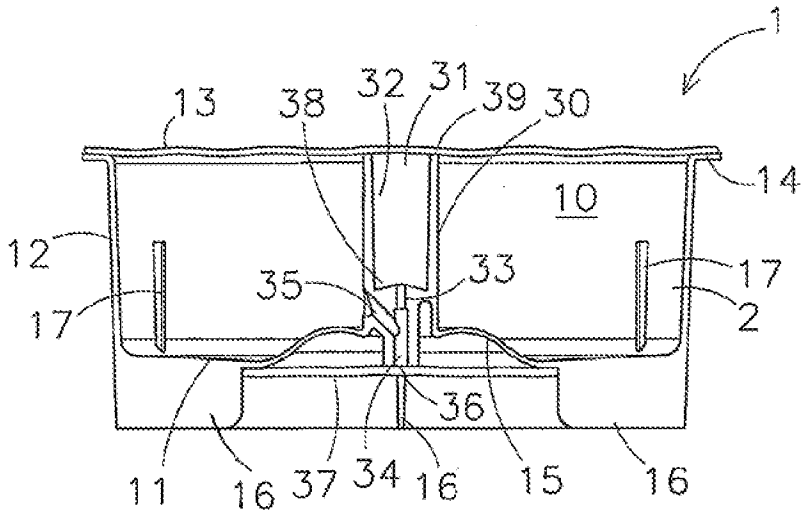


Fig 1

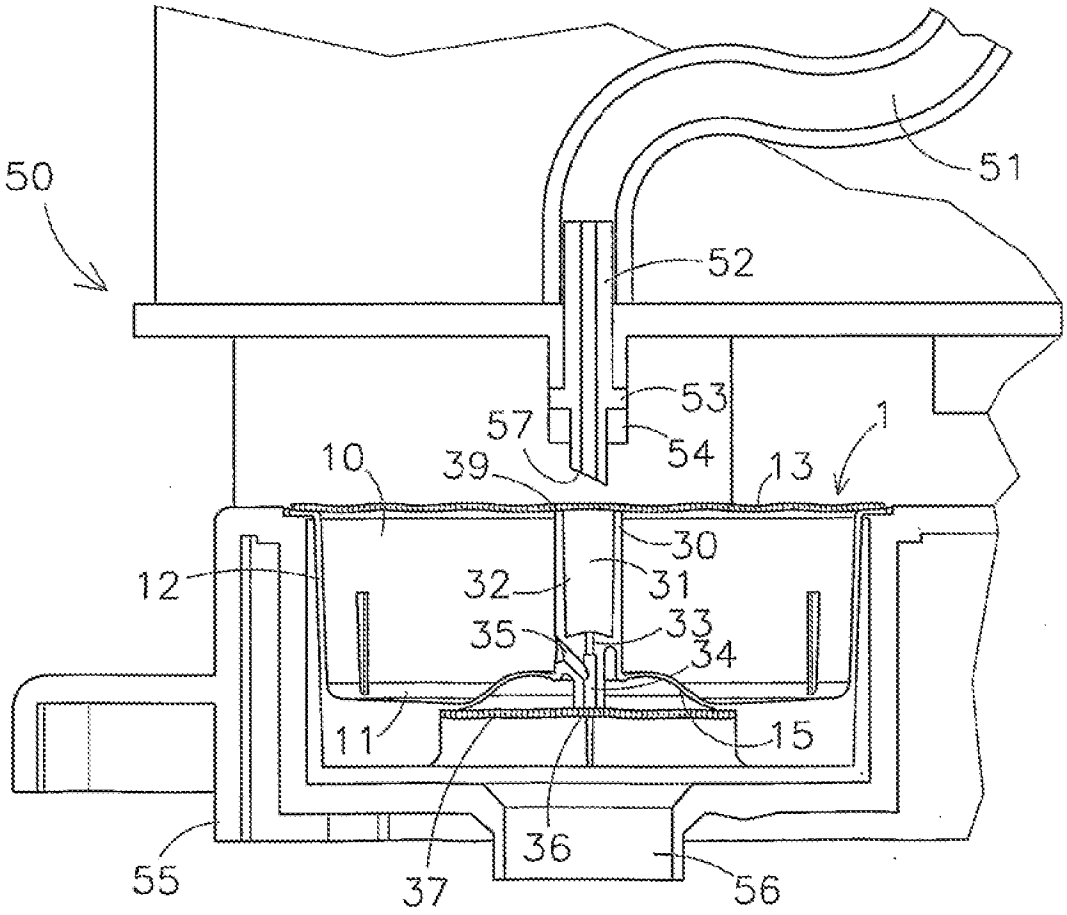


Fig 2

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 246 of 387

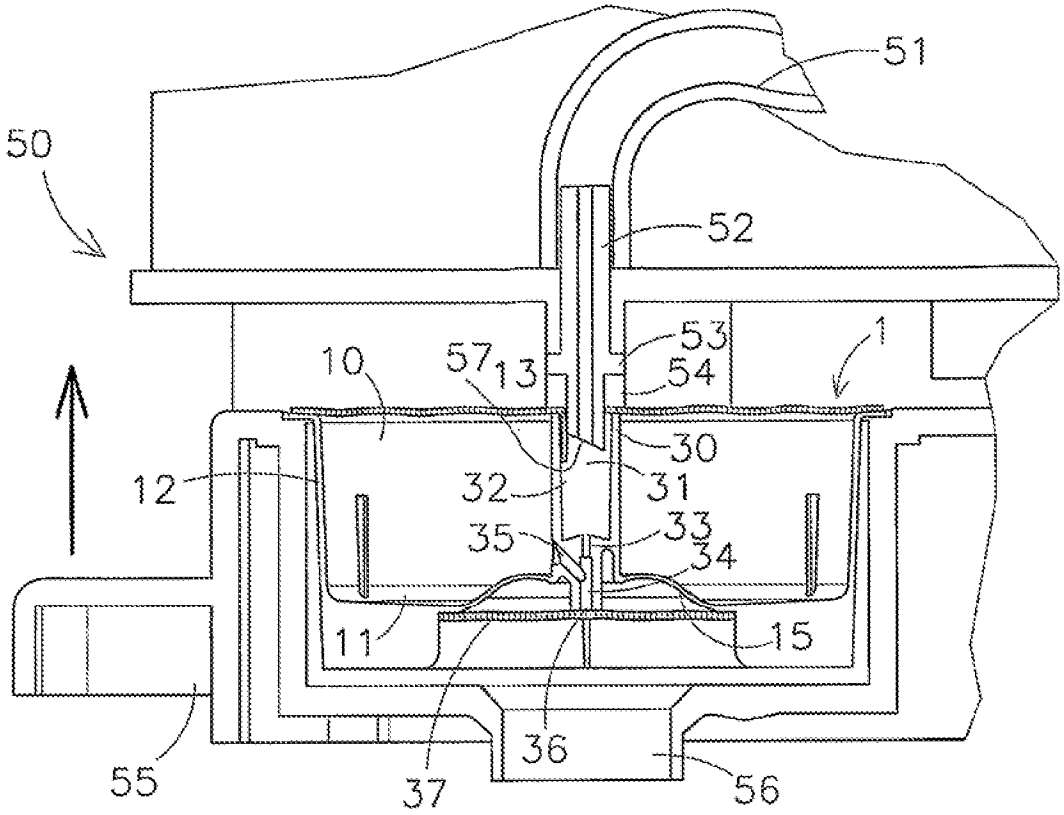

50
51
52
53
54
1
10
57
13
30
31
12
32
35
33
34
11
15
55
37
36
56

Fig 3

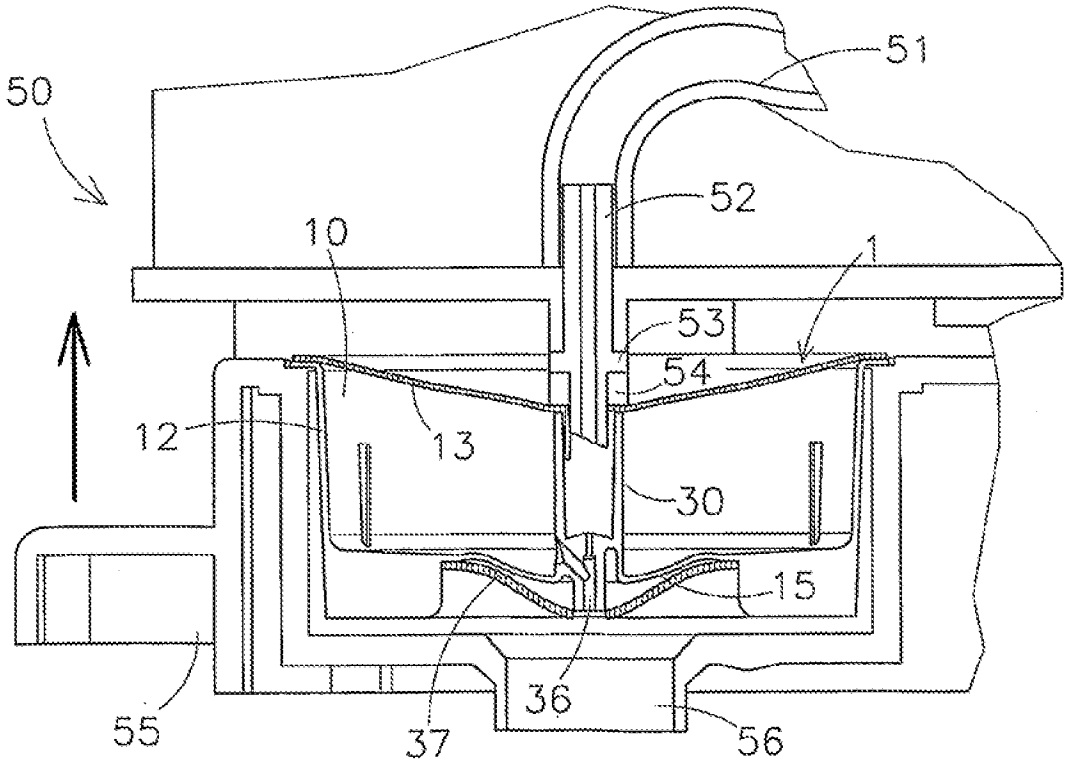

50
51
52
10
1
53
54
12
13
30
15
55
37
36
56

Fig 4

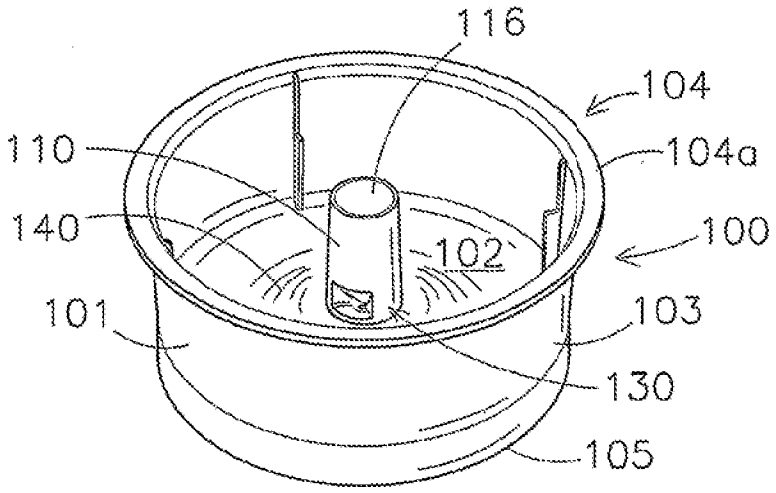


Fig 5

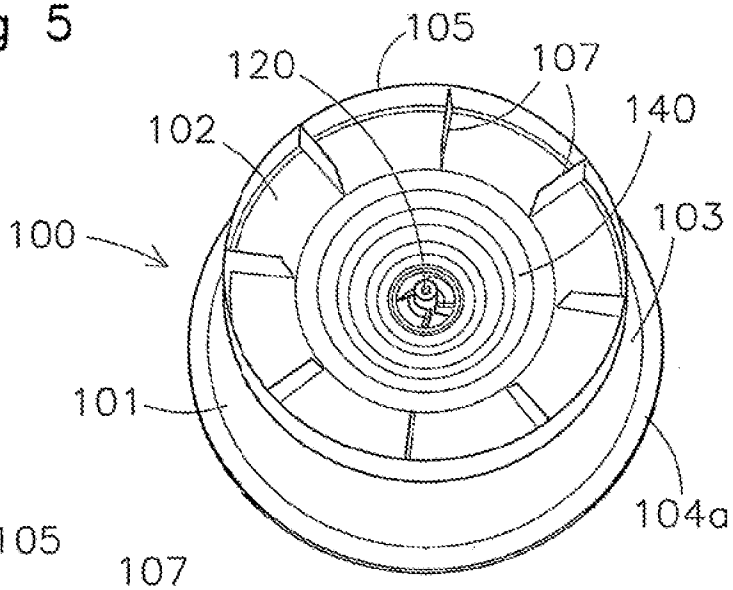


Fig 6a

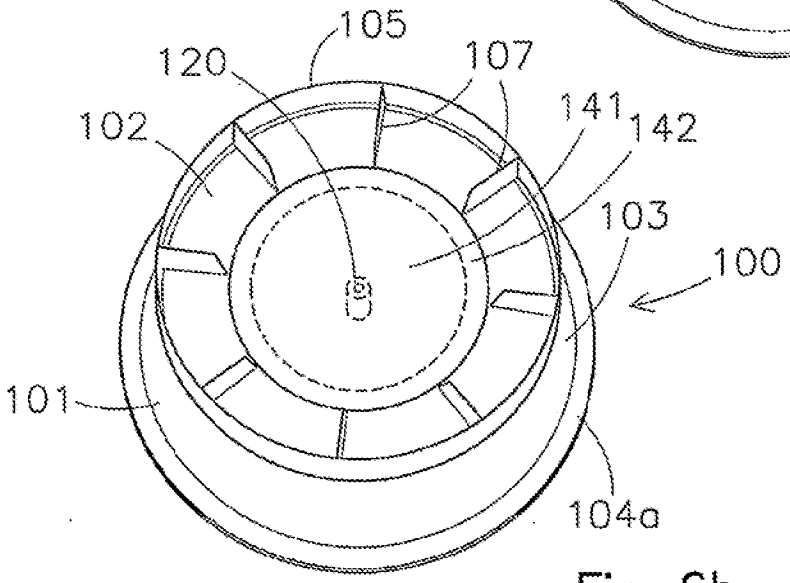


Fig 6b

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 248 of 387

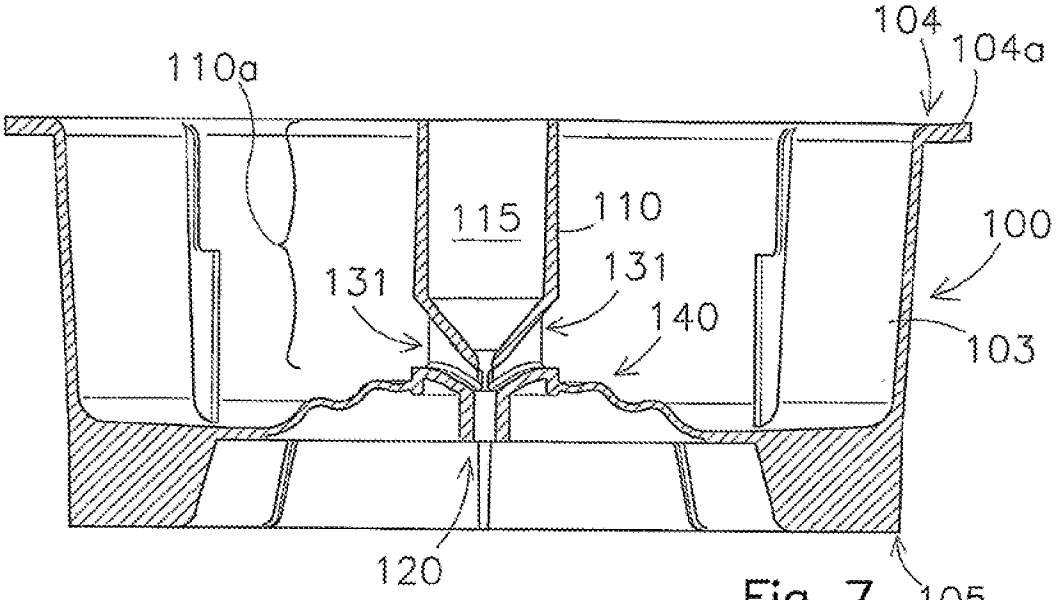


Fig 7

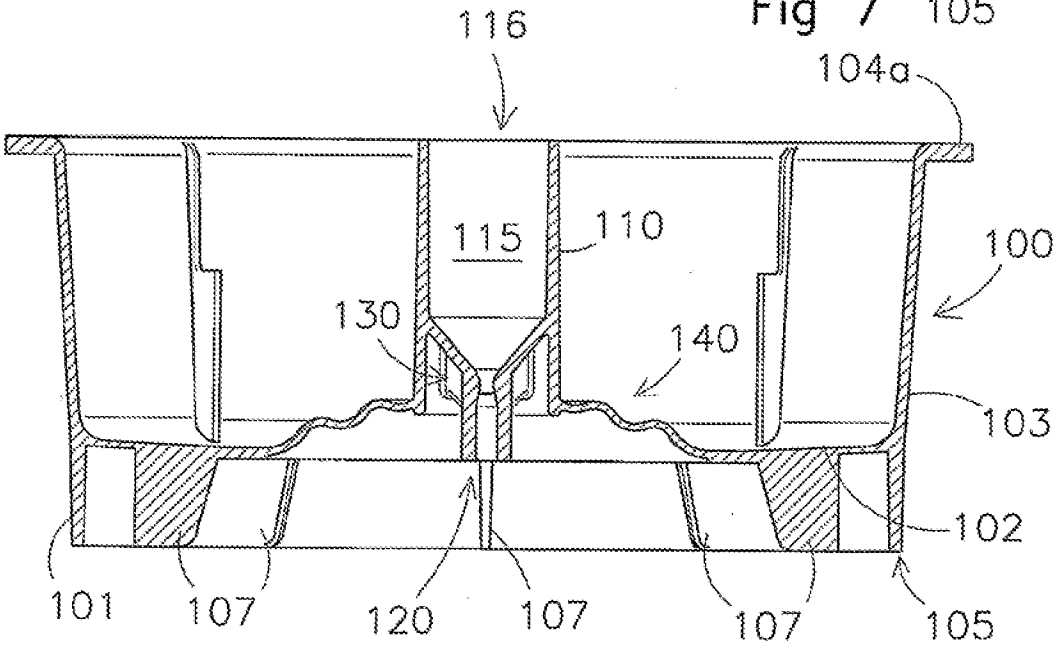


Fig 8

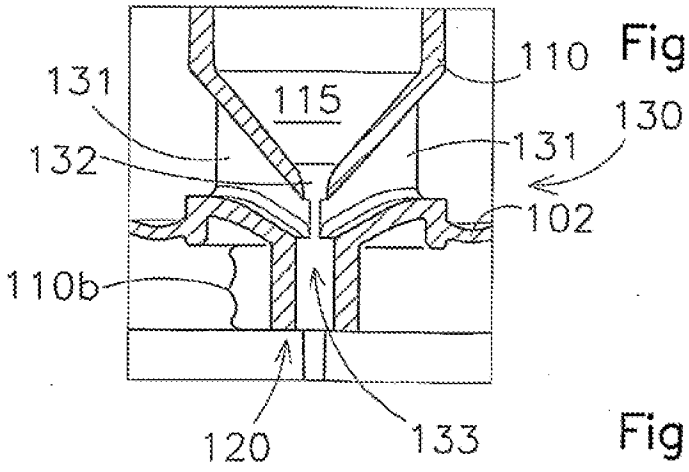


Fig 9

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 249 of 387

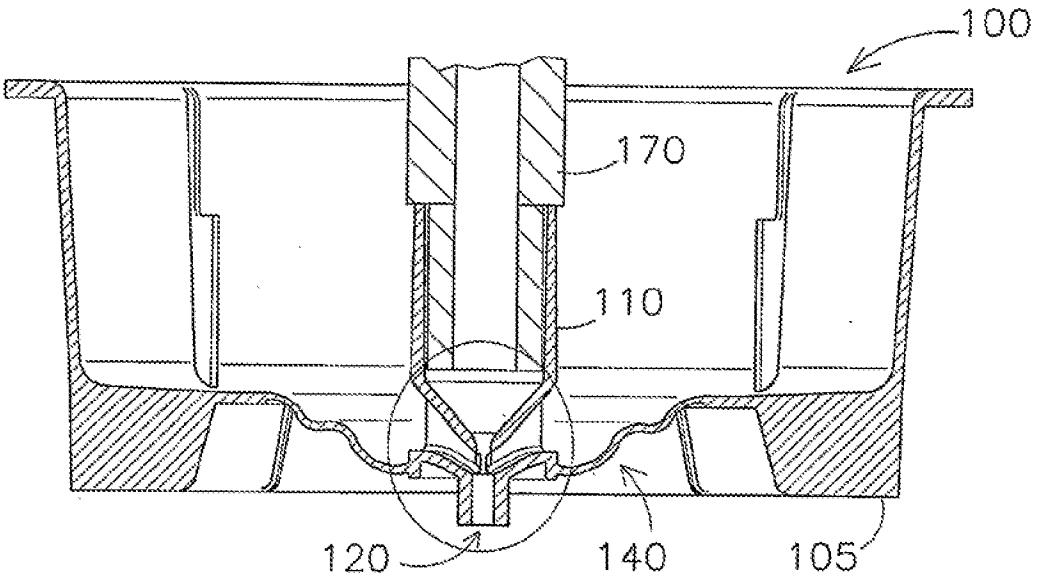


Fig 10

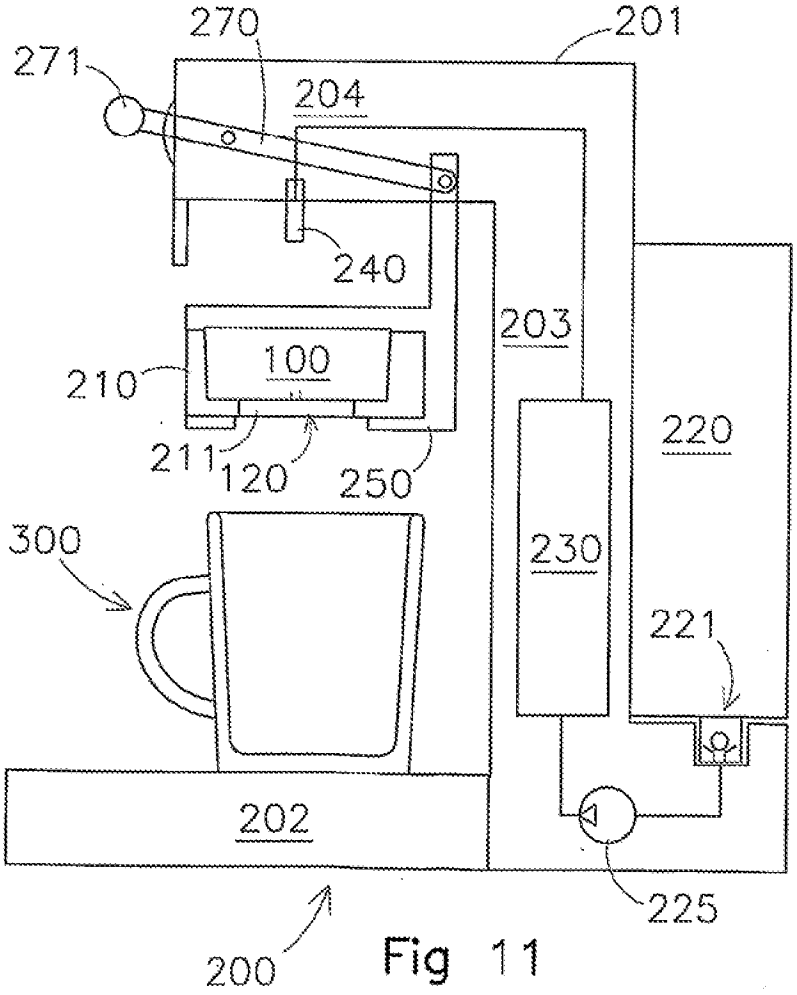


Fig 11

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 250 of 387

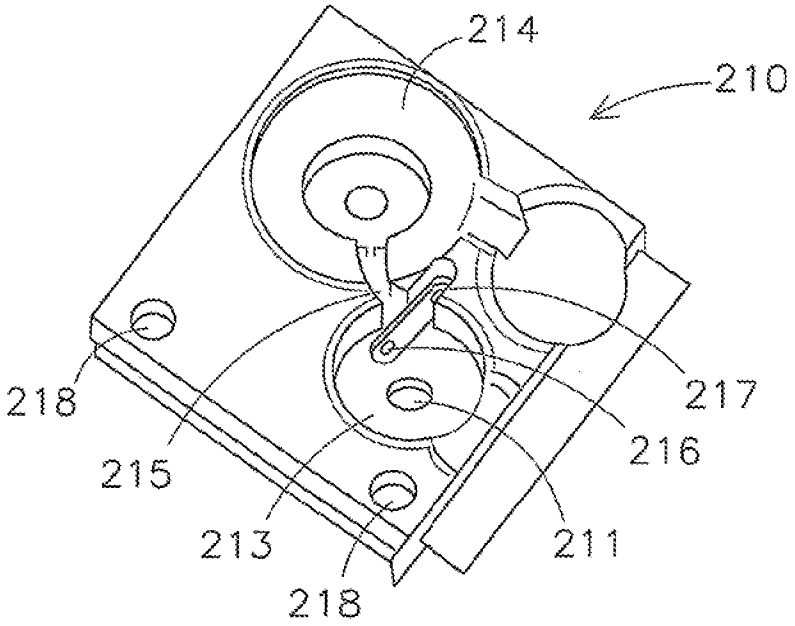


Fig 12

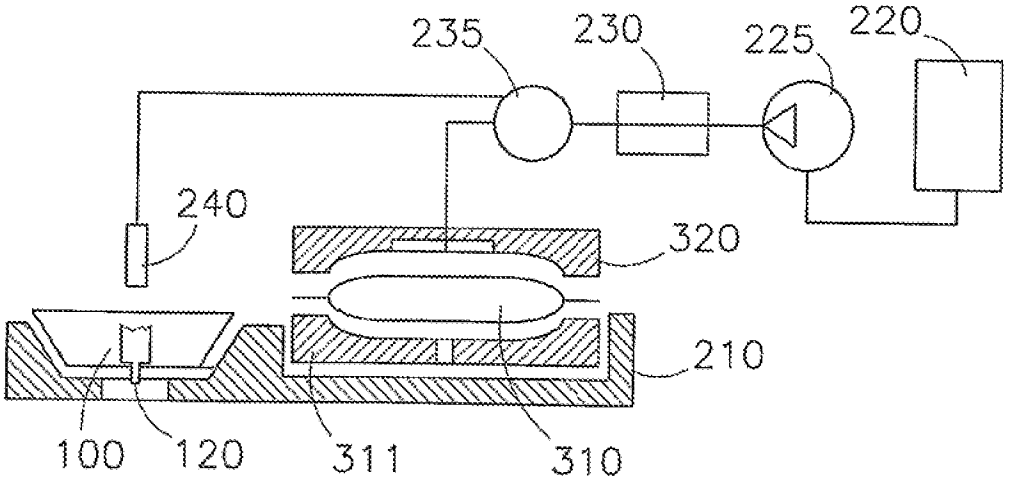


Fig 13

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 251 of 387

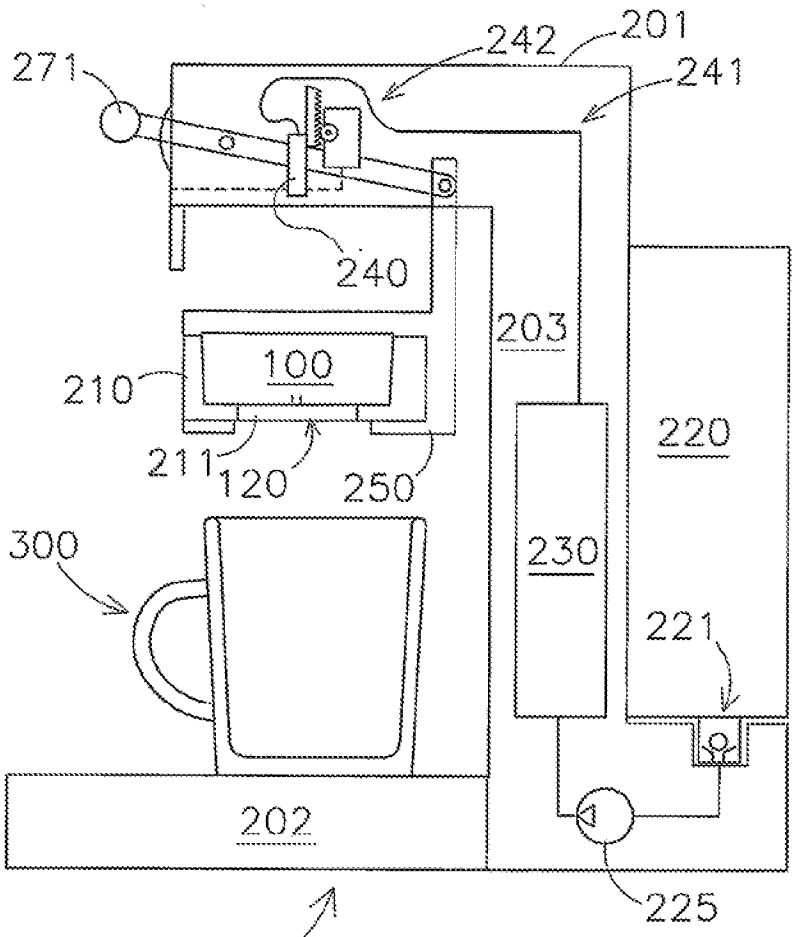


Fig 14

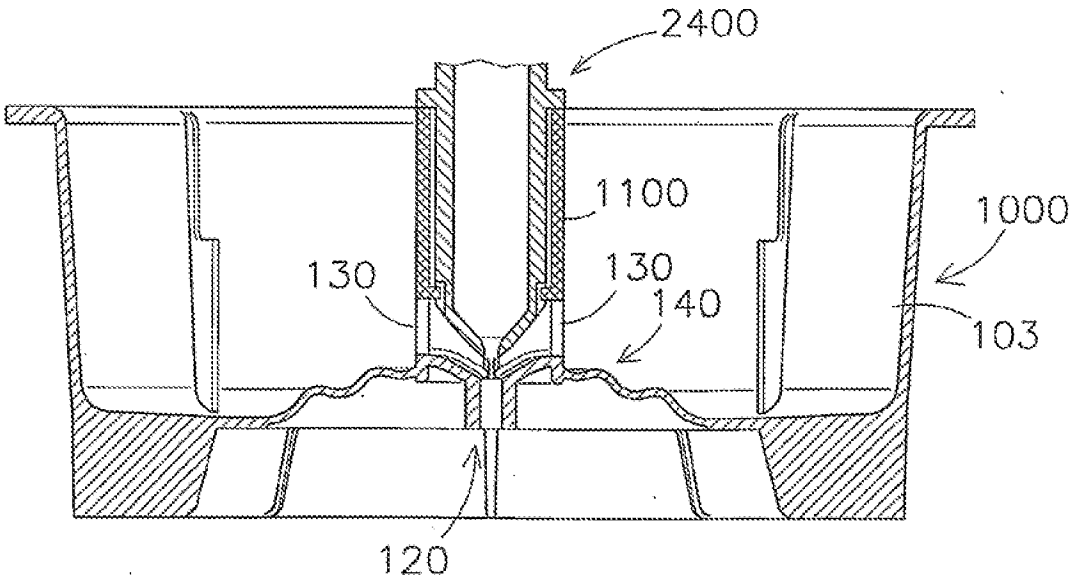


Fig 15

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 252 of 387

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2007/000046

A. CLASSIFICATION OF SUBJECT MATTER
INV. B65D85/804

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)
B65D A47J B67D

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 practical, 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.
A	EP 1 440 913 A1 (KRAFT FOODS R & D INC [DE]) 28 July 2004 (2004-07-28) paragraphs [0005] - [0011], [0026] - [0032], [0051], [0114]; figures 1-11,40-42	1,13,17, 47,50, 71,81
P,A	WO 2006/137737 A (FRIESLAND BRANDS BV [NL]; BONGERS CORNELIS MARGARETHA TH [NL]) 28 December 2006 (2006-12-28) page 15, line 6 - line 26; figures 13,14	1,13,17, 47,50, 71,78

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"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)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"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

"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.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 April 2007	15/05/2007

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Leijten, René

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NL2007/000046

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 70,82,83
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 70,82,83

Claims 70, 82 and 83 do no define the matter for which protection is sought in terms of technical features. (Rule 6.3 PCT)

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.5), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2007/000046

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1440913 A1	28-07-2004	AT 328811 T	15-06-2006
		AU 2004205386 A1	05-08-2004
		BR PI0406877 A	03-01-2006
		CA 2514072 A1	05-08-2004
		CN 1761604 A	19-04-2006
		DE 602004001053 T2	12-04-2007
		DK 1440913 T3	25-09-2006
		GB 2397500 A	28-07-2004
		WO 2004065257 A1	05-08-2004
		HK 1065756 A1	12-01-2007
		JP 2006516419 T	06-07-2006
		KR 20050107747 A	15-11-2005
		MX PA05007863 A	18-10-2005
WO 2006137737 A	28-12-2006	NONE	

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 256 of 387

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 November 2010 (04.11.2010)

PCT

(10) International Publication Number
WO 2010/125326 A1

(51) International Patent Classification:
A47J 31/36 (2006.01) *A47J 31/46* (2006.01)
A47J 31/06 (2006.01)

(21) International Application Number:
PCT/GB2010/000551

(22) International Filing Date:
24 March 2010 (24.03.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0907612.6 1 May 2009 (01.05.2009) GB

(71) Applicant *(for all designated States except US)*: **KRAFT FOOD R&D, INC.** [US/US]; Three Lakes Drive, Northfield, IL 60093 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **HANSEN, Nick Andrew** [GB/GB]; 17 Pittmaston Clos, Banbury, Oxfordshire OX16 1AH (GB). **BENTLEY, Andrew** [GB/GB]; 1 Greens Garth, Bloxham, Banbury, Oxfordshire OX15 4NR (GB). **HINCKLEY, Elizabeth** [GB/GB]; 4 The Banks, Main Street, Badby, Northamptonshire NN11 3AN (GB). **NORTON, Mark** [GB/GB]; 17 Lidsey Rd, Banbury, Oxfordshire OX16 0ND (GB).

(74) Agents: **BUCKS, Teresa Anne** et al.; Boult Wade Tennant, Verulam Gardens, 70 Gray's Inn Road, London WC1X 8BT (GB).

(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, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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.

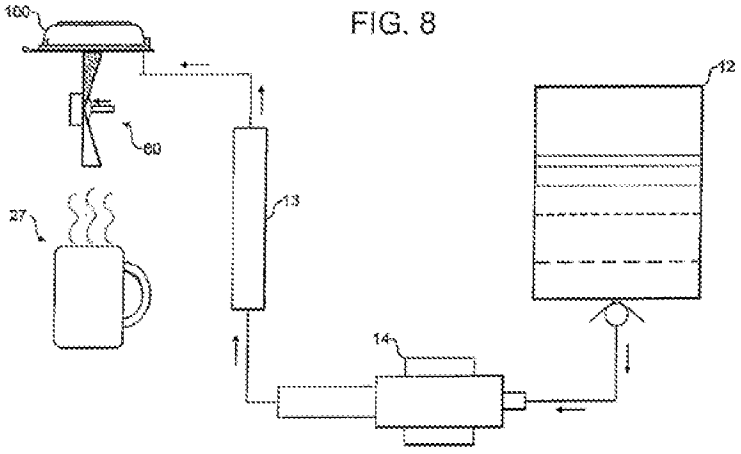
(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

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

(54) Title: BEVERAGE PREPARATION MACHINES

FIG. 8



(57) Abstract: The present invention relates to improvements in methods of preparing beverages using a beverage preparation machines and in particular to a beverage preparation machine (10) of the type which uses pre-packaged containers (100) of beverage ingredients. The method is characterised by controlling the volume of air resident in at least a part of a delivery system of the machine to produce predetermined characteristics in a prepared beverage.

WO 2010/125326 A1

BEVERAGE PREPARATION MACHINES

The present invention relates to improvements in beverage preparation machines and in particular to a beverage preparation machine of the type which uses pre-packaged containers of beverage ingredients.

Coffee houses have been a part of the "coffee culture" since the 17th century. Throughout the years methods of making coffee have been refined and skilled people trained to produce the best coffee beverages. The first coffee machines were developed in the early 1800s and an automatic espresso machine was invented in the 1930s. The automation of the coffee making process has, in turn, lead to a rapid growth, particularly in the last ten years, in the number of coffee houses/shops with more specialist drinks, such as espresso and cappuccino, being in high demand. These types of beverages have historically been regarded as luxury items because of the need for expensive, complex machines capable of producing the high pressures necessary for making them, which had to be properly operated and maintained by a trained barista to produce good quality. Coffee aficionados agree that an espresso can be spoiled by a badly trained operator despite the use of a good quality machine and good quality coffee. This trend, however, has not only lead to an increased demand from consumers for luxury top quality beverages, but also a desire for a greater variety of speciality beverages, and the ability to make such beverages in the comfort of one's own home.

Although there is no agreed technical definition, it is generally understood that, compared to drip coffee, barista quality espresso has a thicker consistency, due to a higher amount of dissolved solids and fine oil droplets suspended throughout the drink. It has a smooth, yet thick, dark reddish brown crema making up 10 to 30% of the beverage. The crema is a polyphasic emulsion of air and the oils, proteins and sugars extracted from the coffee which is produced at a high pressure, traditionally in the region of 9 to 10 bar. The higher pressures increase the rate of coffee wetting and improve extraction as well as being responsible for the development of the crema.

It is acknowledged, by discerning espresso drinkers, that espresso produced using water which is cooler than the optimum temperature tastes sour and that produced with water which is hotter than this temperature tastes bitter. The optimum temperature is claimed to be between 92 and 96°C. Other factors which affect the quality of the espresso include the roasting and age of the coffee beans, the grind size, the compaction of the grinds prior to brewing, and the brew time. The "best" espresso is achieved by balancing these key elements of the brewing process.

Domestic coffee machines have also developed significantly since the first filter machines were invented in the 1960s and coffee machines are now essential pieces of kitchen equipment in many households. Some such machines dispense individual servings of a beverage directly into a drinking receptacle, and derive the beverage from a bulk supply of beverage ingredients or from individual packages

IPR2023-00502
Nespresso USA, Inc. Ex. 1002 Part 5
Page 259 of 387

of beverage ingredients such as pods, pads or cartridges. In the following specification such packages will be referenced by the general term cartridges. Machines which use such cartridges eliminate the need for cleaning and can enable the user to make a selection of beverages. An example of one type of such cartridge is described in EP-A-1440903. The beverages are formed from brewing, mixing, dissolving or suspending the beverage ingredients in water. For example, for coffee beverages, heated water is forced through the cartridges to form the extracted solution. The use of cartridges in such machines has become increasingly popular due to their convenience and the quality of the beverage produced.

An example of a machine for preparing beverages using this type of cartridge is described in EP-A-1440644. This type of machine provided, inter alia, an improvement over the prior art known at the time in that it operated at a lower pressure than the previously known machines, which were designed for the commercial or industrial markets rather than the domestic market. Hence it was more suitable for the domestic market in terms of cost, reliability and performance. However, the problem that faces systems that operate at a lower pressure is that they are generally not capable of producing barista quality espressos, which require a significantly higher pressure.

With the change in consumer trends, however, there is a desire for domestic machines which are capable of producing barista quality espresso and a range of other beverages, for

which no training is necessary, which are affordable and which require little or no cleaning.

Some machines available on the market claim to produce higher quality beverages but for various reasons, they are comparatively expensive machines. Examples of such machines are the Gaggia L'Amante ™, the Gaggia Evolution ™, the Nespresso Delonghi Latissimma 660 ™, and the Krups XN2101 ™.

Most of these machines require specially designed cartridges of increased complexity and a particular specification of materials to cope with the high pressures involved in the brewing process for espresso. These cartridges generally incorporate filters and the process uses the geometry of the cartridge to enable the desired quality of the beverage to be produced under high pressure. This constrains the use of the cartridges in the machine for which it is designed.

It is, however, desirous to provide an improved beverage preparation machine capable of making a selection of beverages, including a premium quality espresso as well as non-espresso beverages, preferably using pre-packed beverage cartridges. The machine may also be a bulk brewer or other non-cartridge machine

It is also desirous to provide a machine which is backwardly compatible with existing cartridges, such as those described in EP-A-1440903, which are used in existing low pressure beverage preparation machines.

Accordingly, the present invention provides a method of preparing beverages using a beverage preparation machine for preparing beverages from one or more beverage ingredients, characterised by controlling the volume of gas in at least a part of a delivery system of the machine to produce predetermined characteristics in a prepared beverage.

The volume of gas is preferably actively controlled by increasing the volume to increase the gas:liquid ratio in the beverage produced, decreasing the volume to decrease the gas:liquid ratio or maintaining the volume.

Preferably the volume of gas in the delivery system is controlled by inducting additional gas into the delivery system, venting gas from the delivery system and/or purging the delivery system.

The method preferably further comprises the step of measuring the actual volume of gas resident in the delivery system.

An actual volume of gas resident in the delivery system may be calculated from stored parameters relating to a volume of gas remaining in the delivery system after a last operation of the machine.

Control of the volume of gas is preferably effected on a beverage by beverage basis and is preferably effected automatically according to the type of beverage being produced.

Alternatively the control of the volume of gas is effected manually.

The volume of gas upstream and/or downstream of the beverage ingredients may be controlled.

Preferably the volume of gas is controlled by selectively opening and/or closing valve means in the delivery system prior to and/or during beverage preparation.

The invention also provides a beverage preparation machine for preparing a beverage from one or more beverage ingredients, characterised by the provision of means for controlling the volume of gas in at least a part of a delivery system of the machine to produce predetermined characteristics in a prepared beverage.

The machine preferably comprises means for determining the actual volume of gas resident in the delivery system.

The means for determining the actual volume of gas resident in the delivery system may comprise means for calculating the actual volume from stored parameters relating to a volume of gas remaining in the delivery system after a last operation of the machine.

Preferably the stored parameters comprise a basic volume parameter stored in the control means, said basic volume being the actual volume of gas which resides in the delivery system of an unused machine or a machine after a purging cycle has been run.

The stored parameters may comprise parameters relating to the actual volume of gas remaining in the delivery system after each type of beverage which the machine is programmed to prepare.

The means for determining the actual volume of gas resident in the delivery system preferably comprise means for measuring the actual volume of gas in the delivery system.

Parameters relating to predetermined volumes of gas required to be present in the delivery system for preparing a predetermined range of beverages are preferably stored in the control means, said control means being programmed to calculate the difference between the predetermined volume required for a beverage in preparation and the actual volume present.

The means for controlling the actual volume of gas may comprise valve and/or purge means for venting gas and/or pump means for injecting additional gas into the delivery system.

Preferably the valve means comprise an outlet valve downstream and/or a valve upstream of the beverage ingredients.

Operation of the valve means is preferably controlled relative to the beverage preparation cycle to vary the actual volume of gas present in the delivery system.

Preferred embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a front perspective view of a prior art beverage preparation machine with the cartridge head in a closed position;

Figure 2 is a front perspective view of the machine of Figure 1 with the cartridge head in an open position;

Figure 3 is a rear elevation of the machine of Figure 1 with some parts omitted for clarity;

Figure 4 is a front perspective view of a cartridge head of the machine of Figure 1 with some parts omitted for clarity;

Figure 5 is another front perspective view of the cartridge head of Figure 4, with some parts omitted for clarity;

Figure 6 is a cross-sectional view of the cartridge head of Figure 4 in a closed position accommodating a version of a beverage cartridge;

Figure 7 is a cross-sectional side elevation of the cartridge head of Figure 4 in an open position accommodating the beverage cartridge;

Figure 7a is a plan view of a rubber seal for the cartridge head of Figure 4;

Figure 8 is a schematic showing the various component parts of the machine of Figure 1 incorporating a new variable outlet valve;

Figure 9 is a section of schematic of an outflow from the cartridge head incorporating the variable outlet valve of Figure 8;

Figures 10-12 are cross-sectional front elevations of one embodiment of the variable valve in the outflow of Figure 9 showing it's closed, open and restricted positions respectively;

Figures 13a and 13b are cross-sectional end elevations of an alternative variable outlet valve used in the outflow of Figure 9 in its open and closed position respectively;

Figures 14 and 15 are cross-sectional side elevations of the valve of Figures 13a and 13b;

Figure 16a is a side elevation of a beverage receptacle containing a coffee beverage having a large volume of crema produced using an improved gas management system;

Figure 16b is a chart showing the brew parameters used in producing the beverage illustrated in Figure 16a;

Figure 17a is a side elevation of a beverage receptacle containing a coffee beverage having a small volume of crema produced using the improved gas management system;

Figure 17b is a chart showing the brew parameters used in producing the beverage illustrated in Figure 17a;

Figure 18 is a plan view of a beverage cartridge suitable for use in the beverage preparation machine of Figure 1;

Figure 19 is cross-sectional side elevation of an outer member of the cartridge of Figure 18;

Figure 20 is a cross-sectional side elevation of a detail of the outer member of Figure 19 showing an inwardly directed cylindrical extension;

Figure 21 is a cross-sectional side elevation of a detail of the outer member of Figure 19 showing a slot;

Figure 22 is a perspective view from above of the outer member of Figure 19;

Figure 23 is a perspective view from above of the outer member of Figure 19 in an inverted orientation;

Figure 24 is a plan view from above of the outer member of Figure 19;

Figure 25 is a cross-sectional drawing of an inner member of the cartridge;

Figure 25a is a cross-sectional drawing of a detail of the inner member of Figure 25 showing an aperture;

Figure 26 is a perspective view from above of the inner member of Figure 25;

Figure 27 is a perspective view from above of the inner member of Figure 25 in an inverted orientation;

Figure 28 is another cross-sectional drawing of the inner member of Figure 25;

Figure 28a is a cross-sectional drawing of another detail of the inner member of Figure 25 showing an air inlet;

Figure 29 is a cross-sectional side elevation of the cartridge in an assembled condition; and

Figure 30 is a cross-sectional side elevation of another version of cartridge.

In order to cater for the desired wide selection of good quality beverage types, having different characteristics, the present invention involves one or more significant improvements to known beverage preparation machines. These improvements enable sufficiently high pressures to be generated and maintained for the production of good quality espressos, and the pressure to be varied in a manner which is invisible to the user and requires no

manual intervention. Furthermore they enable the crema to be improved in a way not previously possible.

These improvements, which will be described in more detail below, include:-

1. providing a variable geometry valve downstream of the beverage cartridge to enable the beverage preparation machine to operate at a range of pressures; and

2. providing greater control over the end appearance of the dispensed beverage, in particular beverages with crema, by controlling the volume of gas passed through the beverage ingredients.

The aforementioned improvements will be described with reference to a known beverage preparation machine 10 which is illustrated in Figures 1 to 7 of the accompanying drawings. It should be noted, however, that the improvements find application in a wide range of beverage preparation machines capable of using a wide range of cartridges which, as noted above, include pods, pads, rigid and semi-rigid cartridges.

The beverage preparation machine 10 of Figures 1 to 3 generally comprises a housing 11, a tank 12, a water heater 13, a control processor (not shown), a user interface 16 and a cartridge head 17. The cartridge head 17 in turn generally comprises a cartridge holder 18 for holding, in use, a beverage cartridge 100 and cartridge recognition means 20. The cartridge head 17 further comprises inlet and outlet

piercers 21,22 for forming in the beverage cartridge 100, in use, an inlet 107 for liquid to enter the cartridge 100 and an outlet 108 for the prepared beverage to exit the beverage cartridge 100.

Although water is likely to be the most common liquid used in preparing beverages such as coffee, the machine 10 is also capable of handling other liquids, such as milk or milk preparations, for mixing with the beverage ingredients 200. Any references herein to water should also be taken to include any form of liquid used in preparing beverages.

The housing 11 is preferably made in whole or in part from a suitable plastics material or metal. The housing 11 preferably comprises a clam-shell design having a front half 25 and a rear half 26 which allow access during assembly for fitting of the machine 10 components.

The front half 25 of the housing 11 defines a dispensing station 27 where dispensation of the beverage takes place, which includes a cupstand 23 with a drip tray located beneath. The machine user interface 16 is also located on the front of the housing 11 and comprises a plurality of control switches, for example, a start/stop button 28, and a number of status indicators 29-32. The status indicators 29-32 are preferably light emitting diodes (LED) which, for example, indicate readiness of the machine 10, whether an error has occurred in the machine 10 operation, and the mode of operation of the machine 10. The LEDs 29-32 may be controlled to illuminate at a constant intensity, to flash intermittently, or both depending on the

status of the machine 10. The LEDs 29-32 may have a variety of colours including green, red and yellow. The start/stop button 28 controls commencement of the dispense cycle and is preferably a manually operated push-button, switch or similar.

The tank 12 is located to the rear of the housing 11 and is preferably incorporated in, or connected to, the rear half 26 of the housing 11. The tank 12 has an inlet for filling the tank 12 with water, or other liquid, which is closed off when the tank 12 is in position in the machine 10. An outlet is provided towards a lower end of the tank 12 which communicates with the pump 14. The tank 12 may be made from a transparent or translucent material to allow a consumer to view the quantity of water remaining in the tank 12. Alternatively, the tank 12 may be made from an opaque material but have provided a viewing window therein. In addition, or in place of the above, the tank 12 may be provided with a low level sensor which prevents operation of the pump 14 and optionally triggers a warning indicator, such as an LED, when the liquid level in the tank descends to a preselected level. The tank 12 preferably has an internal capacity of approximately 1.5 litres.

The pump 14 is operatively connected between the tank 12 and the water heater 13, as shown schematically in Figure 8, and is controlled by the control processor. A suitable pump provides a flow rate of 900 ml/min of water at a pressure of 6 bar. The flow rate of water through the machine 10 can be controlled by the control processor to be a percentage of the maximum flow rate of the pump 14 by

cycle chopping the electrical supply to the pump. Preferably the pump can be driven at any of 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% or 100% of the maximum rated flow rate. The accuracy of the volume of water pumped is preferably + or - 5% leading to a + or - 5% accuracy in the final volume of the dispensed beverage. A volumetric flow sensor (not shown) is preferably provided in the flow line either upstream or downstream of the pump 14. Preferably, the volumetric flow sensor is a rotary sensor.

The heater 13 is located in the interior of the housing 11. One suitable heater 13 has a power rating of 1550 W and is able to heat water received from the water pump 14 from a starting temperature of approximately 20 °C to a nominal operating temperature of around 85°C in under 1 minute. Preferably the dwell time between the end of one dispense cycle and the heater 13 being able to commence a subsequent dispense cycle is less than 10 seconds. The heater maintains the selected temperature to within + or - 2 °C during the dispense cycle. The water for the dispense cycle is delivered to the cartridge head 17 at a predetermined temperature. The heater 13 is able to quickly adjust the delivery temperature to the required temperature, generally between 80°C and 98°C and possibly higher from the incoming water temperature. Where desired, the machine 10 can incorporate a steam purge. The preferred means of generating the steam purge is to utilise a water heater 13 in the form of a flash (also known as an instantaneous or flow) heater. Typically such flash heaters comprise a tube through which the water passes wherein the tube is heated by one or more resistive elements. The flash heater can be used not only

for heating water for forming beverages but also, at higher power settings, for generating a steam purge by boiling off water remaining with the flash heater tube after the beverage has been formed. An advantage of flash heaters is that there is no significant delay whilst water in a boiler heats up. Flash heaters heat water on demand and switch off immediately after each brewing cycle and are therefore very energy efficient.

Water output from the heater 13 is fed via a suitable delivery system to the cartridge head 17 and cartridge 100 by means of a valve. If the pressure of the water flow is acceptable, the water is passed to the cartridge 100. If the pressure is below or above predetermined limits then the water is diverted by means of the valve to a waste recovery receptacle.

The delivery system comprises conduits which connect the tank 12, the water pump 14, the water heater 13 and the cartridge head 17 (as shown in Figure 8) to transport the water from the tank 12 to the cartridge 100.

The cartridge holder 18 is designed to be capable of handling the opening forces generated by the pressure inside the cartridges 100, which is around 250kg for espresso beverages. During operation of the machine 10 the cartridges 100 attempt to expand, but the integrity of the cartridges 100 must be maintained. In addition the user must not be able to open the holder 18 whilst the system is pressurised and suitable locking mechanisms are provided to achieve this.

One suitable design of cartridge head 17, as described in WO-A-2006/014936, is shown in Figures 4 to 7. The cartridge holder 18 of the cartridge head 17 comprises a fixed lower part 43, a rotatable upper part 44 and a pivotable cartridge mount 45 positioned between the fixed lower part 43 and the rotatable upper part 44. The upper part 44, lower part 43 and cartridge mount 45 are rotated about a common hinge axis 46. Figures 4 to 7 show the holder 18 with some components of the machine 10 omitted for clarity.

The rotatable upper part 44 and pivotable cartridge mount 45 are moved relative to the fixed lower part 43 by means of a clamping mechanism. The clamping mechanism comprises a clamping lever having first and second members or parts 47 and 48. The first part 47 of the clamping lever comprises a U-shaped arm which is pivotably mounted to the upper part 44 at two first pivot points 48, one on each side of the holder 18.

The second part of the clamping lever comprises two over-centre arms 49, one on each side of the holder 18 which are each pivotably mounted to the upper part 44 at a second pivot point 50 located on the hinge axis 46 coupling the upper part 44 to the fixed lower part 43. Each over-centre arm 49 is a reciprocal member comprising a cylinder 49a, a stem 49b and a resilient sleeve 49c. The cylinder 49a has an internal bore and is rotatably mounted at one end at the hinge axis 46. A first end of the stem 49b is slidingly received in the bore of the cylinder 49a. The opposite end of the stem 49b is rotatably mounted to the U-shaped arm 47

at a third pivot point 51. The third pivot points 51 are unconnected to, and freely moveable relative to, the upper part 44 and lower part 43. The resilient sleeve 49c is mounted externally on the stem 49b and extends, in use, between abutment surfaces on the cylinder 49a and stem 49b. The resilient sleeve 49c accommodates shortening of the over-centre arm 49 but biases the over-centre arm 49 into an extended configuration. Movement of the third pivot points 51 towards and away from the hinge axis 46 is thus possible by relative movement of the stems 49b in the cylinders 49a. The resilient sleeves 49c are preferably formed from silicone. Whilst the illustrated embodiment uses two over-centre arms 49, it will be apparent that the closure mechanism may be configured with only one over-centre arm 49.

The U-shaped arm 47 extends around the front of the holder 18 and comprises two downwardly dependant hook members 52, one on each side of the holder 18, each comprising a cam surface facing the hinge axis 46. The fixed lower part 43 of the holder 18 is provided with two bosses 53, or detents, located one on each side of the lower part 43 at or near a front edge 54 thereof aligned generally with the hook members 52.

As shown in Figure 4, the U-shaped arm 47 may be formed from a one piece plastics moulding comprising an ergonomic hand grip and the hook members 52 integral to the arm 47.

The cartridge mount 45 is rotatably mounted between the upper and lower parts 43, 44 of the holder 18. The mount 45

is provided with a substantially circular recess 55 which receives in use the beverage cartridge 100 (which is described in greater details below). The recess 55 includes an irregularity 56 for accommodating the handle portion 24 of the beverage cartridge 100 which also acts to prevent rotation of the beverage cartridge 100 in the holder 18. The cartridge mount 45 is sprung relative to the fixed lower part 43 such that in the open position, as shown in Figure 7, the cartridge mount 45 is biased out of contact with the fixed lower part 43 so that the cartridge mount 45 is moved out of contact with the outlet and inlet piercer members 21, 22. The cartridge mount 45 is provided with an aperture 57 for receiving there through the inlet and outlet piercers 21, 22 and a head of the cartridge recognition means 20 when the cartridge mount 45 is moved into the closed position.

The upper part 43 comprises a generally circular body 58 housing a circular viewing window 59 through which a consumer can view the beverage cartridge 100 during a dispense cycle and also visually confirm whether a cartridge 100 is loaded in the machine 10. The viewing window 59 is cup-shaped having a downwardly directed rim. In addition, the viewing window 59 is provided with a clamping member in the form of an inwardly directed tubular extension 61 as shown in Figure 7. The extension 61 is directed towards the lower part 44 and lies within the volume of the cartridge head when in the closed position as shown in Figure 6. The viewing window 59 is able to move axially relative to the housing 58 of the upper part 43. One arrangement of accomplishing the relative movement is to provide a wave spring (not shown), or similar resilient means such as a

rubberised ring, positioned between the viewing window 59 and the circular housing 58. In an alternative arrangement, a series of helical compression springs (not shown) are provided extending between the viewing window 59 and the housing 58. In both cases the resilient means allows the viewing window 59 to move axially relative to the circular housing 58 by a small degree.

When the holder 18 is in the closed position, a distal end 62 of the tubular extension 61 of viewing window 59 bears against the clamping surface 18a of the beverage cartridge 100 biasing it against the lower part 44 as shown in Figure 6 (in which the arrangement is illustrated containing a cartridge having a greater depth). The pressure exerted by the tubular extension 61 on the outer member 102 ensures a fluid tight seal between the cartridge 100 and the holder 18. It should be noted that the height of the viewing window 59, and hence also the cartridge head 17, is such that cartridges 100 of various depths can be inserted. In Figure 6 the arrangement is shown with a relative deep cartridge. The same cartridge head 17 can also accommodate shallower cartridges. In this case there will be a gap between the upper surface 11 of the cartridge 100 and the window 59. However the cartridge 100 is fully sealed at inlet and outlet by the pressure applied by the tubular extension 61.

The lower part 43 comprises the inlet and outlet piercers 21, 22 and the head of the cartridge recognition means 20. The inlet piercer 21 comprises a hollow needle-like tube 63 having a sharpened end 64 for perforating the

laminate 108 of the beverage cartridge 100 in use. The inlet piercer 21 is in fluid communication with a water conduit 65, as shown in Figure 7, which passes through the lower part 43 and is connected to an outlet conduit 66 of the water heater 13. The outlet piercer 22 is similar in type to the outlet piercer described in the EP-A-0389141 and EP-A-0 334572 and comprises an open ended cylinder of circular or D-shaped cross-section having dimensions larger than the beverage discharge spout 109. An arcuate portion 67 of the upper end of the outlet piercer 22 is serrated to pierce and eventually cut the laminate of the beverage cartridge 100. The remainder of the upper end is cut back longitudinally of the cylinder at least to the base of the teeth 68 of the serrated portion to fold or pull the cut laminate 108 away from the outlet aperture before the beverage is dispensed there through. The outlet piercer 22 pierces the laminate 105 externally of the discharge spout 143 and when the cartridge mount 45 is in the closed position, rests in the annulus between the discharge spout 143 and the outer wall 42 of the discharge funnel 140. The outlet piercer 22 folds back the cut laminate 105 into the annulus. Thereby both the outlet piercer 22 and the cut laminate 105 are held out of the way of the discharged beverage.

The outlet piercer 22 is surrounded by a ledge which is raised relative to its surroundings by 0.5mm.

Advantageously, the outlet piercer 22 is removable from the lower part 43 to enable it to be thoroughly cleaned, for example, in a dishwasher. The removable outlet piercer 22 is received in a recess in the lower part 43 where it is

seated. The inlet piercer 21 and/or the outlet piercer 22 may be made of a metal, such as stainless steel, or from a plastics material. Advantageously, the use of plastic cutting elements is enabled by use of a laminate 105 which is able to be punctured and cut by a non-metallic material. Consequently, the piercers 21, 22 can be made less sharp which lowers the risk of injury to the consumer. In addition, plastic piercing elements are not prone to rust. Preferably, the inlet piercer 21 and the outlet piercer 24 are formed as a single, integral unit which is removable from the lower part 43.

In use, the upper part 44 of the holder 18 is movable from an open position in which it is orientated vertically or towards the vertical as shown in Figure 2, to a closed position in which it is orientated substantially horizontally and in interengagement with the fixed lower part 43 and cartridge mount 45. The upper part 44 is moved from the open to the closed positions by operation of the clamping lever. To close the upper part 44 a user takes hold of the clamping lever by the U-shaped arm 47 and pulls downwards. Consequently, the upper part 44 rotates which first brings the tubular extension 61 of the viewing window 59 into contact with the clamping surface 118a of the beverage cartridge 100. Continued rotation of the upper part 44 rotates the upper part 44 and cartridge mount 45 down into contact with the lower part 43. Further rotation of the U-shaped arm 47 causes the U-shaped arm 47 to rotate relative to the upper part 44 and the lower part 43 resulting in the hook members 52 of the upper part 44 engaging the bosses 53 of the lower part 43 with the cam

surface riding over the bosses 53. During this last stage of rotation the cartridge 100 is compressed between the cartridge mount 45 and the viewing window 59. As a result, the viewing window 59 is moved axially slightly relative to the circular housing 58 of the upper part 44 against the bias of the wave spring or helical springs. This movement allows for a take up of tolerances in the beverage cartridge 100 and beverage preparation machine 10 and ensures that the amount of compressive force applied to the cartridge 100 is kept within an acceptable range. The clamping force of the mechanism as moderated by the action of the wave spring or helical springs ensures a clamping pressure on the cartridge 100. It has been found that a force of between 150N and 400N is required to counter the pressure in the cartridge 100. During closure of the cartridge head the laminate 105 of the cartridge 100 is tensioned as it is brought into contact with the ledge surrounding the outlet piercer 22 which causes the laminate 105 to flex out of plane as the distal end of the outer tube 42 of the cylindrical funnel is moved upwardly by 0.5mm relative to the flange 147. This movement also ensures that the great majority of the compressive force applied to the cartridge 100 acts through the central region of the cartridge 100 through the load-bearing inner member 103. These clamping forces help prevent failure of the cartridge 100 during pressurisation and also ensure that the inner member 103 and outer member 102 are fully seated relative to one another and thus that all internal passageways and apertures remain at their intended dimensions even during internal pressurisation.

In the closed position, the separation of the distal end 62 of the tubular extension 61 and the lower part 44 is shown by reference D in Figure 6. This distance is fixed by the dimensions of the viewing window 59, housing 58 and lower part 44. The distance D is chosen to be the same or marginally smaller than the distance d between the clamping surface 118a and laminate 105 under surface of the cartridges 100. In this way, on closure of the cartridge head 17 the cartridges 100 are subjected to a fixed, known degree of compression. In addition, both the first and second embodiments of cartridge can be clamped with the same degree of compression since distance D is the same for both cartridge types.

An imaginary datum line can be drawn between the first and second pivot points 48, 50 of the holder 18. As can be seen in Figure 7, in the open position the third pivot points 51 are located on the side of the datum line nearest the fixed lower part 43. As the upper part 44 reaches the closed position, the third pivot points 51 of the clamping lever pass through the datum line joining the first and second pivot points 48, 50 to the opposite side of the line, furthest from the fixed lower part 43. Consequently, the U-shaped arm 47 'snaps through' from a first stable position to a second stable position. The snap through action is accommodated by shortening of the over-centre arms 49 and consequential compression of the resilient sleeves 49c. Once the third pivot points 51 are past the imaginary datum line, the recovery of the resilient sleeves 49c acts to continue the motion of the third pivot points 51 away from the imaginary datum line. The clamping lever thus has a bi-

stable operation in that the lever is stable in the open or closed positions but unstable at the point when the third pivot points 51 lie on the imaginary datum line joining the first and second pivot points 48, 50. Thus, the snap-through action of the clamping lever provides a positive closure mechanism which leads to a definite closure action wherein in the final stages of the clamping lever's rotation, the snap-through action of the U-shaped arm 47 and second arms forces the hook members 52 firmly into engagement with the bosses 53. In addition, the resilient sleeves 49c provide a resistance to re-opening of the upper part 44 since a minimum force is required to compress the sleeves 49c sufficiently to move the third pivot points 51 back into line with the datum line joining the first and second pivot points 48, 50. Advantageously, the interengagement of the hook members 52 and the bosses 53 prevents separation of the upper and lower parts other than by rotation of the clamping lever. This is useful in preventing opening of the cartridge head 17 during operation when the cartridge head 17 is subject to internal pressurisation.

The pressure exerted by the upper section 44 ensures a full fluid tight seal between the cartridge 100 and the cartridge holder 18. The clamping forces help prevent failure of the cartridge 100 during pressurisation and also ensure that all of the internal passageways and apertures within the cartridge 100 remain at their intended dimensions even during internal pressurisation. To improve the seal with the cartridges 100 the applicant has now found that lining the recess 55 of the cartridge mount 45 with a rubber seal 55a (see Figure 7a) improves the machine's ability to

withstand the significantly higher pressures generated during the brewing cycle.

Control of the brew cycle is effected by the control processor of the beverage preparation machine 10, which comprises a processing module and a memory. The control processor is operatively connected to, and controls operation of, the heater 13, pump 14, user interface 16, and other components described below.

The operational behaviour of the machine 10 is determined by software embedded in the control processor, for example as described in EP-A-1440644. The memory of the control processor includes one or more variables for one or more operational parameters for the beverage preparation machine 10. In the prior art machines these are generally the temperature of the liquid passed through the beverage cartridge 100 during the operating stage, the speed of charging the beverage cartridge 100, the presence or otherwise of a soak step, the total dispensed volume of the beverage, the flow rate of the liquid during the discharge stage, and the period of the purge stage.

One purpose of the cartridge recognition means 20 is, inter alia, to allow the machine 10 to recognise the type of beverage cartridge 100 that has been inserted and to adjust one or more operational parameters accordingly. The variables for the operational parameters are stored in the memory. The cartridge 100 comprises a code 120 provided on or in the cartridge 100 representing the operational parameters required for optimal dispensation of the beverage

in that cartridge 100. An example of the code is described in EP-A-1440644.

The control processor memory further stores information on the type of beverage dispensed so that the operating cycle of the machine 10 may be adjusted for the next cartridge 100. This is especially advantageous where two or more beverage cartridges 100 are used sequentially to form a beverage. For example a coffee cartridge may be dispensed followed by a milk cartridge to form a cappuccino beverage. Alternatively a chocolate cartridge could be used followed by a milk cartridge to produce a creamy hot chocolate beverage. By using a memory that stores information on the first beverage dispensed, the manner of dispensing the second cartridge, say a milk cartridge, may be altered to achieve an optimum beverage. In the above example the milk dispensed for hot chocolate may, typically, be diluted less than the milk added to the coffee. In addition, the milk dispensed for chocolate may be dispensed at a slower flow rate to lessen the degree of foaming of the beverage. Many combinations of cartridges are possible and operating parameters as will be obvious to the skilled person. In addition, the memory may be used to allow the machine 10 to 'predict' the type of beverage that a user will next want to dispense. For example, if a user predominantly drinks one beverage type then the machine can instruct the water heater to remain at the optimum temperature for that beverage type.

Operation of the known prior art machines 10 comprises insertion of a beverage cartridge 100 into the cartridge head 17, carrying out a dispense cycle in which the beverage

is dispensed and removal of the cartridge 100 from the machine.

To insert the cartridge 100 the cartridge holder 18 is opened as described above to expose the cartridge mount 45. The cartridge 100 is then placed on the cartridge mount 45 received within the recess 46. The cartridge holder 18 is then closed by operation of the clamping handle 51 as described above. During closure the inlet and outlet piercers pierce the cartridge 100 to form the cartridge inlet 107 and outlet 108.

To commence the operating cycle the user operates the start/stop button 28. The operating cycle comprises the steps of cartridge recognition and the beverage preparation cycle.

Cartridge recognition is performed by the optical cartridge recognition means 20 as described above assuming that the outputs from the cartridge sensor and lock sensor are satisfactory. Once the barcode 40 has been decoded the operational parameters of the machine 10 are adjusted by the control processor. The preparation cycle is then automatically commenced. The preparation cycle has four main stages, although not all of these are used for all beverage types:

1. Pre-wet
2. Pause
3. Brew stage
4. Purge

In the pre-wet stage the cartridge 100 is charged with liquid from the storage tank 12 by means of the pump 14. The charging with water causes the beverage ingredients 200 in the chamber 160 to be wetted. The charging may take place at a "fast" flow rate of 600 ml/min or a "slow" flow rate of 325 ml/min. The slow charging rate is particularly useful for cartridges 100 containing viscous liquid beverage ingredients where the ingredients require some dilution before they are able to be pumped at a higher volume flow rate. The volume of liquid injected into the cartridge 100 is selected to ensure that liquid or beverage does not drip out of the cartridge outlet 108 during this stage.

The pause stage allows the beverage ingredients 200 to soak in the liquid injected during the pre-wet stage for a predetermined period of time. Both the pre-wetting and soaking stages are known to increase the yield of the extractibles from the beverage ingredients 200 and to improve the end flavour of the beverage. Pre-wetting and soaking are particularly used where the beverage ingredients are roast and ground coffee.

In the brew stage liquid is passed through the cartridge 100 in order to produce the beverage from the beverage ingredients 200. The temperature of the liquid is determined by the control processor which sends instructions to the heater 13 to heat the liquid passing from the tank 12 to the cartridge head 17. Liquid enters the cartridge holder 18 via an inlet valve and the inlet piercer and then passes into the inlet chamber 126 of the beverage cartridge 100.

Brewing and/or mixing of the beverage in the beverage cartridge 100 occurs, as described in EP-A-1440644, before the prepared beverage exits the cartridge outlet 104, enters the outlet valve 37 and is directed into a suitably placed receptacle in the dispensing station 27.

During the purge cycle the temperature of the water heater 13 is raised sufficiently high to convert the water remaining in the system to steam and blowing the pressurised steam through the beverage preparation machine 10 and the beverage cartridge 100. This ensures that all beverage is dispensed and that the flow path is cleared ready for dispensing another beverage. The purge cycle may not commence immediately on cessation of the brew/mixing stage to allow for the majority of the fluid to clear the flow path.

Once the operating cycle has been completed, the machine automatically stops and the consumer removes the cartridge 100 by opening the cartridge holder 18 and manually removing and disposing of the cartridge 100. Alternatively, the machine 10 may be provided with an automatic ejection mechanism for removing the cartridge automatically on opening the cartridge holder 18.

The first of the significant improvements to the known beverage preparation machines 10 referred to above is the provision of variable geometry valve 60 (see Figures 9 to 15) provided adjacent the cartridge outlet 108 to provide post-cartridge pressure control. This enables the machine 10 to produce a wide variety of beverages, as it allows the

cartridges 100 to be selectively brewed at either high or low pressure or a varying pressure during the brew cycle, depending on the type of brew cycle required for the beverage ingredients in the cartridge as identified by the cartridge recognition means 20, thus providing an automated variable pressure system. The modified machine is capable of producing beverages at a range of pressures, for example from 0 to 9 bar, and more preferably from 0 to 6 bar.

The variable geometry valve 60 is positioned downstream of the cartridge 100, and preferably positioned in the beverage outlet 37, which is partially housed in, and extends from, the lower section 43 of the cartridge head 17 (see Figures 6 and 7). The valve 60 has at least an open and a restricted state, and more preferably all of the states identified below:-

1. Open (Figure 11)
2. Restricted (Figure 12)
3. Closed (Figure 10)
4. Cleaning/purging.

Various types of valve may be used for the outlet valve 60, such as ball valves, pinch valves, sleeve valves, seat valves or disc valves. The embodiment illustrated in Figures 10 to 12 is a ball type valve which has a rotating element 69 located in a chamber 70 in the beverage outlet 37. The rotating element 69 is rotatable between preset positions to provide the required states. The diameter of the bore of the valve 60 in the unrestricted position is preferably at least

5mm which is required, for example, for cartridges 100 providing low pressure filter beverages.

An alternative suitable valve is a pinch valve illustrated in Figures 13 to 15 which comprises a flexible tube 71, preferably made of silicon rubber or an elastomeric material, and a clamping mechanism 72. In the unrestricted position (Figures 13a and 14) the beverage flows freely through the tube 71. The clamping mechanism 72 is activated to provide a restricted position (Figures 13b and 15) and closed position.

The valve 60 is controlled automatically by the control processor of the machine 10. Once the type of cartridge 100 inserted into the machine 10 has been identified, by the decoding the barcode 40, the control processor selects the correct initial setting and, if appropriate, any subsequent operation of the valve 60 for the relevant beverage type.

The machine 10 can operate in a range of modes, with the valve 60 in one or more positions, some examples of which are:-

1. Valve Open Throughout The Brewing Cycle

When the valve 60 is in its open position the operating pressure is below 2 bar allowing a steady state through flow rate of up to 400 ml/min. The beverage is dispensed under similar conditions to those described in EP-A-1440644. This mode is particularly useful as it renders the machine 10 backwardly compatible with existing cartridges for preparing

low pressure beverages, such as tea, foamed milk or chocolate.

2. Valve Restricted Throughout The Brewing Cycle

When the valve 60 is in its restricted position it creates a relatively high back pressure within the cartridge 100, which results in an operating pressure of up to 4, 6 or even 9 bar and provides a steady state through flow rate of 60 to 300 ml/min. This is sufficient to obtain the necessary solids extraction and emulsification of oils in the beverage ingredients 200 for an espresso beverage. The consequential restriction in the beverage outlet 37 provides a shearing and mixing action in the beverage flowing through the valve 60, giving rise to good air/liquid emulsification and resulting in an improved crema. This mode can advantageously be used for preparing higher pressure beverages, such as espressos and cappuccinos, from cartridges 100 which do not have means for entraining air to effect the mixing action, i.e. so called non-eductor cartridges.

3. Valve Closed Then Restricted

If the valve 60 is closed immediately at the start of the brewing cycle (before the pump 14 commences and during the pre-wet cycle), this enables a higher pressure to be developed within the cartridge 100 than when the valve 60 is in it's restricted position.

Further combinations may be appropriate, such as valve closed then open or valve closed then restricted then open according to the desired effect to be achieved.

If required, the valve 60 can be pulsed between various positions during the brewing cycle, or a part thereof. This manner of valve operation during the delivery cycle enables beverages with a crema having a graduated colour and/or bubble size to be produced.

During the purge cycle the valve 60 is controlled by the control processor to divert the steam to a drain area rather than to the dispensing station 27 to preserve the appearance of the beverage and prevent contamination.

The second of the significant improvements to the known beverage preparation machines 10 referred to above is the addition to the brew control system of gas management. Surprisingly the applicant has now discovered that the characteristics of beverages prepared in this type of beverage preparation machine 10 can be modified beyond boundaries hereto seen in prior art machines. The surprising effect is enacted by controlling the volume of gas in the delivery system during the preparation of the beverage to prescribe the amount of high quality crema resulting in a controlled amount of crema on a beverage varying from a delicate layer up to a surprisingly deep layer in the final beverage. The applicant has found a way to successfully use gases within the beverage preparation machine to modify the gas:liquid ratio to produce a surprising volume of good stable crema in prepared beverages never seen before in

prior art machines. Maintaining a greater volume of gas resident in the delivery system enables a much larger gas:liquid ratio to be achieved during brewing and dispensing and this produces a correspondingly larger volume of crema. Decreasing the volume of gas enables the ratio to be decreased to reduce the crema volume. The bubble size is also influenced by the gas:liquid ratio, so a lower ratio can be used to provide a tight and creamy crema and a higher ratio used to provide a more loose and bubbly crema. This improvement therefore provides the ability to optimise the crema volume and bubble size for each beverage dispensed. It has been found that by manipulating the gas good quality espressos can be brewed with a crema volume greater than 25% of the beverage volume whilst minimising the occurrence of bubbles having a diameter of more than 172 microns which is not previously seen to be possible in known beverage preparation machines of this type.

The improvement is achieved by adapting the control of the brew cycle to provide means for managing the volume of gas within the delivery system which conveys the water from the tank 12 to the beverage ingredients 200 and to the dispensing outlet. All further references in this specification to the delivery system are intended to include any predetermined section thereof, for example the section extending from the water heater 13 to the cartridge 100 and may also include, if relevant, some gas contained within a headspace of the cartridge 100.

The "basic volume" of gas which can reside within the delivery system of any given machine 10 is dependant on its

construction. The "actual volume" at any given time will vary according to whether the machine 10 has just been used to prepare a beverage, what type of beverage it was used for and whether a steam purge cycle has been run. Thus the improved brew cycle control incorporates means for varying the volume of gas in the delivery system according to the type of beverage to be dispensed (i.e. one requiring a crema with smaller and fewer bubbles or one which requires a greater froth of larger bubbles) taking into account the actual volume of gas already present. The means for varying the volume of gas may be achieved by combinations of:-

1. purging the delivery system after a brewing cycle is complete, and prior to a subsequent high pressure brew, which will increase the gas:liquid ratio;
2. venting gas from the delivery system prior to high pressure brewing, which will decrease the gas:liquid ratio; and
3. inducting gas into the delivery system prior to high pressure brewing, which will increase the gas:liquid ratio.

Valve means are preferably provided to enable the volume of gas within the delivery system to be reduced and an air pump to enable gas (typically air) to be injected into the system. A separate, dedicated air valve may be incorporated in the delivery system, either upstream or downstream of the cartridge 100. Preferably the variable geometry valve 60 described above may be used as the valve means.

To enable this improved brew cycle control to be effected, additional parameters to those described in connection with the basic machine 10 may be stored in the memory of the control processor. These additional parameters include the basic volume of gas for the specific construction of machine 10 (which will apply to the machine 10 which is unused or after it has been purged) and the volume required during high pressure brewing for optimising the crema for each specific beverage. Preferably the additional parameters also include the actual volume of gas which will remain in the delivery system after each type of brew operation which the machine 10 is capable of. However this is not wholly necessary if the machine 10 is programmed to run a steam purge cycle after every beverage is dispensed, which effectively resets the actual volume to the basic volume, because it flushes the dispensing system downstream of the water heater 13 of any remaining liquid.

The brew cycle will therefore include an additional step, namely a gas adjustment cycle before the pre-wet cycle. The gas adjustment cycle thus includes:-

1. An assessment of the required volume of gas for the type of beverage to be prepared. This will most conveniently be the selection from the processor memory of the required parameter associated with the cartridge code 120;

2. The determination of the actual volume of gas currently resident in the delivery means according to the

last operation of the machine 10. This will be the basic volume for an unused machine or if a purge cycle has been run. If the machine has just been used to prepare a beverage and no purge cycle run, the processor ideally selects from the memory the parameter for the remaining gas according to the last beverage. Alternatively, means may also be provided to specifically monitor the volume of gas within the delivery system at any point in time;

3. A calculation of the volume of gas to be inducted into or vented from the delivery system to achieve the required volume;

4. The modification of the volume of gas, if required, by the induction of additional gas (typically air) or the venting of excess gas.

In one example the beverage preparation machine 10 has a basic volume of gas of 36ml in the section of the delivery means extending between the water heater 13 and the beverage ingredients 200.

There are a number of different modes of operation for step 4 depending on the outcome of step 3, depending on what type of valve means are used. If the valve means are downstream of the cartridge, i.e. an outlet valve, one way of controlling the volume of air upstream of the beverage ingredients 200 prior to high pressure brewing is by closing the outlet valve at different points in the brew cycle as follows:-

1. The Correct Volume of Gas is Present

If the processor calculates that it requires the full basic volume of gas (36ml) for the beverage to be dispensed, as determined from the reading of the code 120, it closes the outlet valve at the start of the brew cycle, before any water flows from the water heater 13. This means that the compression of gas in the delivery system will commence immediately and the cartridge 100 will be subject to higher pressures during the pre-wet and soak cycles, with the valve only opening to dispense the resultant beverage. As the outlet valve is closed before the pump 14 is started, all of the 36ml of trapped gas is mixed in to the resulting beverage and a larger volume of slightly coarser crema is obtained (Figure 16a). In the example shown the volume of crema Y in a graduated glass, flat bottomed beaker was 20ml compared to the volume of liquid X, which was 50ml.

The chart shown in Figure 16b represents an example of brew cycle parameters used to produce a beverage in this mode with a large volume of crema under test conditions.

In this chart, a stop condition of 0 seconds (e.g. against the remove gas step) indicates that the step is not carried out.

2. Too Much Gas is Present

If, on the other hand, a beverage with a small volume of crema is indicated by the cartridge 100 inserted and there is an excess of gas present in the system, the outlet

valve is closed after the pump 14 has operated for a short time until the excess gas in the delivery system has escaped through the open valve at low pressure. With the valve being closed later in the brew cycle, the required volume of gas is vented to atmosphere via the cartridge 100 and valve, so a smaller quantity of trapped gas is left to be compressed and mixed in to the resulting beverage during high pressure brewing and consequently a smaller volume of finer crema is obtained (Figure 17a). In the example shown the volume of crema Y in a graduated glass, flat bottomed beaker was 5ml compared to the volume of liquid X, which was 50ml.

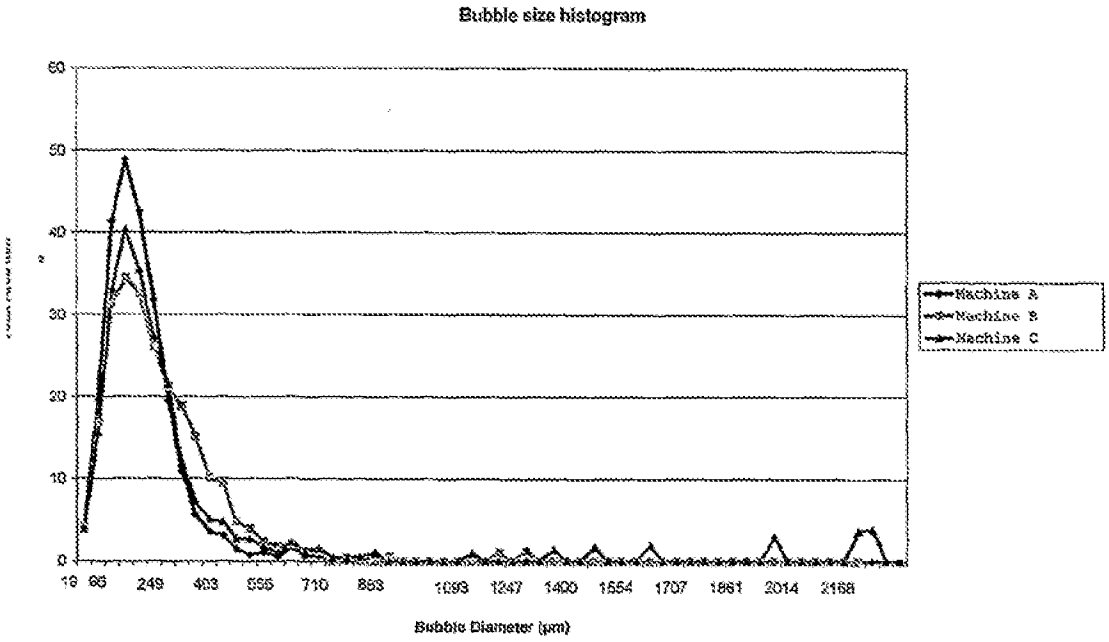
The chart shown in Figure 17b represents an example of brew parameters used to produce a beverage in this mode with a small volume of crema under test conditions.

3. Insufficient Gas Present

If step 3 indicates that more gas needs to be inducted, the outlet valve is closed immediately and the air pump operated until the deficit has been made up. Thereafter high pressure brewing commences.

The following graph is a digital image analysis showing a comparison of the crema characteristics produced by the present beverage preparation machine 10 (machine A) utilising the gas management system and two prior art machines (machines B and C) without such gas management system. Comparing the profiles for each machine from the peak (~172µm diameter) rightwards (increasing bubble size), it can be seen that machine A exhibits a very tight

distribution of small bubbles within the crema. Machine C (the Nespresso Latissma (tm)which is a high pressure machine which has a pressure rating of around 19 bar and operates at a pressure between 9 and 15 bar) produces a broader/coarser distribution with a number of larger diameter bubbles, whilst machine B (the applicant's own Tassimo/Bosch Machine(tm) similar to that described in EP-A-1440644 which is a low pressure machine operating at pressures below 2 bar) is coarser still, though without the larger bubbles seen for machine C.



The tail to the left of the chart (extremely small bubbles) is characteristic of the limits of the image analysis systems used to produce the graph, though is qualitatively similar.

Some elements of the control of the gas in the beverage machine 10 may also be effected manually by the use of suitable buttons for the user to press, to indicate the type of beverage being produced and the required crema characteristics.

Whilst this improvement has been described with reference to beverage machines 10 which use cartridges 100, it may also be used in bulk brewers and other non-cartridge machines.

Embodiments of cartridges 100 which are suitable for use in the machine 10 having the improvements described above are shown in Figures 18 to 30.

The cartridge 100 generally comprises an outer member 102, an inner member 103 and a laminate 105. The outer member 102, inner member 103 and laminate 105 are assembled to form the cartridge 100 which has an interior 106 for containing one or more beverage ingredients, an inlet 107, an outlet 108 and a beverage flow path linking the inlet 107 to the outlet 108 and which passes through the interior 106. The inlet 107 and outlet 108 are initially sealed by the laminate 105 and are opened in use by piercing or cutting of the laminate 105. The beverage flow path is defined by spatial inter-relationships between the outer member 102, inner member 103 and laminate 105 as discussed below. Other components may optionally be included in the cartridge 100, such as a filter 104, as will be described further below.

A first version of cartridge 100 which will be described is shown in Figures 19 to 29. The first version of the cartridge 100 is particularly designed for use in dispensing espresso-style products such as roast and ground coffee where it is desirable to produce a crema. However, this version of the cartridge 100 may be used with other products such as chocolate, coffee, tea, sweeteners, cordials, flavourings, alcoholic beverages, flavoured milk, fruit juices, squashes, sauces and desserts.

As can be seen from Figure 23, the overall shape of the cartridge 100 is generally circular or disc-shaped with the diameter of the cartridge 100 being significantly greater than its height. A major axis X passes through the centre of the outer member as shown in Figure 19. Typically the overall diameter of the outer member 102 is 74.5 mm ±6mm and the overall height is 16 mm ±3mm. Typically the volume of the cartridge 100 when assembled is 30.2 ml ±20%.

The outer member 102 generally comprises a bowl-shaped shell 110 having a curved annular wall 113, a closed top 111 and an open bottom 112. The diameter of the outer member 102 is smaller at the top 111 compared to the diameter at the bottom 112, resulting from a flaring of the annular wall 113 as one traverses from the closed top 111 to the open bottom 112. The annular wall 113 and closed bottom 112 together define a receptacle having an interior 134.

A hollow inwardly directed cylindrical extension 118 is provided in the closed top 111 centred on the major axis X. As more clearly shown in Figure 20, the cylindrical

extension 18 comprises a stepped profile having first, second and third portions 119, 120 and 121. The first portion 119 is right circular cylindrical. The second portion 120 is frusto-conical in shape and is inwardly tapered. The third portion 121 is another right circular cylinder and is closed off by a lower face 131. The diameter of the first, second and third portion 119, 120 and 121 incrementally decreases such that the diameter of the cylindrical extension 118 decreases as one traverses from the top 111 to the closed lower face 131 of the cylindrical extension 118. A generally horizontal shoulder 132 is formed on the cylindrical extension 118 at the junction between the second and third portions 120 and 121.

An outwardly extending shoulder 133 is formed in the outer member 102 towards the bottom 112. The outwardly extending shoulder 133 forms a secondary wall 115 co-axial with the annular wall 113 so as to define an annular track forming a manifold 116 between the secondary wall 115 and the annular wall 113. The manifold 116 passes around the circumference of the outer member 102. A series of slots 117 are provided in the annular wall 113 level with the manifold 116 to provide gas and liquid communication between the manifold 116 and the interior 134 of the outer member 102. As shown in Figure 21, the slots 117 comprise vertical slits in the annular wall 113. Between twenty and forty slots are provided. In the embodiment shown thirty-seven slots 117 are provided generally equi-spaced around the circumference of the manifold 16. The slots 117 are preferably between 1.4 and 1.8 mm in length. Typically the length of each slot 117 is 1.6 mm representing 10% of the overall height of the

outer member 102. The width of each slot 117 is between 0.25 and 0.35 mm. Typically, the width of each slot 117 is 0.3 mm. The width of the slots 117 is sufficiently narrow to prevent the beverage ingredients passing there through into the manifold 116 either during storage or in use.

An inlet chamber 126 is formed in the outer member 102 at the periphery of the outer member 102. A cylindrical wall 127 is provided, as most clearly shown in Figure 23, which defines the inlet chamber 126 within, and partitions the inlet chamber 126 from, the interior 134 of the outer member 102. The cylindrical wall 127 has a closed upper face 128 which is formed on a plane perpendicular to the major axis X and an open lower end 129 co-planar with the bottom 12 of the outer member 102. The inlet chamber 26 communicates with the manifold 116 via two slots 130 as shown in Figure 19. Alternatively, between one and four slots may be used to communicate between the manifold 116 and the inlet chamber 126.

A lower end of the outwardly extending shoulder 133 is provided with an outwardly extending flange 135 which extends perpendicularly to the major axis X. Typically the flange 135 has a width of between 2 and 4 mm. A portion of the flange 135 is enlarged to form a handle 124 by which the outer member 102 may be held. The handle 124 is provided with an upturned rim 125 to improve grip.

The outer member 102 is formed as a single integral piece from high density polyethylene, polypropylene, polystyrene, polyester, or a laminate of two or more of

these materials. A suitable polypropylene is the range of polymers available from DSM UK Limited (Redditch, United Kingdom). The outer member may be opaque, transparent or translucent. The manufacturing process may be injection moulding.

The inner member 103 as shown in Figures 25 to 28, comprises an annular frame 141 and a downwardly extending cylindrical funnel 140. A major axis X passes through the centre of the inner member 103 as shown in Figure 25.

As best shown in Figures 26 and 27, the annular frame 141 comprises an outer rim 151 and an inner hub 152 joined by ten equi-spaced radial spokes 153. The inner hub 152 is integral with and extends from the cylindrical funnel 140. Filtration apertures 155 are formed in the annular frame 141 between the radial spokes 153. A filter 104 is disposed on the annular frame 141 so as to cover the filtration apertures 155. The filter is preferably made from a material with a high wet strength, for example a non-woven fibre material of polyester. Other materials which may be used include a water-impermeable cellulosic material, such as a cellulosic material comprising woven paper fibres. The woven paper fibres may be admixed with fibres of polypropylene, polyvinyl chloride and/or polyethylene. The incorporation of these plastic materials into the cellulosic material renders the cellulosic material heat-sealable. The filter 104 may also be treated or coated with a material which is activated by heat and/or pressure so that it can be sealed to the annular frame 141 in this way.

As shown in the cross-sectional profile of Figure 25, the inner hub 152 is located at a lower position than the outer rim 151, resulting in the annular frame 141 having a sloping lower profile.

The upper surface of each spoke 153 is provided with an upstanding web 154 which divides a void space above the annular frame 141 into a plurality of passages 157. Each passage 157 is bounded on either side by a web 154 and on a lower face by the filter 104. The passages 157 extend from the outer rim 151 downwardly towards, and open into, the cylindrical funnel 140 at openings 156 defined by the inner extremities of the webs 154.

The cylindrical funnel 140 comprises an outer tube 142 surrounding an inner discharge spout 143. The outer tube 142 forms the exterior of the cylindrical funnel 140. The discharge spout 143 is joined to the outer tube 142 at an upper end of the discharge spout 143 by means of an annular flange 147. The discharge spout 143 comprises an inlet 145 at an upper end which communicates with the openings 156 of the passages 157 and an outlet 144 at a lower end through which the prepared beverage is discharged into a cup or other receptacle. The profile of the discharge spout 43 comprises a stepped profile with a distinct dog-leg 166 near an upper end of the tube 143.

As shown in Figure 25, the discharge spout 143 is provided with a partition 165 which extends part way up the discharge spout 143 from the outlet 144. The partition 165

helps to prevent the beverage spraying and/or splashing as it exits the discharge spout 143.

A rim 167 is provided upstanding from the annular flange 147 joining the outer tube 142 to the discharge spout 143. The rim 167 surrounds the inlet 145 to the discharge spout 143 and defines an annular channel 169 between the rim 167 and the upper portion of the outer tube 142. The rim 167 is provided with an inwardly directed shoulder 168. At one point around the circumference of the rim 167 an aperture 170 is provided in the form of a slot which extends from an upper edge of rim 167 to a point marginally below the level of the shoulder 168 as most clearly shown in Figures 25 and 25a. The slot has a width of 0.64 mm.

An air inlet 171 is provided in annular flange 147 circumferentially aligned with the aperture 170 as shown in Figures 28 and 28a. The air inlet 171 comprises an aperture passing through the flange 147 so as to provide communication between a point above the flange 147 and the void space below the flange 147 between the outer tube 142 and discharge spout 143. Preferably, and as shown, the air inlet 171 comprises an upper frusto-conical portion 173 and a lower cylindrical portion 172. The air inlet 171 is typically formed by a mould tool such as a pin. The tapered profile of the air inlet 171 allows the mould tool to be more easily removed from the moulded component. The wall of the outer tube 142 in the vicinity of the air inlet 171 is shaped to form a chute leading from the air inlet 171 to the inlet 145 of the discharge spout 143. As shown in Figure 28a, a canted shoulder 174 is formed between the air inlet

171 and the chute to ensure that the jet of beverage issuing from the slot 170 does not immediately foul on the upper surface of the flange 147 in the immediate vicinity of the air inlet 171.

The inner member 103 may be formed as a single integral piece from polypropylene or a similar material as described above and by injection moulding in the same manner as the outer member 102.

Alternatively, the inner member 103 and/or the outer member 102 may be made from a biodegradable polymer. Examples of suitable materials include degradable polyethylene (for example, SPITEK supplied by Symphony Environmental, Borehamwood, United Kingdom), biodegradable polyester amide (for example, BAK 1095 supplied by Symphony Environmental), poly lactic acids (PLA supplied by Cargil, Minnesota, USA), starch-based polymers, cellulose derivatives and polypeptides.

The laminate 105 is formed from two layers, a first layer of aluminium and a second layer of cast polypropylene. The aluminium layer is between 0.02 and 0.07 mm in thickness. The cast polypropylene layer is between 0.025 and 0.065 mm in thickness. In one embodiment the aluminium layer is 0.06 mm and the polypropylene layer is 0.025 mm thick. This laminate 105 is particularly advantageous as it has a high resistance to curling during assembly. As a result the laminate 105 may be pre-cut to the correct size and shape and subsequently transferred to the assembly station on the production line without undergoing distortion. Consequently,

the laminate 108 is particularly well suited to welding. Other laminate materials may be used including PET/Aluminium/PP, PE/EVOH/PP, PET/metallised/PP and Aluminium/PP laminates. Roll laminate stock may be used instead of die cut stock.

The cartridge 100 may be closed by a rigid or semi-rigid lid instead of a flexible laminate 105.

Assembly of the cartridge 100 involves the following steps:

a) the inner member 103 is inserted into the outer member 102;
b) the filter 104 is cut to shape and placed onto the inner member 103 so to be received over the cylindrical funnel 140 and come to rest against the annular frame 141;
c) the inner member 103, outer member 102 and filter 104 are joined by ultrasonic welding;
d) the cartridge 100 is filled with one or more beverage ingredients;
e) the laminate 105 is affixed to the outer member 102.

These steps will be discussed in greater detail below.

The outer member 103 is orientated with the open bottom 112 directed upwards. The inner member 103 is then inserted into the outer member 102 with the outer rim 151 being received as a loose fit in an axial extension 114 at top 111 of the cartridge 100. The cylindrical extension 118 of the

outer member 102 is at the same time received in the upper portion of the cylindrical funnel 140 of the inner member 103.

The third portion 121 of the cylindrical extension 118 is seated inside the support rim 167. The shoulder 132 of the cylindrical extension 118 between the second portion 120 and third portion 121 bears against the upper edge of the support rim 167 of the inner member 103. An interface zone is thus formed between the inner member 103 and the outer member 102 comprising a face seal between the cylindrical extension 118 and the support rim 167 which extends around nearly the whole circumference of the cartridge 100. The seal between the cylindrical extension 118 and the support rim 167 is not fluid-tight though since the slot 170 in the support rim 167 extends through the support rim 167 and downwardly to a point marginally below the shoulder 168. Consequently the interface fit between the cylindrical extension 118 and the support rim 167 transforms the slot 170 into an aperture providing gas and liquid communication between the annular channel 169 and the discharge spout 143. The aperture is typically 0.64 mm wide by 0.69 mm long.

The filter 104 is then placed over the inner member 103 such that the filter material contacts the annular rim 151. An ultrasonic welding process is then used to join the filter 104 to the inner member 103 and at the same time, and in the same process step, the inner member 103 to the outer member 102. The inner member 103 and filter 104 are welded around the outer rim 151. The inner member 103 and outer

member 102 are joined by means of weld lines around the outer rim 151 and also the upper edges of the webs 154.

As shown most clearly in Figure 29, the outer member 102 and inner member 103 when joined together define a void space in the interior 106 below the annular flange 141 and exterior the cylindrical funnel 140 which forms a filtration chamber. The filtration chamber 160 and passages 157 above the annular frame 141 are separated by the filter paper 104.

The filtration chamber 160 contains the one or more beverage ingredients 200. The one or more beverage ingredients 200 are packed into the filtration chamber 160. For an espresso-style beverage the ingredient is typically roast and ground coffee. The density of packing of the beverage ingredients in the filtration chamber 130 can be varied as desired. Typically, for a filtered coffee product the filtration chamber contains between 5.0 and 10.2 grams of roast and ground coffee in a filtration bed of thickness of typically 5 to 14 mm. Optionally, the interior 106 may contain one or more bodies, such as spheres, which are freely movable within the interior 106 to aid mixing by inducing turbulence and breaking down deposits of beverage ingredients during discharge of the beverage.

The laminate 105 is then affixed to the outer member 102 by forming a weld 161 around the periphery of the laminate 105 to join the laminate 105 to the lower surface of the outwardly extending flange 135. The weld 161 is extended to seal the laminate 105 against the lower edge of the cylindrical wall 127 of the inlet chamber 126. Further,

a weld 162 is formed between the laminate 105 and the lower edge of the outer tube 142 of the cylindrical funnel 140. The laminate 105 forms the lower wall of the filtration chamber 160 and also seals the inlet chamber 126 and cylindrical funnel 140. However, a small gap 163 exists prior to dispensation between the laminate 105 and the lower edge of the discharge spout 43. A variety of welding methods may be used, such as heat and ultrasonic welding, depending on the material characteristics of the laminate 105.

Advantageously, the inner member 103 spans between the outer member 102 and the laminate 105. The inner member 103 is formed from a material of relative rigidity, such as polypropylene. As such, the inner member 103 forms a load-bearing member that acts to keep the laminate 105 and outer member 102 spaced apart when the cartridge 100 is compressed. It is preferred that the cartridge 100 is subjected to a compressive load of between 130 and 280N in use. The compressive force acts to prevent the cartridge failing under internal pressurisation and also serves to squeeze the inner member 103 and outer member 102 together. This ensures that the internal dimensions of passageways and apertures in the cartridge 100 are fixed and unable to change during pressurisation of the cartridge 100.

In use the water, under pressure, enters the cartridge 100 through the inlet 107 into the inlet chamber 126. From there the water is directed to flow through the slots 117 and round the manifold 116 and into the filtration chamber 160 of the cartridge 1 through the plurality of slots 117. The water is forced radially inwardly through the filtration

chamber 160 and mixes with the beverage ingredients 200 contained therein. The water is at the same time forced upwardly through the beverage ingredients 200. The beverage formed by passage of the water through the beverage ingredients 200 passes through the filter 104 and filtration apertures 155 into the passages 157 lying above the annular frame 141.

Beverage in the radial passages 157 flows downwardly along the passages 157 formed between the webs 154 and through the openings 156 and into the annular channel 169 of the cylindrical funnel 140. From the annular channel 169 the beverage is forced under pressure through the aperture 128 by the back pressure of beverage collecting in the filtration chamber 160 and passages 157. The beverage is thus forced through aperture as a jet and into an expansion chamber formed by the upper end of the discharge spout 143. As shown in Figure 29, the jet of beverage passes directly over the air inlet 171. Passage of the beverage through the restriction of the aperture causes the pressure of the beverage to be reduced. As the beverage enters the discharge spout 143 the pressure of the beverage is still relatively low. As a result air is entrained into the beverage stream in the form of a multitude of small air bubbles as the air is drawn up through the air inlet 171. The jet of beverage issuing from the aperture is funnelled downwards to the outlet 144 where the beverage is discharged into a receptacle such as a cup where the air bubbles form the desired crema. Thus, the aperture and the air inlet 171 together form an eductor which acts to entrain air into the beverage. Flow of beverage into the eductor should be kept

as smooth as possible to reduce pressure losses. It should be noted that, in the high pressure state, the air eduction mechanism is de-activated.

The sealing of the filter 104 onto the spokes 153 and the welding of the rim 151 with the outer member 102 ensures that there are no short-circuits and all the beverage has to pass through the filter 104.

Figure 30 shows a second embodiment of beverage cartridge 100 which can be used in the beverage preparation machine 10 of the present invention. Like components between the first and second embodiments have been referenced with like numerals. Many of the components and functions of the second embodiment of cartridge 100 are the same as for the first embodiment. However, it can be seen from Figure 30 that the cartridge 100 has a greater overall height compared to the cartridge 100 shown in Figure 29. The outer member 102 is taller and thereby defines a larger void space in which a larger quantity of beverage ingredients 200 can be stored. The second embodiment of cartridge 100 is therefore suitable for dispensing larger volumes of beverage. The diameter of the outer member 102 and cartridge 100 are the same as in the first embodiment. Typically the storage volume of the cartridge 100 when assembled is 50 to 58 ml ±20%. As with the first embodiment, the upper surface of the outer member 102 is provided with a recess having a clamping surface 118 located at a bottom thereof. According to the present invention, the separation D between surface 118a and the underside of the laminate 105 is the same as for the first embodiment. As a result, the elongated recess extends

approximately 60% of the distance towards the laminate 105. This advantageously allows for a simplified clamping arrangement to be used as described below.

Also, the second embodiment of cartridge 100 lacks an eductor air inlet 171.

The first and second embodiments of cartridge 1 described above are given as examples of an "eductor" type of cartridge and a "non-eductor" type cartridge which may be used with the improved beverage preparation machine described above.

CLAIMS:

1. A method of preparing beverages using a beverage preparation machine for preparing beverages from one or more beverage ingredients, characterised by controlling the volume of air resident in at least a part of a delivery system of the machine to produce predetermined characteristics in a prepared beverage.

2. A method of preparing beverages as claimed in claim 1 in which the volume of air is actively controlled by increasing the volume to increase the air:liquid ratio in the beverage produced, decreasing the volume to decrease the air:liquid ratio or maintaining the volume.

3. A method of preparing beverages as claimed in any one of the preceding claims in which the volume of air in the delivery system is controlled by inducting additional gas into the delivery system, venting air from the delivery system and/or purging the delivery system.

4. A method of preparing beverages as claimed in any one of the preceding claims further comprising the step of measuring the actual volume of air resident in the delivery system.

5. A method of preparing beverages as claimed in any one of the preceding claims in which an actual volume of air resident in the delivery system is calculated from stored parameters relating to a volume of air remaining in the delivery system after a last operation of the machine.

6. A method of preparing beverages as claimed in any one of the preceding claims in which the control of the volume of air is effected on a beverage by beverage basis.

7. A method of preparing beverages as claimed in any one of the preceding claims in which the control of the volume of air is effected automatically according to the type of beverage being produced.

8. A method of preparing beverages as claimed in any one of claims 1 to 5 in which the control of the volume of a is effected manually.

9. A method of preparing beverages as claimed in any one of the preceding claims in which the volume of air upstream of the beverage ingredients is controlled.

10. A method of preparing beverages as claimed in any one of the preceding claims in which the volume of air downstream of the beverage ingredients is controlled.

11. A method of preparing beverages as claimed in any one of the preceding claims in which the volume of air is controlled by selectively opening and/or closing valve means in the delivery system prior to and/or during beverage preparation.

12. A beverage preparation machine for preparing a beverage from one or more beverage ingredients, characterised by the provision of means for controlling the volume of air

resident in at least a part of a delivery system of the machine to produce predetermined characteristics in a prepared beverage.

13. A beverage preparation machine as claimed in claim 12 further comprising means for determining the actual volume of air resident in the delivery system.

14. A beverage preparation machine as claimed in claim 13 in which the means for determining the actual volume of air resident in the delivery system comprise means for calculating the actual volume from stored parameters relating to a volume of air remaining in the delivery system after a last operation of the machine.

15. A beverage preparation machine as claimed in claim 14 in which the stored parameters comprise a basic volume parameter stored in the control means, said basic volume being the actual volume of air which resides in the delivery system of an unused machine or a machine after a purging cycle has been run.

16. A beverage preparation machine as claimed in claim 14 or claim 15 in which the stored parameters comprise parameters relating to the actual volume of air remaining in the delivery system after each type of beverage which the machine is programmed to prepare.

17. A beverage preparation machine as claimed in claim 13 in which the means for determining the actual volume of air

resident in the delivery system comprise means for measuring the actual volume of air in the delivery system.

18. A beverage preparation machine as claimed in any one of claims 13 to 17 in which parameters relating to predetermined volumes of air required to be present in the delivery system for preparing a predetermined range of beverages are stored in the control means, said control means being programmed to calculate the difference between the predetermined volume required for a beverage in preparation and the actual volume present.

19. A beverage preparation machine as claimed in any one of claims 13 to 18 in which the means for controlling the actual volume of air comprise valve and/or purge means for venting air and/or pump means for injecting additional air into the delivery system.

20. A beverage preparation machine as claimed in claim 19 in which the valve means comprise an outlet valve downstream of the beverage ingredients.

21. A beverage preparation machine as claimed in claim 19 or claim 20 in which the valve means comprise a valve upstream of the beverage ingredients.

22. A beverage preparation machine as claimed in any one of claims 18 to 22 in which the operation of the valve means is controlled relative to the beverage preparation cycle to vary the actual volume of air present in the delivery system.

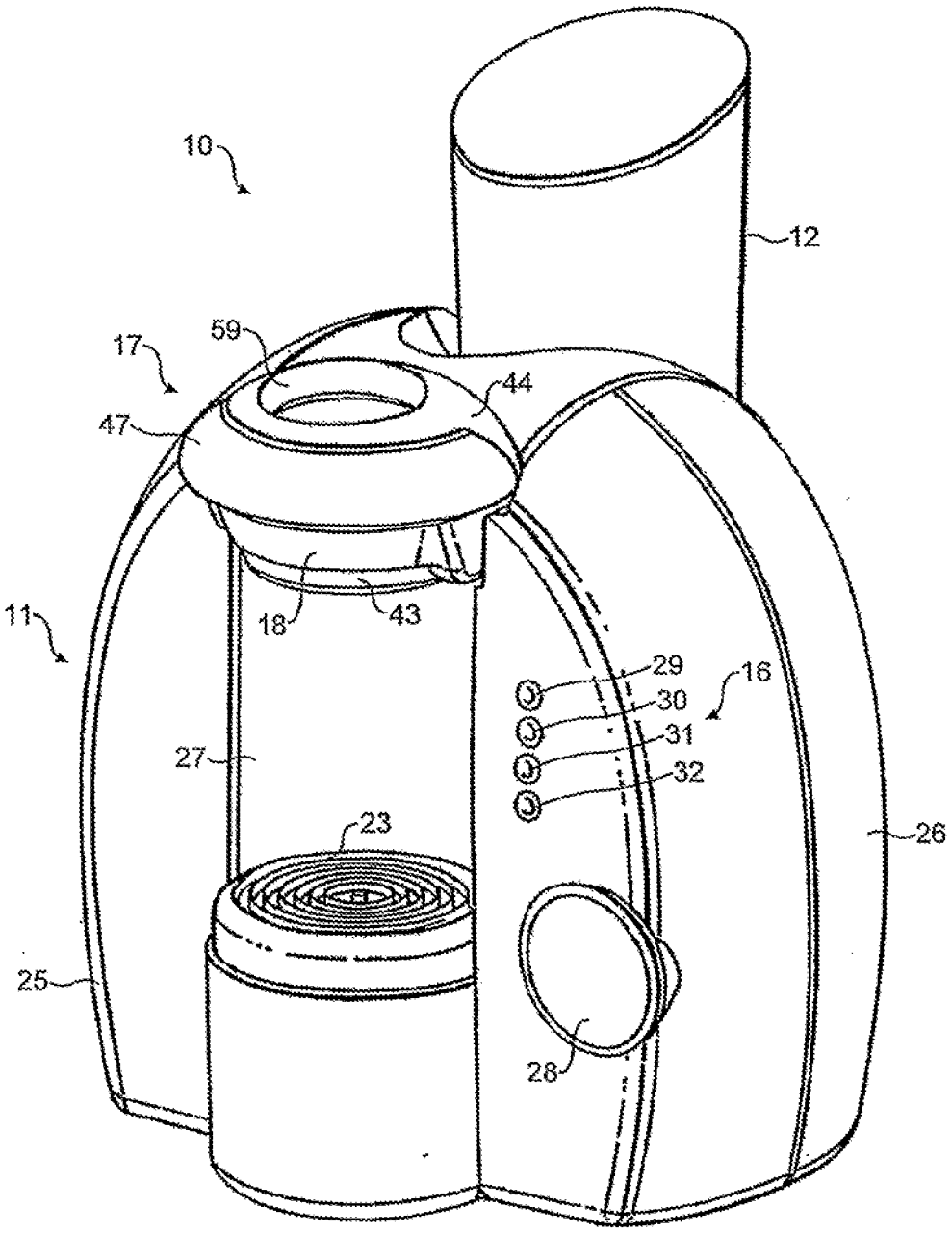


FIG. 1

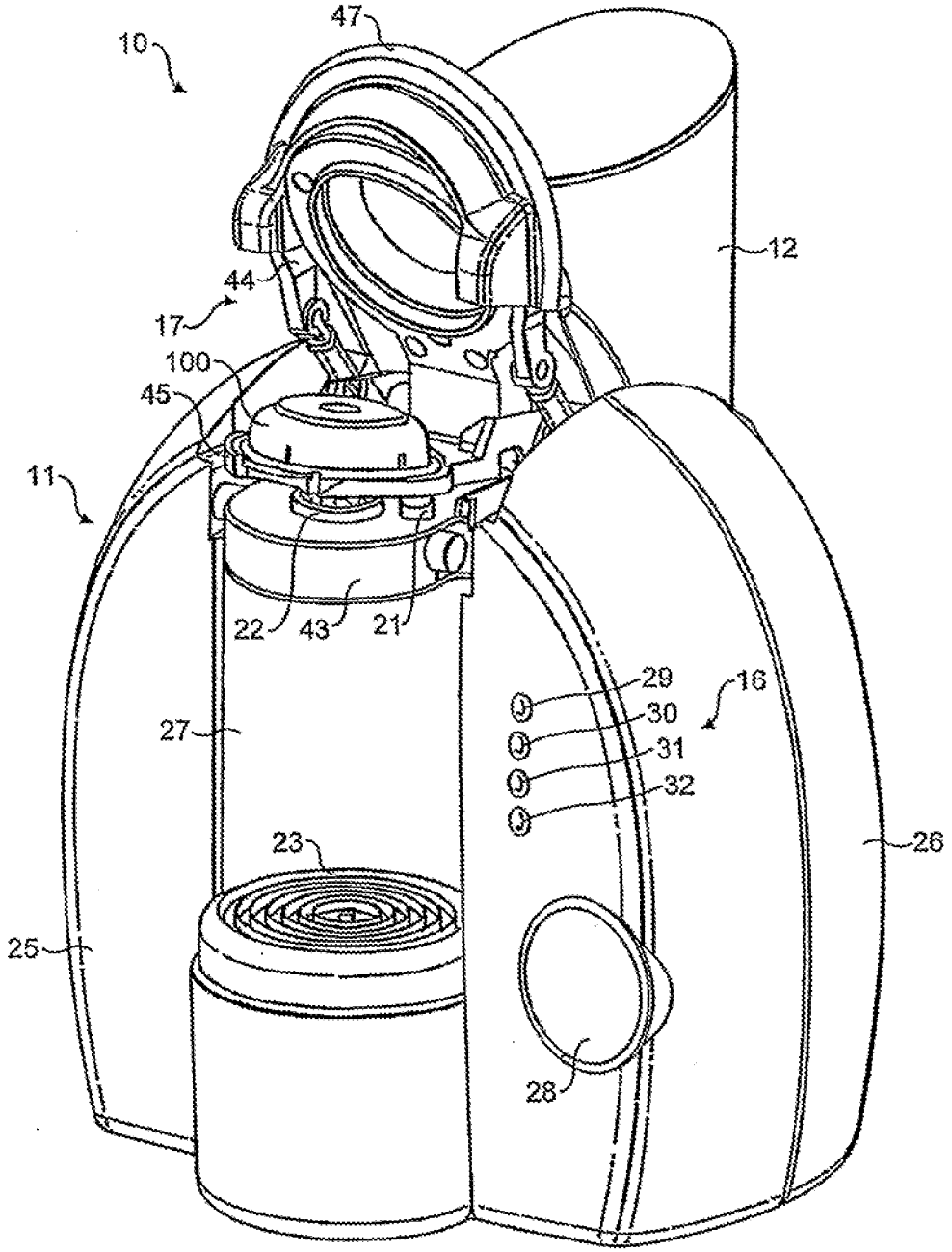


FIG. 2

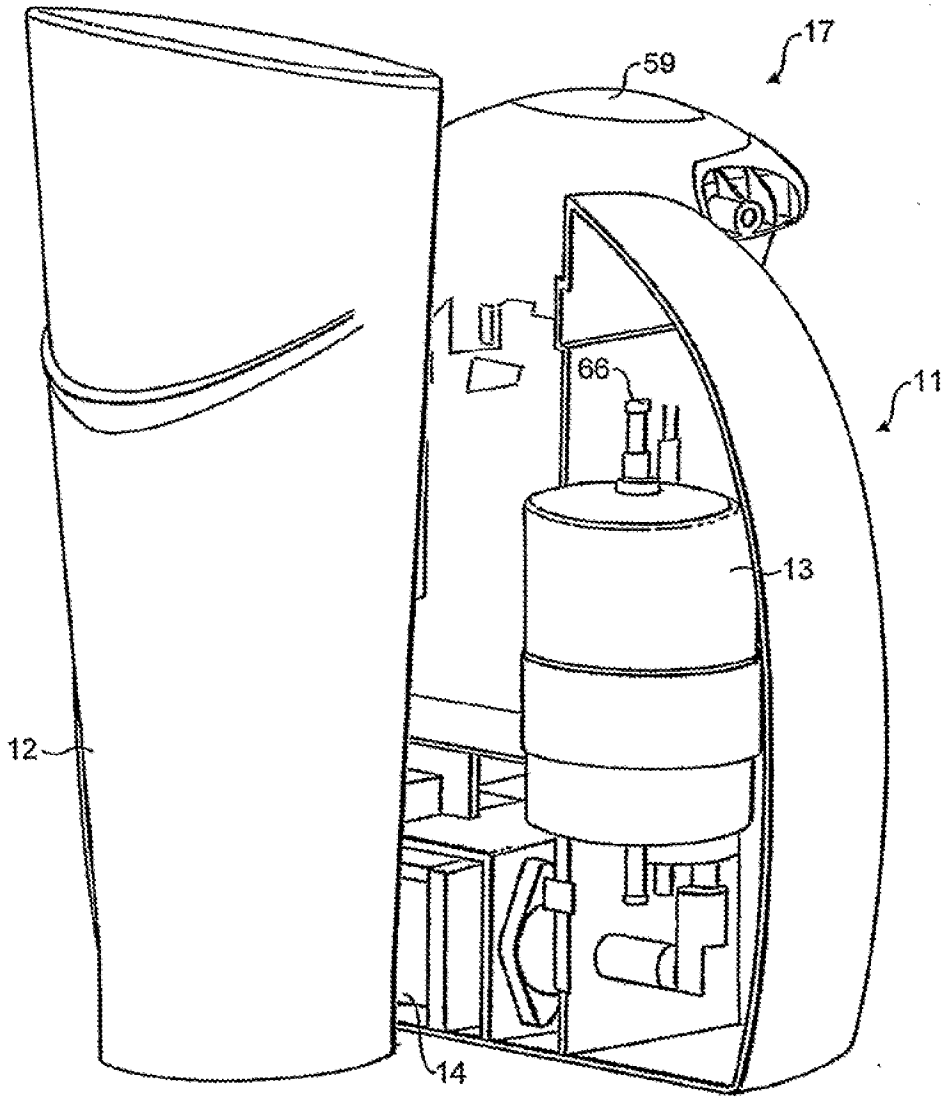


FIG. 3

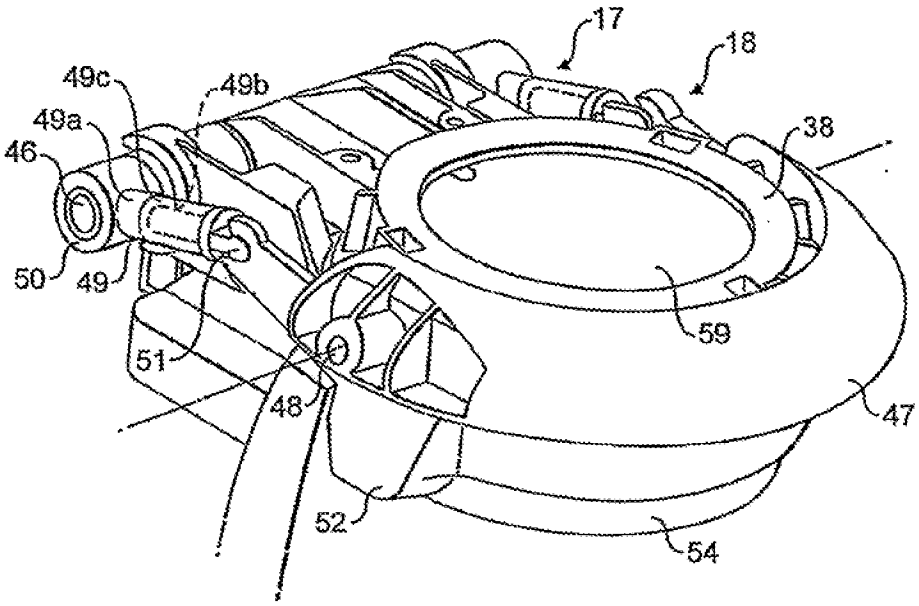

17
18
49c
49b
49a
46
38
50
49
59
51
48
47
52
54

FIG. 4

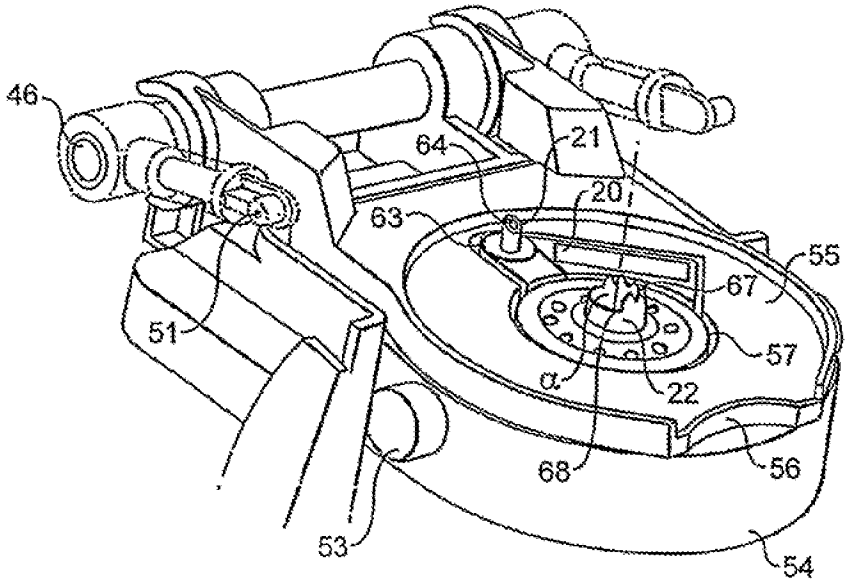

46
64
21
20
63
55
67
51
57
α
22
68
56
53
54

FIG. 5

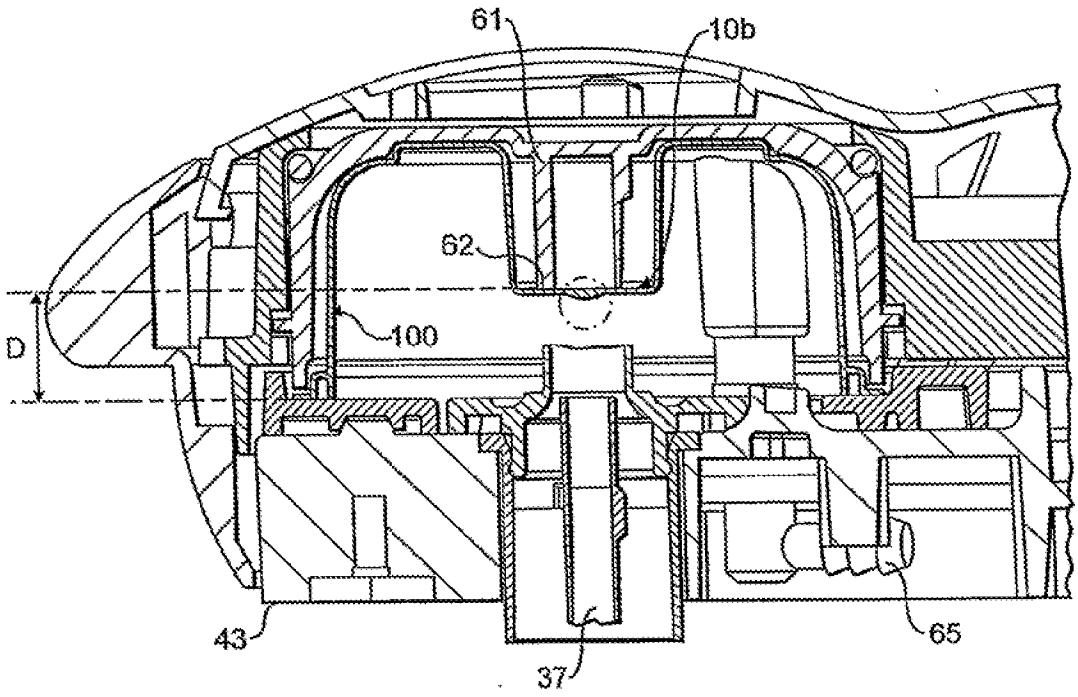


FIG. 6

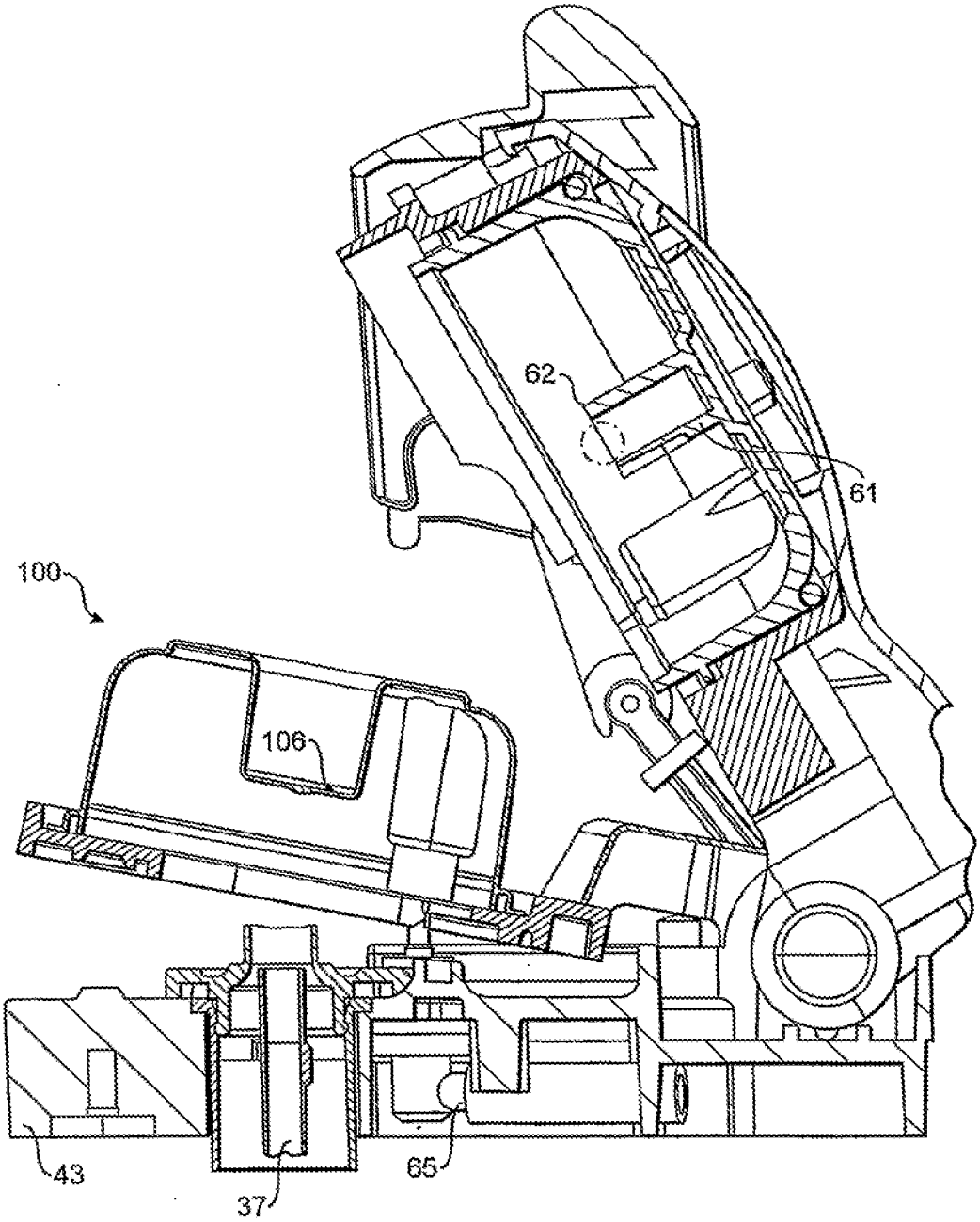


FIG. 7

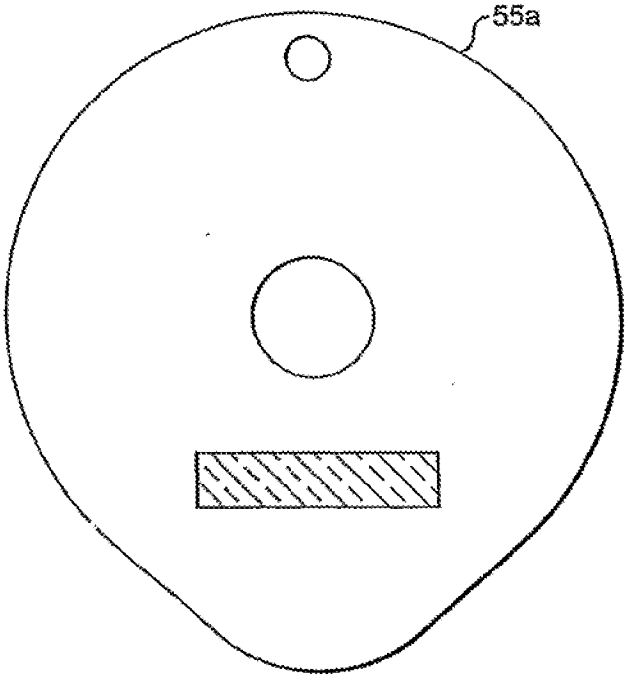


FIG. 7a

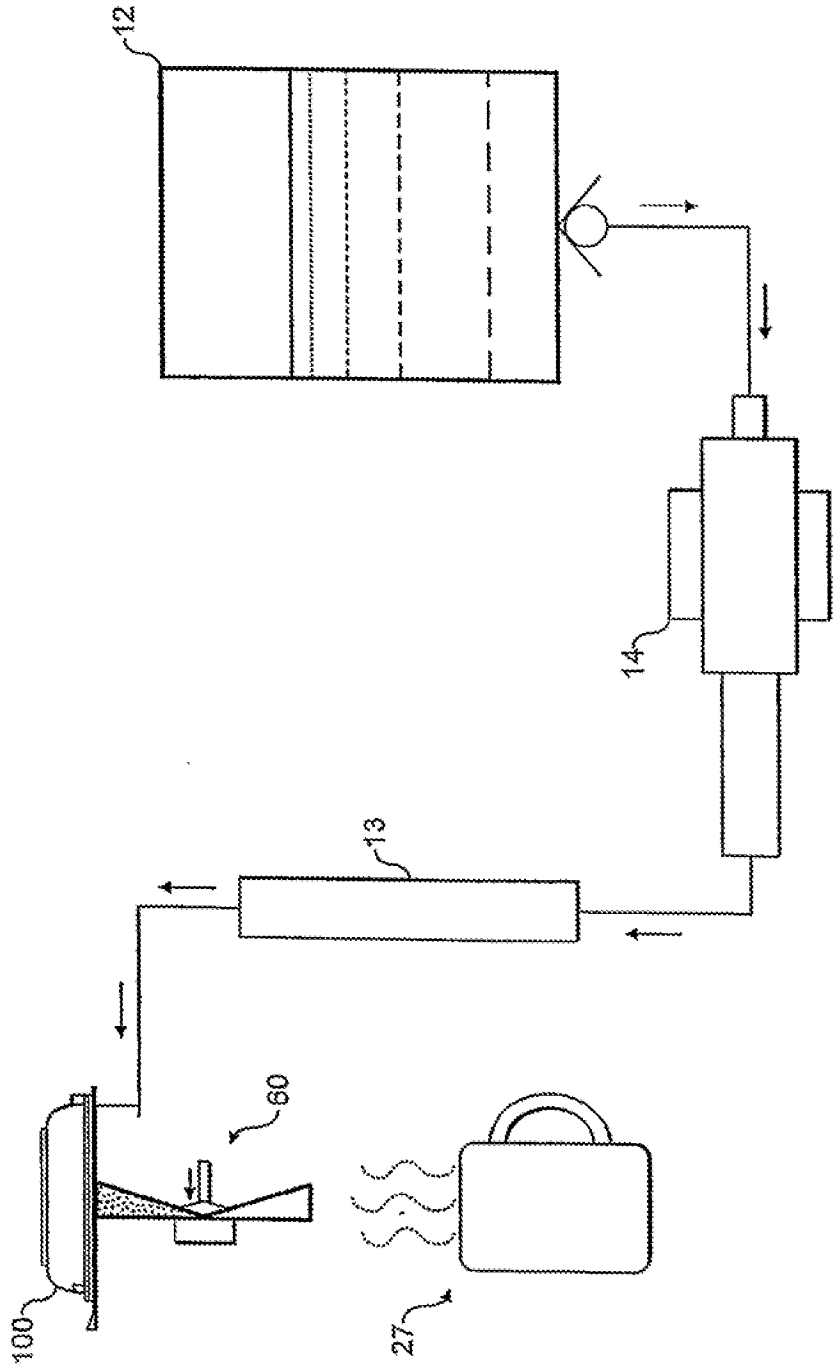


FIG. 8

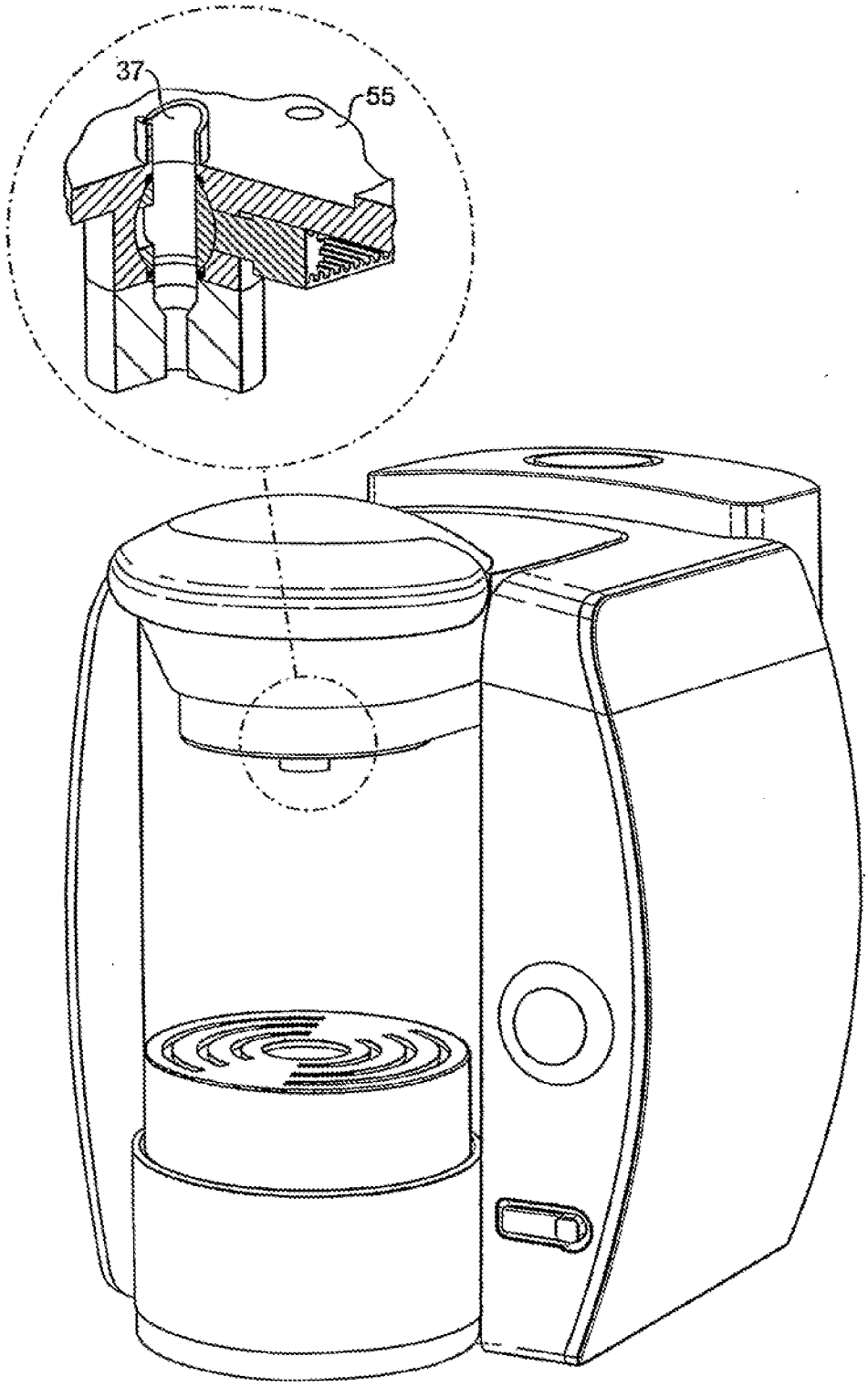


FIG 9

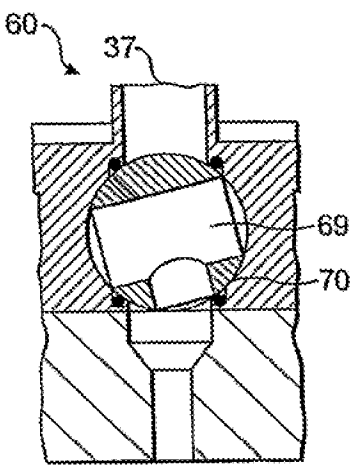


FIG. 10

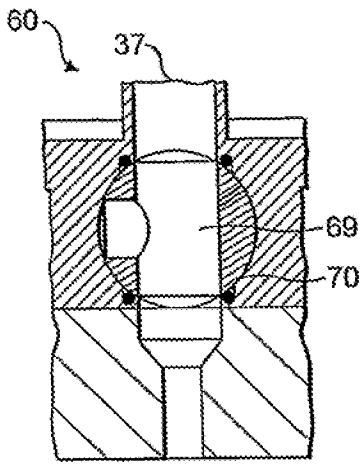


FIG. 11

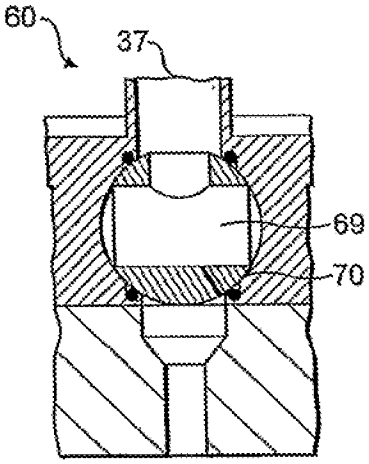


FIG. 12

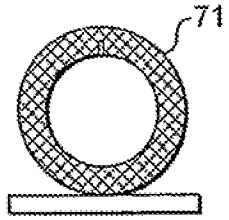


FIG. 13a

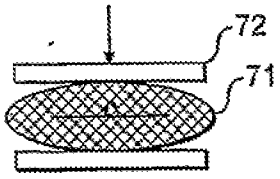


FIG. 13b

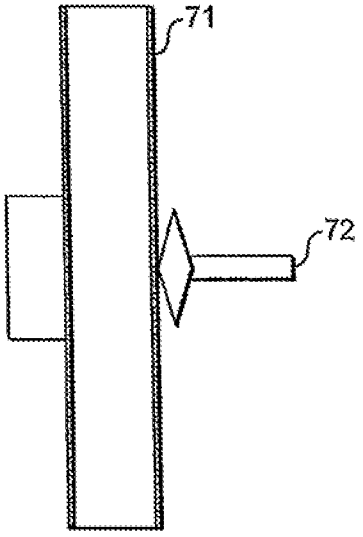


FIG. 14

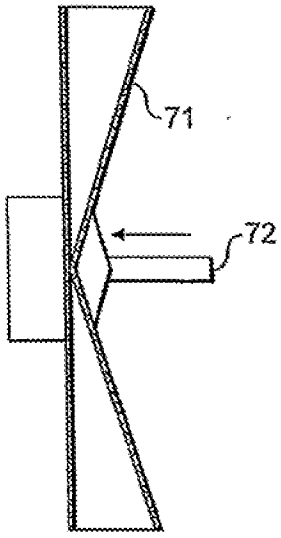


FIG. 15

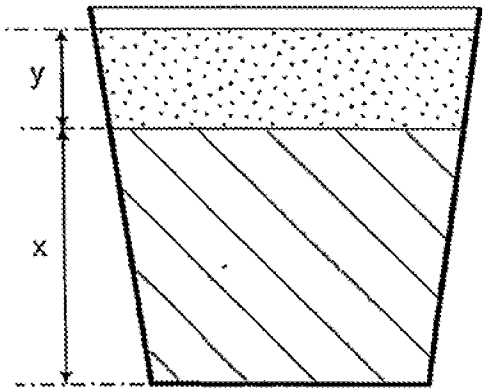


FIG. 16a

STEP	WATER PUMP STATE/SPEED	AIR PURGE PUMP/PWM	RECIRCULATION VALVE STATE	RESTRICTION BYPASS VALVE STATE	STOP CONDITION/DURATION OF STEP
Set valves	No change/0	Stop/0	Recirculate	Open	Time >=1 second
Heat	Stop/0	Stop/0	Recirculate	Open	Boiler temperature >=97°C
Set valves	No change/0	No change/0	Brew	Open	Time >=1 second
Remove gas	Run/50	No change/0	No change	Open	Time >=2 seconds
Set valves	Stop/0	No change/0	No change	Closed	Time >=5 seconds
Pressure wet	Run/100	No change/0	No change	No change	Disc inlet pressure >=2 bar
Soak	Stop/0	No change/0	No change	No change	Time >=10 seconds
Brew	Run/30	Stop/0	No change	No change	Time >=32 seconds
Stop pump	Stop/0	Stop/0	No change	No change	Time >=0.5 seconds
Open purge	Stop/0	Stop/0	No change	Open	Time >=3 seconds
Pause	No change/0	No change/0	No change	Open	Time <=1 seconds
Air purge	Stop/0	Run/50	No change	Open	Time >=8 seconds
Pause	Stop/0	Stop/0	Recirculate	No change	Time >=2 seconds
Reset	Stop/0	Stop/0	Recirculate	Closed	Time >=0 seconds

FIG. 16b

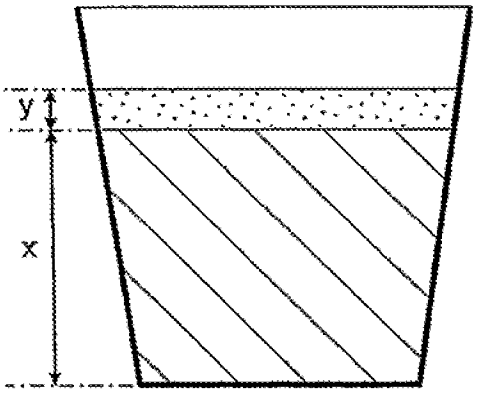


FIG. 17a

STEP	WATER PUMP STATE/SPEED	AIR PURGE PUMP/PWM	RECIRCULATION VALVE STATE	RESTRICTION BYPASS VALVE STATE	STOP CONDITION/DURATION OF STEP
Set valves	No change/0	Stop/0	Recirculate	Open	Time >=1 second
Heat	Stop/0	Stop/0	Recirculate	Open	Boiler temperature >=97°C
Set valves	No change/0	No change/0	Brew	Open	Time >=1 second
Remove gas	Run/70	No change/0	No change	Open	Time >=8 seconds
Set valves	Stop/0	No change/0	No change	Closed	Time >=5 seconds
Pressure wet	Run/100	No change/0	No change	No change	Disc inlet pressure >=2 bar
Soak	Stop/0	No change/0	No change	No change	Time >=10 seconds
Brew	Run/30	Stop/0	No change	No change	Time >=32 seconds
Stop pump	Stop/0	Stop/0	No change	No change	Time >=0.5 seconds
Open purge	Stop/0	Stop/0	No change	Open	Time >=3 seconds
Pause	No change/0	No change/0	No change	Open	Time <=5 seconds
Air purge	Stop/0	Run/50	No change	Open	Time >=8 seconds
Pause	Stop/0	Stop/0	Recirculate	Open	Time >=2 seconds
Reset	Stop/0	Stop/0	Recirculate	Open	Time >=0 seconds

FIG. 17b

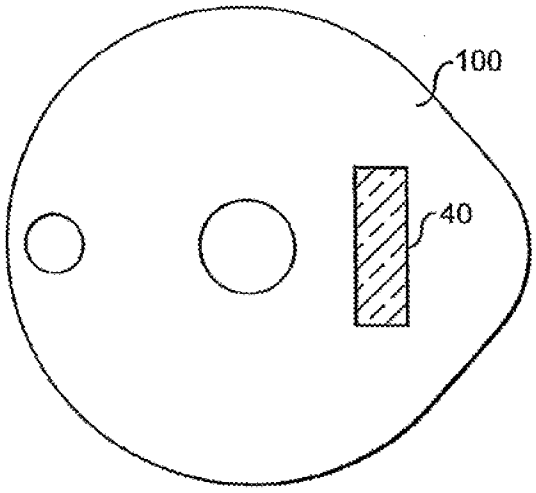

100
40

FIG. 18

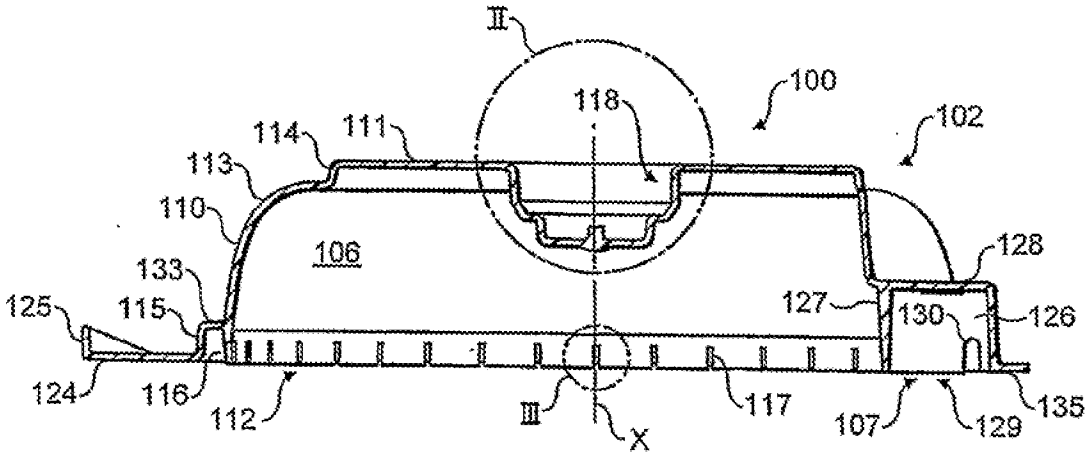

II
100
118
102
114
111
113
110
106
133
125
115
128
127
130
126
124
116
112
III
X
117
107
129
135

FIG. 19

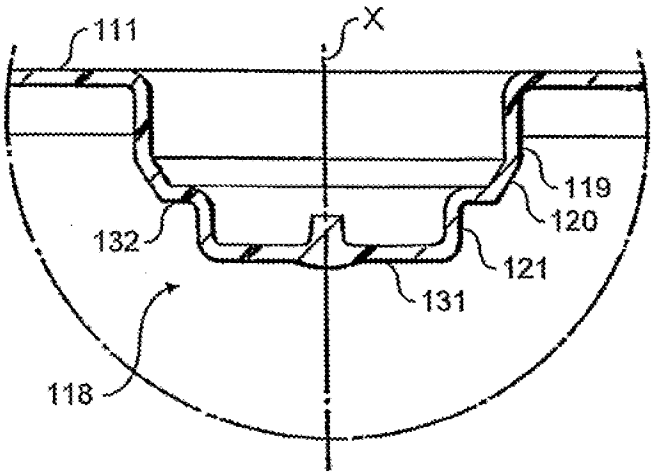


FIG. 20

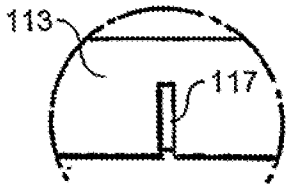


FIG. 21

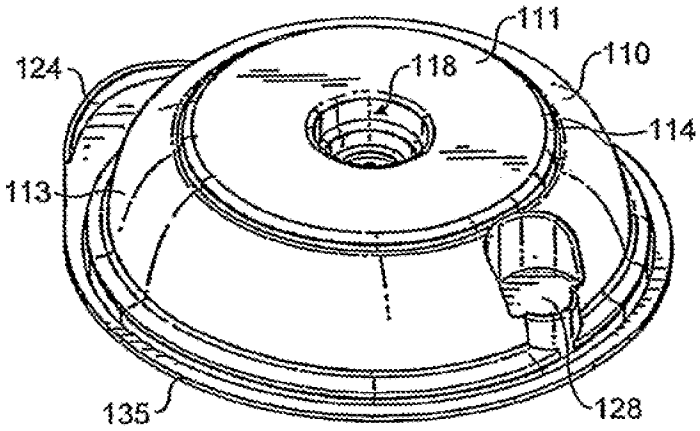


FIG. 22

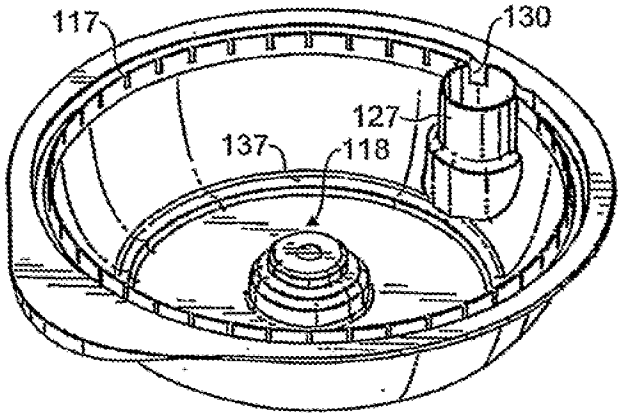


FIG. 23

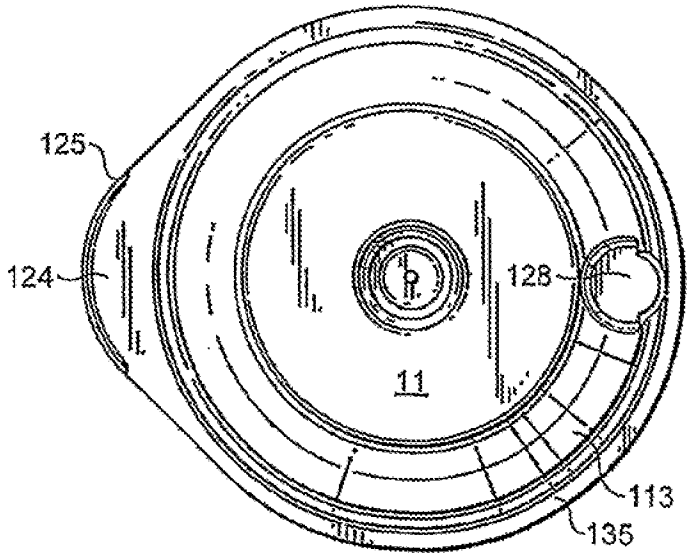


FIG. 24

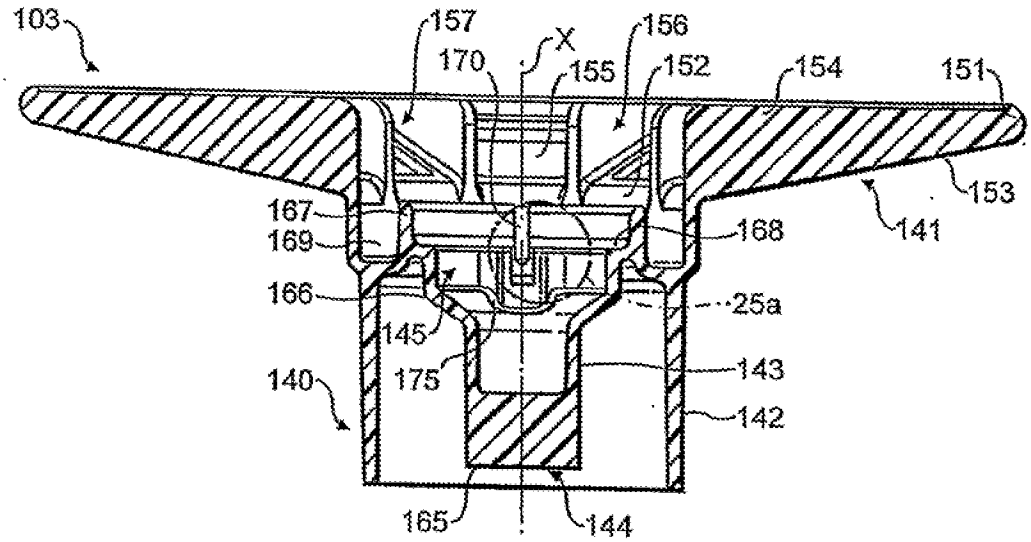


FIG. 25

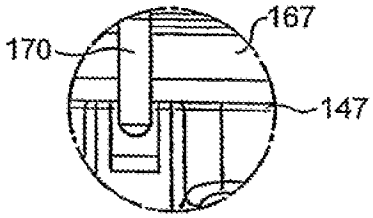


FIG. 25a

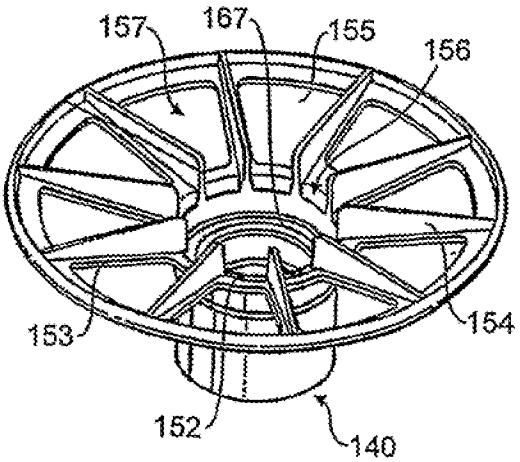


FIG. 26

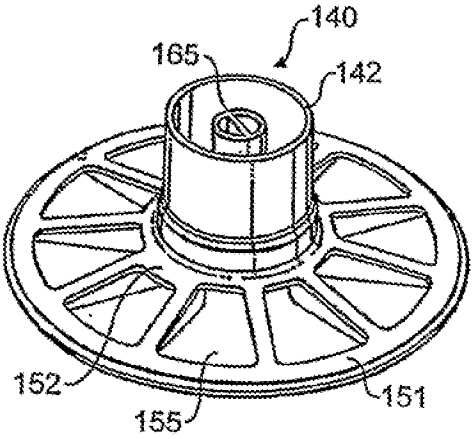


FIG. 27

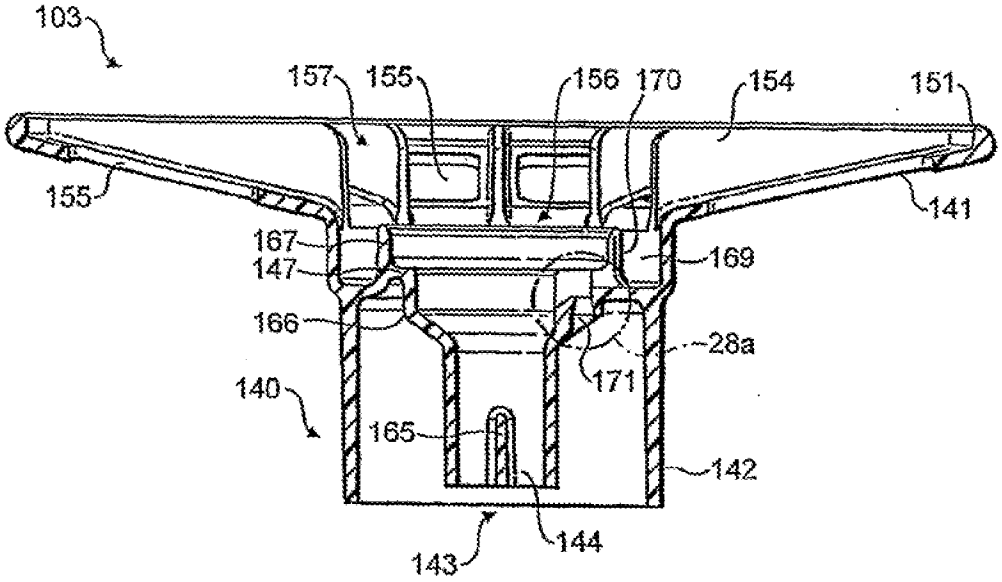


FIG. 28

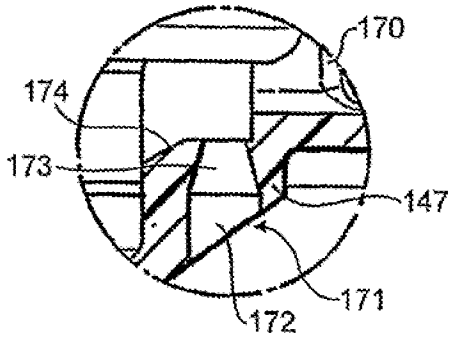


FIG. 28a

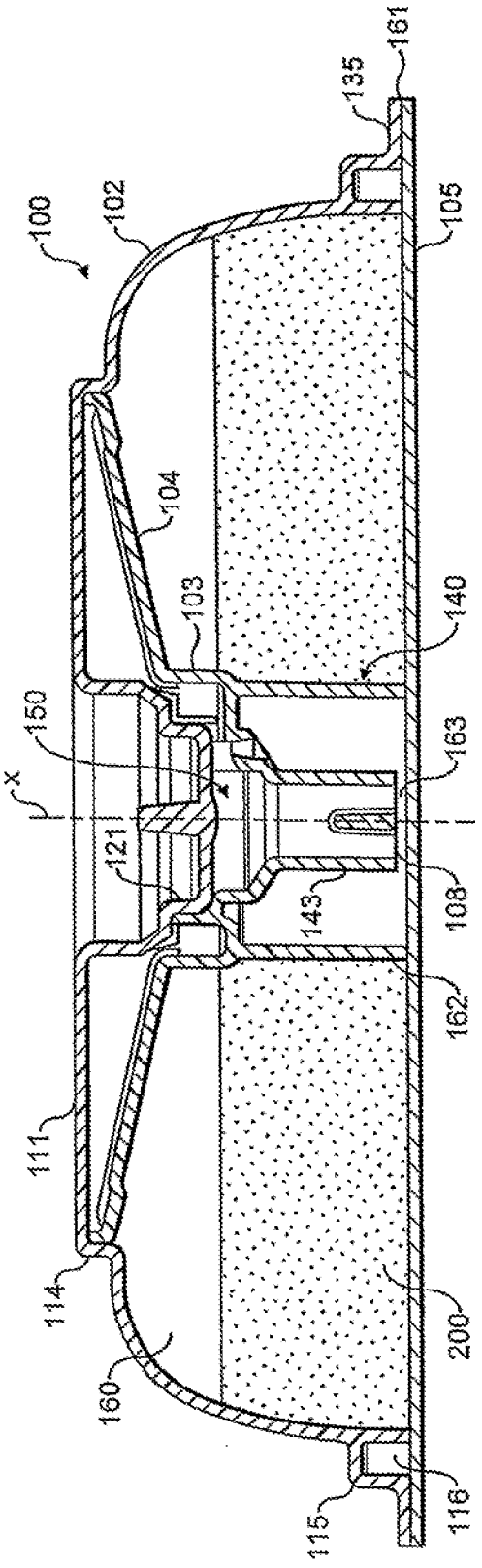

161
135
100
102
105
104
103
140
150
163
x
121
143
108
162
111
114
200
160
115
116

FIG. 29

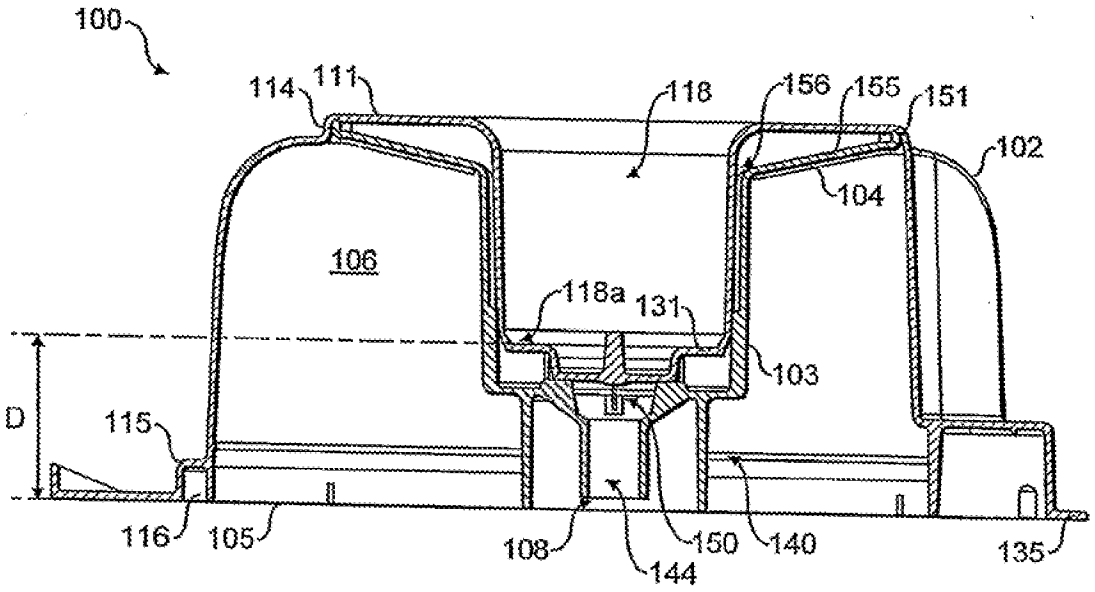

100
114
111
118
156
155
151
102
104
106
118a
131
103
D
115
116
105
108
144
150
140
135

FIG. 30

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2010/000551

A. CLASSIFICATION OF SUBJECT MATTER
INV. A47J31/36 A47J31/06 A47J31/46
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)
A47J

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 practical, search terms used)
EPO-Internal, PAJ, 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	GB 2 434 969 A (HALE ROBERT [CA]) 15 August 2007 (2007-08-15)	1-4,6-12
A	paragraphs [0018] - [0037]; figures	21
X	US 6 405 637 B1 (CAI EDWARD Z [US]) 18 June 2002 (2002-06-18) column 3, line 23 - column 30, line 6; figures	1-4,6-12
X	WO 2004/098360 A1 (SALTON [US]; WINSTANLEY PETER [US]; ROSSI GIAMPIERO [IT]) 18 November 2004 (2004-11-18) page 4, line 14 - page 11, line 16; figures	1-4,6-12

-/--

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"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)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"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

"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.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 July 2010	08/07/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	De Terlizzi, Marino

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 440 644 A1 (KRAFT FOODS R & D INC [DE]) 28 July 2004 (2004-07-28) cited in the application paragraphs [0092] - [0094]; figures	1-4,6-12
X	EP 1 133 944 A2 (FIANARA INT BV [NL]) 19 September 2001 (2001-09-19)	1-4,6-12
A	paragraphs [0015] - [0032]; figures	20
X	EP 1 016 364 A2 (ANTICA TORREF DEL BORGO BARDAS [IT]) 5 July 2000 (2000-07-05)	1-4,6-12
A	paragraphs [0013] - [0061]; figures	20
X	EP 0 232 460 A2 (FELDMUEHLE AG [DE]) 19 August 1987 (1987-08-19) column 3, line 20 - column 4, line 34; figures	1-4,6-12
X	US 2007/056994 A1 (WOODNORTH DOUGLAS [US] ET AL) 15 March 2007 (2007-03-15) paragraphs [0018] - [0043]; figures	1-4,6-12
X	EP 0 781 520 A1 (BRAUN AG [DE]) 2 July 1997 (1997-07-02) column 7, line 53 - column 15, line 36; figures	1-4,6-12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2010/000551

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2434969 A	15-08-2007	CA 2578417 A1	09-08-2007
		US 2007181004 A1	09-08-2007
US 6405637 B1	18-06-2002	NONE	
WO 2004098360 A1	18-11-2004	AU 2004235780 A1	18-11-2004
		BR PI0409864 A	16-05-2006
		CA 2527978 A1	18-11-2004
		EP 1638434 A1	29-03-2006
		WO 2004099035 A1	18-11-2004
		ZA 200509670 A	25-10-2006
EP 1440644 A1	28-07-2004	AT 322854 T	15-04-2006
		DE 602004000608 T2	28-09-2006
		DK 1440644 T3	31-07-2006
		ES 2262096 T3	16-11-2006
		GB 2397501 A	28-07-2004
		HK 1065692 A1	10-11-2006
EP 1133944 A2	19-09-2001	AT 294525 T	15-05-2005
		AU 759650 B2	17-04-2003
		AU 2310901 A	20-09-2001
		BR 0100980 A	16-10-2001
		CA 2340543 A1	15-09-2001
		CN 1313065 A	19-09-2001
		DE 50106064 D1	09-06-2005
		ES 2240383 T3	16-10-2005
		HK 1040042 A1	06-05-2005
		HU 0100896 A2	28-09-2001
		IN 192798 A1	22-05-2004
		JP 2001275839 A	09-10-2001
		MX PA01002647 A	28-04-2005
		NZ 510050 A	29-06-2001
		PT 1133944 E	30-06-2005
		RU 2214147 C2	20-10-2003
		SG 87206 A1	19-03-2002
		TR 200100739 A2	22-10-2001
		US 2001022138 A1	20-09-2001
EP 1016364 A2	05-07-2000	NONE	
EP 0232460 A2	19-08-1987	DE 3603186 A1	06-08-1987
US 2007056994 A1	15-03-2007	AT 430507 T	15-05-2009
		AU 2006291158 A1	22-03-2007
		CA 2622038 A1	22-03-2007
US 2007056994 A1		CN 101272718 A	24-09-2008
		EP 1924178 A1	28-05-2008
		HK 1119037 A1	31-07-2009
		JP 2009507608 T	26-02-2009
		KR 20080059195 A	26-06-2008
		WO 2007033016 A1	22-03-2007
EP 0781520 A1	02-07-1997	DE 19549227 A1	03-07-1997
		US 5778765 A	14-07-1998

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 November 2010 (04.11.2010)

PCT

(10) International Publication Number
WO 2010/125329 A1

(51) International Patent Classification:
A47J 31/36 (2006.01) *A47J 31/06* (2006.01)

(21) International Application Number:
PCT/GB2010/000784

(22) International Filing Date:
16 April 2010 (16.04.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0907611.8 1 May 2009 (01.05.2009) GB

(71) Applicant *(for all designated States except US)*: **KRAFT FOODS R&D, INC.** [US/US]; Three Lakes Drive, Northfield, IL 60093 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **HANSEN, Nick Andrew** [GB/GB]; 17 Pitmaston Close, Banbury OX16 1AH (GB). **BENTLEY, Andrew** [GB/GB]; 1 Greens Garth, Bloxham, Banbury, Oxfordshire OX15 4NR (GB).

(74) Agents: **BUCKS, Teresa Anne** et al.; Boult Wade Tennant, Verulam Gardens, 70 Gray's Inn Road, London WC1X 8BT (GB).

(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, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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.

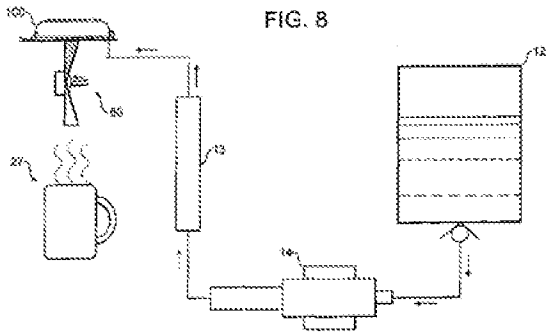
(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

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

(54) Title: BEVERAGE PREPARATION MACHINES

FIG. 8



(57) Abstract: The present invention relates to improvements in beverage preparation machines and in particular to a beverage preparation machine of the type which uses pre-packaged containers of beverage ingredients. The beverage preparation machine (10) comprises a cartridge recognition device (20) for determining the type of beverage to be prepared from a cartridge (100) inserted into the machine and a variable geometry valve (60) located downstream of a cartridge when inserted in the machine. The valve enables preparation of beverages at a range of pressures by having at least an open position and at least one restricted flow position, and a controller for selecting an initial valve position and controlling the subsequent operation of the valve according to the determination of the type of beverage to be prepared by the cartridge recognition device.

WO 2010/125329 A1

BEVERAGE PREPARATION MACHINES

The present invention relates to improvements in beverage preparation machines and in particular to a beverage preparation machine of the type which uses pre-packaged containers of beverage ingredients.

Coffee houses have been a part of the "coffee culture" since the 17th century. Throughout the years methods of making coffee have been refined and skilled people trained to produce the best coffee beverages. The first coffee machines were developed in the early 1800s and an automatic espresso machine was invented in the 1930s. The automation of the coffee making process has, in turn, lead to a rapid growth, particularly in the last ten years, in the number of coffee houses/shops with more specialist drinks, such as espresso and cappuccino, being in high demand. These types of beverages have historically been regarded as luxury items because of the need for expensive, complex machines capable of producing the high pressures necessary for making them, which had to be properly operated and maintained by a trained barista to produce good quality. Coffee aficionados agree that an espresso can be spoiled by a badly trained operator despite the use of a good quality machine and good quality coffee. This trend, however, has not only lead to an increased demand from consumers for luxury top quality beverages, but also a desire for a greater variety of speciality beverages, and the ability to make such beverages in the comfort of one's own home.

Although there is no agreed technical definition, it is generally understood that, compared to drip coffee, barista quality espresso has a thicker consistency, due to a higher amount of dissolved solids and fine oil droplets suspended throughout the drink. It has a smooth, yet thick, dark reddish brown crema making up 10 to 30% of the beverage. The crema is a polyphasic emulsion of air and the oils, proteins and sugars extracted from the coffee which is produced at a high pressure, traditionally in the region of 9 to 10 bar. The higher pressures increase the rate of coffee wetting and improve extraction as well as being responsible for the development of the crema.

It is acknowledged, by discerning espresso drinkers, that espresso produced using water which is cooler than the optimum temperature tastes sour and that produced with water which is hotter than this temperature tastes bitter. The optimum temperature is claimed to be between 92 and 96°C. Other factors which affect the quality of the espresso include the roasting and age of the coffee beans, the grind size, the compaction of the grinds prior to brewing, and the brew time. The "best" espresso is achieved by balancing these key elements of the brewing process.

Domestic coffee machines have also developed significantly since the first filter machines were invented in the 1960s and coffee machines are now essential pieces of kitchen equipment in many households. Some such machines dispense individual servings of a beverage directly into a drinking receptacle, and derive the beverage from a bulk supply of beverage ingredients or from individual packages

of beverage ingredients such as pods, pads or cartridges. In the following specification such packages will be referenced by the general term cartridges. Machines which use such cartridges eliminate the need for cleaning and can enable the user to make a selection of beverages. An example of one type of such cartridge is described in EP-A-1440903. The beverages are formed from brewing, mixing, dissolving or suspending the beverage ingredients in water. For example, for coffee beverages, heated water is forced through the cartridges to form the extracted solution. The use of cartridges in such machines has become increasingly popular due to their convenience and the quality of the beverage produced.

An example of a machine for preparing beverages using this type of cartridge is described in EP-A-1440644. This type of machine provided, inter alia, an improvement over the prior art known at the time in that it operated at a lower pressure than the previously known machines, which were designed for the commercial or industrial markets rather than the domestic market. Hence it was more suitable for the domestic market in terms of cost, reliability and performance. However, the problem that faces systems that operate at a lower pressure is that they are generally not capable of producing barista quality espressos, which require a significantly higher pressure.

With the change in consumer trends, however, there is a desire for domestic machines which are capable of producing barista quality espresso and a range of other beverages, for

which no training is necessary, which are affordable and which require little or no cleaning.

Some machines available on the market claim to produce higher quality beverages but for various reasons they are comparatively expensive machines. Examples of such machines are the Gaggia L'Amante ™, the Gaggia Evolution ™, the Nespresso Delonghi Latissimma 660 ™, and the Krups XN2101 ™, which also uses a capsule system.

Most of these machines require specially designed cartridges of increased complexity and a particular specification of materials to cope with the high pressures involved in the brewing process for espresso. These cartridges generally incorporate filters and the process uses the geometry of the cartridge to enable the desired quality of the beverage to be produced under high pressure. This constrains the use of the cartridges in the machine for which it is designed.

It is, however, desirous to provide an improved beverage preparation machine capable of making a selection of beverages, including a premium quality espresso as well as non-espresso beverages, preferably using pre-packed beverage cartridges. The machine may also be a bulk brewer or other non-cartridge machine.

It is also desirous to provide a machine which is backwardly compatible with existing cartridges, such as those described in EP-A-1440903, which are used in existing low pressure beverage preparation machines.

Accordingly, the present invention provides a beverage preparation machine for preparing beverages from a cartridge containing one or more beverage ingredients, said machine comprising a cartridge recognition device for determining the type of beverage to be prepared from a cartridge inserted into the machine, characterised by the provision of a variable geometry valve located downstream of a cartridge when inserted in the machine, said valve enabling preparation of beverages at a range of pressures by having at least an open position and at least one restricted flow position, and a controller for selecting an initial valve position and controlling the subsequent operation of the valve according to the determination of the type of beverage to be prepared by the cartridge recognition device.

The variable geometry valve preferably additionally has a closed position preventing flow and/or a purge position for diverting purge waste away from a dispensing area.

Preferably the controller is programmed to change the variable geometry valve position during the preparation of the beverage according to pressure and/or flow requirements of the beverage preparation cycle.

The variable geometry valve may be a rotating ball valve or a pinch valve.

The restricted position of the variable geometry valve preferably creates a back pressure in the cartridge of 2 to 9 bar, and preferably 2 to 6 bar.

The invention also provides a method of preparing beverages using a beverage preparation machine for preparing beverages from a cartridge containing one or more beverage ingredients, said machine comprising a variable geometry valve located downstream of a cartridge when inserted in the machine, said valve enabling preparation of beverages at a range of pressures and having at least an open position providing no restriction to the flow of beverage and a restricted flow position, and a cartridge recognition device for determining the type of beverage to be prepared from a cartridge inserted into the machine, the method comprising the steps of determining the type of beverage to be produced from a cartridge, selecting an initial valve position and controlling subsequent operation of the variable geometry valve according to the determination of the type of beverage to be prepared by the cartridge recognition device.

The variable geometry valve position may be changed during a beverage preparation cycle and/or pulsed between positions during a beverage preparation cycle.

Preferred embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a front perspective view of a prior art beverage preparation machine with the cartridge head in a closed position;

Figure 2 is a front perspective view of the machine of Figure 1 with the cartridge head in an open position;

Figure 3 is a rear elevation of the machine of Figure 1 with some parts omitted for clarity;

Figure 4 is a front perspective view of a cartridge head of the machine of Figure 1 with some parts omitted for clarity;

Figure 5 is another front perspective view of the cartridge head of Figure 4, with some parts omitted for clarity;

Figure 6 is a cross-sectional view of the cartridge head of Figure 4 in a closed position accommodating a version of a beverage cartridge;

Figure 7 is a cross-sectional side elevation of the cartridge head of Figure 4 in an open position accommodating the beverage cartridge;

Figure 7A is a plan view of a rubber seal for the cartridge head of Figure 4;

Figure 8 is a schematic showing the various component parts of the machine of Figure 1 incorporating a new variable outlet valve;

Figure 9 is a section of schematic of an outflow from the cartridge head incorporating the variable outlet valve of Figure 8;

Figures 10-12 are cross-sectional front elevations of one embodiment of the variable valve in the outflow of Figure 9 showing it's closed, open and restricted positions respectively;

Figures 13a and 13b are cross-sectional end elevations of an alternative variable outlet valve used in the outflow of Figure 9 in its open and closed position respectively;

Figures 14 and 15 are cross-sectional side elevations of the valve of Figures 13a and 13b;

Figure 16a is a side elevation of a beverage receptacle containing a coffee beverage having a large volume of crema produced using an improved gas management system;

Figure 16b is a chart showing the brew parameters used in producing the beverage illustrated in Figure 16a;

Figure 17a is a side elevation of a beverage receptacle containing a coffee beverage having a small volume of crema produced using the improved gas management system;

Figure 17b is a chart showing the brew parameters used in producing the beverage illustrated in Figure 17a;

Figure 18 is a plan view of a beverage cartridge suitable for use in the beverage preparation machine of Figure 1;

Figure 19 is cross-sectional side elevation of an outer member of the cartridge of Figure 18;

Figure 20 is a cross-sectional side elevation of a detail of the outer member of Figure 19 showing an inwardly directed cylindrical extension;

Figure 21 is a cross-sectional side elevation of a detail of the outer member of Figure 19 showing a slot;

Figure 22 is a perspective view from above of the outer member of Figure 19;

Figure 23 is a perspective view from above of the outer member of Figure 19 in an inverted orientation;

Figure 24 is a plan view from above of the outer member of Figure 19;

Figure 25 is a cross-sectional drawing of an inner member of the cartridge;

Figure 25a is a cross-sectional drawing of a detail of the inner member of Figure 25 showing an aperture;

Figure 26 is a perspective view from above of the inner member of Figure 25;

Figure 27 is a perspective view from above of the inner member of Figure 25 in an inverted orientation;

Figure 28 is another cross-sectional drawing of the inner member of Figure 25;

Figure 28a is a cross-sectional drawing of another detail of the inner member of Figure 25 showing an air inlet;

Figure 29 is a cross-sectional side elevation of the cartridge in an assembled condition; and

Figure 30 is a cross-sectional side elevation of another version of cartridge.

In order to cater for the desired wide selection of good quality beverage types, having different characteristics, the present invention involves one or more significant improvements to known beverage preparation machines. These improvements enable sufficiently high pressures to be generated and maintained for the production of good quality espressos, and the pressure to be varied in a manner which is invisible to the user and requires no manual intervention. Furthermore they enable the crema to be improved in a way not previously possible.

These improvements, which will be described in more detail below, include:-

1. providing a variable geometry valve downstream of the beverage cartridge to enable the beverage preparation machine to operate at a range of pressures; and

2. providing greater control over the end appearance of the dispensed beverage, in particular beverages with crema, by controlling the volume of gas passed through the beverage ingredients.

The aforementioned improvements will be described with reference to a known beverage preparation machine 10 which is illustrated in Figures 1 to 7 of the accompanying drawings. It should be noted, however, that the improvements find application in a wide range of beverage preparation machines capable of using a wide range of cartridges which, as noted above, include pods, pads, rigid and semi-rigid cartridges.

The beverage preparation machine 10 of Figures 1 to 3 generally comprises a housing 11, a tank 12, a water heater 13, a control processor (not shown), a user interface 16 and a cartridge head 17. The cartridge head 17 in turn generally comprises a cartridge holder 18 for holding, in use, a beverage cartridge 100 and cartridge recognition means 20. The cartridge head 17 further comprises inlet and outlet piercers 21,22 for forming in the beverage cartridge 100, in use, an inlet 107 for liquid to enter the cartridge 100 and an outlet 108 for the prepared beverage to exit the beverage cartridge 100.

Although water is likely to be the most common liquid used in preparing beverages such as coffee, the machine 10 is also capable of handling other liquids, such as milk or milk preparations, for mixing with the beverage ingredients

200. Any references herein to water should also be taken to include any form of liquid used in preparing beverages.

The housing 11 is preferably made in whole or in part from a suitable plastics material or metal. The housing 11 preferably comprises a clam-shell design having a front half 25 and a rear half 26 which allow access during assembly for fitting of the machine 10 components.

The front half 25 of the housing 11 defines a dispensing station 27 where dispensation of the beverage takes place, which includes a cupstand 23 with a drip tray located beneath. The machine user interface 16 is also located on the front of the housing 11 and comprises a plurality of control switches, for example, a start/stop button 28, and a number of status indicators 29-32. The status indicators 29-32 are preferably light emitting diodes (LED) which, for example, indicate readiness of the machine 10, whether an error has occurred in the machine 10 operation, and the mode of operation of the machine 10. The LEDs 29-32 may be controlled to illuminate at a constant intensity, to flash intermittently, or both depending on the status of the machine 10. The LEDs 29-32 may have a variety of colours including green, red and yellow. The start/stop button 28 controls commencement of the dispense cycle and is preferably a manually operated push-button, switch or similar.

The tank 12 is located to the rear of the housing 11 and is preferably incorporated in, or connected to, the rear half 26 of the housing 11. The tank 12 has an inlet for

filling the tank 12 with water, or other liquid, which is closed off when the tank 12 is in position in the machine 10. An outlet is provided towards a lower end of the tank 12 which communicates with the pump 14. The tank 12 may be made from a transparent or translucent material to allow a consumer to view the quantity of water remaining in the tank 12. Alternatively, the tank 12 may be made from an opaque material but have provided a viewing window therein. In addition, or in place of the above, the tank 12 may be provided with a low level sensor which prevents operation of the pump 14 and optionally triggers a warning indicator, such as an LED, when the liquid level in the tank descends to a preselected level. The tank 12 preferably has an internal capacity of approximately 1.5 litres.

The pump 14 is operatively connected between the tank 12 and the water heater 13, as shown schematically in Figure 8, and is controlled by the control processor. A suitable pump provides a flow rate of 900 ml/min of water at a pressure of 6 bar. The flow rate of water through the machine 10 can be controlled by the control processor to be a percentage of the maximum flow rate of the pump 14 by cycle chopping the electrical supply to the pump. Preferably the pump can be driven at any of 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% or 100% of the maximum rated flow rate. The accuracy of the volume of water pumped is preferably + or - 5% leading to a + or - 5% accuracy in the final volume of the dispensed beverage. A volumetric flow sensor (not shown) is preferably provided in the flow line either upstream or downstream of the pump 14. Preferably, the volumetric flow sensor is a rotary sensor.

The heater 13 is located in the interior of the housing 11. One suitable heater 13 has a power rating of 1550 W and is able to heat water received from the water pump 14 from a starting temperature of approximately 20 °C to a nominal operating temperature of around 85°C in under 1 minute. Preferably the dwell time between the end of one dispense cycle and the heater 13 being able to commence a subsequent dispense cycle is less than 10 seconds. The heater maintains the selected temperature to within + or - 2 °C during the dispense cycle. The water for the dispense cycle is delivered to the cartridge head 17 at a predetermined temperature. The heater 13 is able to quickly adjust the delivery temperature to the required temperature, generally between 80°C and 98°C, and possibly higher from the incoming water temperature. The heater 13 comprises an over-temperature cut-off which shuts off the heater 13 if the temperature exceeds 98°C. Where desired, the machine 10 can incorporate a steam purge. The preferred means of generating the steam purge is to utilise a water heater 13 in the form of a flash (also known as an instantaneous or flow) heater. Typically such flash heaters comprise a tube through which the water passes wherein the tube is heated by one or more resistive elements. The flash heater can be used not only for heating water for forming beverages but also, at higher power settings, for generating a steam purge by boiling off water remaining with the flash heater tube after the beverage has been formed. An advantage of flash heaters is that there is no significant delay whilst water in a boiler heats up. Flash heaters heat water on demand and switch off immediately after each brewing cycle and are therefore very energy efficient.

Water output from the heater 13 is fed via a suitable delivery system to the cartridge head 17 and cartridge 100 by means of a valve. If the pressure of the water flow is acceptable, the water is passed to the cartridge 100. If the pressure is below or above predetermined limits then the water is diverted by means of the valve to a waste recovery receptacle.

The delivery system comprises conduits which connect the tank 12, the water pump 14, the water heater 13 and the cartridge head 17 (as shown in Figure 8) to transport the water from the tank 12 to the cartridge 100.

The cartridge holder 18 is designed to be capable of handling the opening forces generated by the pressure inside the cartridges 100, which is around 250kg for espresso beverages. During operation of the machine 10 the cartridges 100 attempt to expand, but the integrity of the cartridges 100 must be maintained. In addition the user must not be able to open the holder 18 whilst the system is pressurised and suitable locking mechanisms are provided to achieve this.

One suitable design of cartridge head 17, as described in WO-A-2006/014936, is shown in Figures 4 to 7. The cartridge holder 18 of the cartridge head 17 comprises a fixed lower part 43, a rotatable upper part 44 and a pivotable cartridge mount 45 positioned between the fixed lower part 43 and the rotatable upper part 44. The upper part 44, lower part 43 and cartridge mount 45 are rotated about a common hinge axis 46. Figures 4 to 7 show the holder

18 with some components of the machine 10 omitted for clarity.

The rotatable upper part 44 and pivotable cartridge mount 45 are moved relative to the fixed lower part 43 by means of a clamping mechanism. The clamping mechanism comprises a clamping lever having first and second members or parts 47 and 48. The first part 47 of the clamping lever comprises a U-shaped arm which is pivotably mounted to the upper part 44 at two first pivot points 48, one on each side of the holder 18.

The second part of the clamping lever comprises two over-centre arms 49, one on each side of the holder 18 which are each pivotably mounted to the upper part 44 at a second pivot point 50 located on the hinge axis 46 coupling the upper part 44 to the fixed lower part 43. Each over-centre arm 49 is a reciprocal member comprising a cylinder 49a, a stem 49b and a resilient sleeve 49c. The cylinder 49a has an internal bore and is rotatably mounted at one end at the hinge axis 46. A first end of the stem 49b is slidingly received in the bore of the cylinder 49a. The opposite end of the stem 49b is rotatably mounted to the U-shaped arm 47 at a third pivot point 51. The third pivot points 51 are unconnected to, and freely moveable relative to, the upper part 44 and lower part 43. The resilient sleeve 49c is mounted externally on the stem 49b and extends, in use, between abutment surfaces on the cylinder 49a and stem 49b. The resilient sleeve 49c accommodates shortening of the over-centre arm 49 but biases the over-centre arm 49 into an extended configuration. Movement of the third pivot points

51 towards and away from the hinge axis 46 is thus possible by relative movement of the stems 49b in the cylinders 49a. The resilient sleeves 49c are preferably formed from silicone. Whilst the illustrated embodiment uses two over-centre arms 49, it will be apparent that the closure mechanism may be configured with only one over-centre arm 49.

The U-shaped arm 47 extends around the front of the holder 18 and comprises two downwardly dependant hook members 52, one on each side of the holder 18, each comprising a cam surface facing the hinge axis 46. The fixed lower part 43 of the holder 18 is provided with two bosses 53, or detents, located one on each side of the lower part 43 at or near a front edge 54 thereof aligned generally with the hook members 52.

As shown in Figure 4, the U-shaped arm 47 may be formed from a one piece plastics moulding comprising an ergonomic hand grip and the hook members 52 integral to the arm 47.

The cartridge mount 45 is rotatably mounted between the upper and lower parts 43, 44 of the holder 18. The mount 45 is provided with a substantially circular recess 55 which receives in use the beverage cartridge 100 (which is described in greater details below). The recess 55 includes an irregularity 56 for accommodating the handle portion 24 of the beverage cartridge 100 which also acts to prevent rotation of the beverage cartridge 100 in the holder 18. The cartridge mount 45 is sprung relative to the fixed lower part 43 such that in the open position, as shown in Figure

7, the cartridge mount 45 is biased out of contact with the fixed lower part 43 so that the cartridge mount 45 is moved out of contact with the outlet and inlet piercer members 21, 22. The cartridge mount 45 is provided with an aperture 57 for receiving there through the inlet and outlet piercers 21, 22 and a head of the cartridge recognition means 20 when the cartridge mount 45 is moved into the closed position.

The upper part 43 comprises a generally circular body 58 housing a circular viewing window 59 through which a consumer can view the beverage cartridge 100 during a dispense cycle and also visually confirm whether a cartridge 100 is loaded in the machine 10. The viewing window 59 is cup-shaped having a downwardly directed rim. In addition, the viewing window 59 is provided with a clamping member in the form of an inwardly directed tubular extension 61 as shown in Figure 7. The extension 61 is directed towards the lower part 44 and lies within the volume of the cartridge head when in the closed position as shown in Figure 6. The viewing window 59 is able to move axially relative to the housing 58 of the upper part 43. One arrangement of accomplishing the relative movement is to provide a wave spring (not shown), or similar resilient means such as a rubberised ring, positioned between the viewing window 59 and the circular housing 58. In an alternative arrangement, a series of helical compression springs (not shown) are provided extending between the viewing window 59 and the housing 58. In both cases the resilient means allows the viewing window 59 to move axially relative to the circular housing 58 by a small degree.

When the holder 18 is in the closed position, a distal end 62 of the tubular extension 61 of viewing window 59 bears against the clamping surface 18a of the beverage cartridge 100 biasing it against the lower part 44 as shown in Figure 6 (in which the arrangement is illustrated containing a cartridge having a greater depth). The pressure exerted by the tubular extension 61 on the outer member 102 ensures a fluid tight seal between the cartridge 100 and the holder 18. It should be noted that the height of the viewing window 59, and hence also the cartridge head 17, is such that cartridges 100 of various depths can be inserted. In Figure 6 the arrangement is shown with a relative deep cartridge. The same cartridge head 17 can also accommodate shallower cartridges. In this case there will be a gap between the upper surface 11 of the cartridge 100 and the window 59. However the cartridge 100 is fully sealed at inlet and outlet by the pressure applied by the tubular extension 61.

The lower part 43 comprises the inlet and outlet piercers 21, 22 and the head of the cartridge recognition means 20. The inlet piercer 21 comprises a hollow needle-like tube 63 having a sharpened end 64 for perforating the laminate 108 of the beverage cartridge 100 in use. The inlet piercer 21 is in fluid communication with a water conduit 65, as shown in Figure 7, which passes through the lower part 43 and is connected to an outlet conduit 66 of the water heater 13. The outlet piercer 22 is similar in type to the outlet piercer described in the EP-A-0389141 and EP-A-0 334572 and comprises an open ended cylinder of circular or D-shaped cross-section having dimensions larger than the

beverage discharge spout 109. An arcuate portion 67 of the upper end of the outlet piercer 22 is serrated to pierce and eventually cut the laminate of the beverage cartridge 100. The remainder of the upper end is cut back longitudinally of the cylinder at least to the base of the teeth 68 of the serrated portion to fold or pull the cut laminate 108 away from the outlet aperture before the beverage is dispensed there through. The outlet piercer 22 pierces the laminate 105 externally of the discharge spout 143 and when the cartridge mount 45 is in the closed position, rests in the annulus between the discharge spout 143 and the outer wall 42 of the discharge funnel 140. The outlet piercer 22 folds back the cut laminate 105 into the annulus. Thereby both the outlet piercer 22 and the cut laminate 105 are held out of the way of the discharged beverage.

The outlet piercer 22 is surrounded by a ledge which is raised relative to its surroundings by 0.5mm.

Advantageously, the outlet piercer 22 is removable from the lower part 43 to enable it to be thoroughly cleaned, for example, in a dishwasher. The removable outlet piercer 22 is received in a recess in the lower part 43 where it is seated. The inlet piercer 21 and/or the outlet piercer 22 may be made of a metal, such as stainless steel, or from a plastics material. Advantageously, the use of plastic cutting elements is enabled by use of a laminate 105 which is able to be punctured and cut by a non-metallic material. Consequently, the piercers 21, 22 can be made less sharp which lowers the risk of injury to the consumer. In addition, plastic piercing elements are not prone to rust.

Preferably, the inlet piercer 21 and the outlet piercer 24 are formed as a single, integral unit which is removable from the lower part 43.

In use, the upper part 44 of the holder 18 is movable from an open position in which it is orientated vertically or towards the vertical as shown in Figure 2, to a closed position in which it is orientated substantially horizontally and in interengagement with the fixed lower part 43 and cartridge mount 45. The upper part 44 is moved from the open to the closed positions by operation of the clamping lever. To close the upper part 44 a user takes hold of the clamping lever by the U-shaped arm 47 and pulls downwards. Consequently, the upper part 44 rotates which first brings the tubular extension 61 of the viewing window 59 into contact with the clamping surface 118a of the beverage cartridge 100. Continued rotation of the upper part 44 rotates the upper part 44 and cartridge mount 45 down into contact with the lower part 43. Further rotation of the U-shaped arm 47 causes the U-shaped arm 47 to rotate relative to the upper part 44 and the lower part 43 resulting in the hook members 52 of the upper part 44 engaging the bosses 53 of the lower part 43 with the cam surface riding over the bosses 53. During this last stage of rotation the cartridge 100 is compressed between the cartridge mount 45 and the viewing window 59. As a result, the viewing window 59 is moved axially slightly relative to the circular housing 58 of the upper part 44 against the bias of the wave spring or helical springs. This movement allows for a take up of tolerances in the beverage cartridge 100 and beverage preparation machine 10 and ensures that the

amount of compressive force applied to the cartridge 100 is kept within an acceptable range. The clamping force of the mechanism as moderated by the action of the wave spring or helical springs ensures a clamping pressure on the cartridge 100. It has been found that a force of between 150N and 400N is required to counter the pressure in the cartridge 100. During closure of the cartridge head the laminate 105 of the cartridge 100 is tensioned as it is brought into contact with the ledge surrounding the outlet piercer 22 which causes the laminate 105 to flex out of plane as the distal end of the outer tube 42 of the cylindrical funnel is moved upwardly by 0.5mm relative to the flange 147. This movement also ensures that the great majority of the compressive force applied to the cartridge 100 acts through the central region of the cartridge 100 through the load-bearing inner member 103. These clamping forces help prevent failure of the cartridge 100 during pressurisation and also ensure that the inner member 103 and outer member 102 are fully seated relative to one another and thus that all internal passageways and apertures remain at their intended dimensions even during internal pressurisation.

In the closed position, the separation of the distal end 62 of the tubular extension 61 and the lower part 44 is shown by reference D in Figure 6. This distance is fixed by the dimensions of the viewing window 59, housing 58 and lower part 44. The distance D is chosen to be the same or marginally smaller than the distance d between the clamping surface 118a and laminate 105 under surface of the cartridges 100. In this way, on closure of the cartridge head 17 the cartridges 100 are subjected to a fixed, known

degree of compression. In addition, both the first and second embodiments of cartridge can be clamped with the same degree of compression since distance D is the same for both cartridge types.

An imaginary datum line can be drawn between the first and second pivot points 48, 50 of the holder 18. As can be seen in Figure 7, in the open position the third pivot points 51 are located on the side of the datum line nearest the fixed lower part 43. As the upper part 44 reaches the closed position, the third pivot points 51 of the clamping lever pass through the datum line joining the first and second pivot points 48, 50 to the opposite side of the line, furthest from the fixed lower part 43. Consequently, the U-shaped arm 47 'snaps through' from a first stable position to a second stable position. The snap through action is accommodated by shortening of the over-centre arms 49 and consequential compression of the resilient sleeves 49c. Once the third pivot points 51 are past the imaginary datum line, the recovery of the resilient sleeves 49c acts to continue the motion of the third pivot points 51 away from the imaginary datum line. The clamping lever thus has a bi-stable operation in that the lever is stable in the open or closed positions but unstable at the point when the third pivot points 51 lie on the imaginary datum line joining the first and second pivot points 48, 50. Thus, the snap-through action of the clamping lever provides a positive closure mechanism which leads to a definite closure action wherein in the final stages of the clamping lever's rotation, the snap-through action of the U-shaped arm 47 and second arms forces the hook members 52 firmly into engagement with the

bosses 53. In addition, the resilient sleeves 49c provide a resistance to re-opening of the upper part 44 since a minimum force is required to compress the sleeves 49c sufficiently to move the third pivot points 51 back into line with the datum line joining the first and second pivot points 48, 50. Advantageously, the interengagement of the hook members 52 and the bosses 53 prevents separation of the upper and lower parts other than by rotation of the clamping lever. This is useful in preventing opening of the cartridge head 17 during operation when the cartridge head 17 is subject to internal pressurisation.

The pressure exerted by the upper section 44 ensures a full fluid tight seal between the cartridge 100 and the cartridge holder 18. The clamping forces help prevent failure of the cartridge 100 during pressurisation and also ensure that all of the internal passageways and apertures within the cartridge 100 remain at their intended dimensions even during internal pressurisation. To improve the seal with the cartridges 100 the applicant has now found that lining the recess 55 of the cartridge mount 45 with a rubber seal 55a (see Figure 7a) improves the machine's ability to withstand the significantly higher pressures generated during the brewing cycle.

Control of the brew cycle is effected by the control processor of the beverage preparation machine 10, which comprises a processing module and a memory. The control processor is operatively connected to, and controls operation of, the heater 13, pump 14, user interface 16, and other components described below.

The operational behaviour of the machine 10 is determined by software embedded in the control processor, for example as described in EP-A-1440644. The memory of the control processor includes one or more variables for one or more operational parameters for the beverage preparation machine 10. In the prior art machines these are generally the temperature of the liquid passed through the beverage cartridge 100 during the operating stage, the speed of charging the beverage cartridge 100, the presence or otherwise of a soak step, the total dispensed volume of the beverage, the flow rate of the liquid during the discharge stage, and the period of the purge stage.

One purpose of the cartridge recognition means 20 is, inter alia, to allow the machine 10 to recognise the type of beverage cartridge 100 that has been inserted and to adjust one or more operational parameters accordingly. The variables for the operational parameters are stored in the memory. The cartridge 100 comprises a code 120 provided on or in the cartridge 100 representing the operational parameters required for optimal dispensation of the beverage in that cartridge 100. An example of the code is described in EP-A-1440644.

The control processor memory further stores information on the type of beverage dispensed so that the operating cycle of the machine 10 may be adjusted for the next cartridge 100. This is especially advantageous where two or more beverage cartridges 100 are used sequentially to form a beverage. For example a coffee cartridge may be dispensed

followed by a milk cartridge to form a cappuccino beverage. Alternatively a chocolate cartridge could be used followed by a milk cartridge to produce a creamy hot chocolate beverage. By using a memory that stores information on the first beverage dispensed, the manner of dispensing the second cartridge, say a milk cartridge, may be altered to achieve an optimum beverage. In the above example the milk dispensed for hot chocolate may, typically, be diluted less than the milk added to the coffee. In addition, the milk dispensed for chocolate may be dispensed at a slower flow rate to lessen the degree of foaming of the beverage. Many combinations of cartridges are possible and operating parameters as will be obvious to the skilled person. In addition, the memory may be used to allow the machine 10 to 'predict' the type of beverage that a user will next want to dispense. For example, if a user predominantly drinks one beverage type then the machine can instruct the water heater to remain at the optimum temperature for that beverage type.

Operation of the known prior art machines 10 comprises insertion of a beverage cartridge 100 into the cartridge head 17, carrying out a dispense cycle in which the beverage is dispensed and removal of the cartridge 100 from the machine.

To insert the cartridge 100 the cartridge holder 18 is opened as described above to expose the cartridge mount 45. The cartridge 100 is then placed on the cartridge mount 45 received within the recess 46. The cartridge holder 18 is then closed by operation of the clamping handle 51 as described above. During closure the inlet and outlet

piercers pierce the cartridge 100 to form the cartridge inlet 107 and outlet 108.

To commence the operating cycle the user operates the start/stop button 28. The operating cycle comprises the steps of cartridge recognition and the beverage preparation cycle.

Cartridge recognition is performed by the optical cartridge recognition means 20 as described above assuming that the outputs from the cartridge sensor and lock sensor are satisfactory. Once the barcode 40 has been decoded the operational parameters of the machine 10 are adjusted by the control processor. The preparation cycle is then automatically commenced. The preparation cycle has four main stages, although not all of these are used for all beverage types:

1. Pre-wet
2. Pause
3. Brew stage
4. Purge

In the pre-wet stage the cartridge 100 is charged with liquid from the storage tank 12 by means of the pump 14. The charging with water causes the beverage ingredients 200 in the chamber 160 to be wetted. The charging may take place at a "fast" flow rate of 600 ml/min or a "slow" flow rate of 325 ml/min. The slow charging rate is particularly useful for cartridges 100 containing viscous liquid beverage ingredients where the ingredients require some dilution

before they are able to be pumped at a higher volume flow rate. The volume of liquid injected into the cartridge 100 is selected to ensure that liquid or beverage does not drip out of the cartridge outlet 108 during this stage.

The pause stage allows the beverage ingredients 200 to soak in the liquid injected during the pre-wet stage for a predetermined period of time. Both the pre-wetting and soaking stages are known to increase the yield of the extractibles from the beverage ingredients 200 and to improve the end flavour of the beverage. Pre-wetting and soaking are particularly used where the beverage ingredients are roast and ground coffee.

In the brew stage liquid is passed through the cartridge 100 in order to produce the beverage from the beverage ingredients 200. The temperature of the liquid is determined by the control processor which sends instructions to the heater 13 to heat the liquid passing from the tank 12 to the cartridge head 17. Liquid enters the cartridge holder 18 via an inlet valve and the inlet piercer and then passes into the inlet chamber 126 of the beverage cartridge 100. Brewing and/or mixing of the beverage in the beverage cartridge 100 occurs, as described in EP-A-1440644, before the prepared beverage exits the cartridge outlet 104, enters the outlet valve 37 and is directed into a suitably placed receptacle in the dispensing station 27.

During the purge cycle the temperature of the water heater 13 is raised sufficiently high to convert the water remaining in the system to steam and blowing the pressurised

steam through the beverage preparation machine 10 and the beverage cartridge 100. This ensures that all beverage is dispensed and that the flow path is cleared ready for dispensing another beverage. The purge cycle may not commence immediately on cessation of the brew/mixing stage to allow for the majority of the fluid to clear the flow path.

Once the operating cycle has been completed, the machine automatically stops and the consumer removes the cartridge 100 by opening the cartridge holder 18 and manually removing and disposing of the cartridge 100. Alternatively, the machine 10 may be provided with an automatic ejection mechanism for removing the cartridge automatically on opening the cartridge holder 18.

The first of the significant improvements to the known beverage preparation machines 10 referred to above is the provision of variable geometry valve 60 (see Figures 9 to 15) provided adjacent the cartridge outlet 108 to provide post-cartridge pressure control. This enables the machine 10 to produce a wide variety of beverages, as it allows the cartridges 100 to be selectively brewed at either high or low pressure or a varying pressure during the brew cycle, depending on the type of brew cycle required for the beverage ingredients in the cartridge as identified by the cartridge recognition means 20, thus providing an automated variable pressure system. The modified machine is capable of producing beverages at a range of pressures, for example from 0 to 9 bar, and more preferably from 0 to 6 bar.

The variable geometry valve 60 is positioned downstream of the cartridge 100, and preferably positioned in the beverage outlet 37, which is partially housed in, and extends from, the lower section 43 of the cartridge head 17 (see Figures 6 and 7). The valve 60 has at least an open and a restricted operating position (i.e. state or mode), and more preferably all of the positions identified below:-

1. Open (Figure 11)
2. Restricted (Figure 12)
3. Closed (Figure 10)
4. Cleaning/purging.

Various types of valve may be used for the outlet valve 60, such as ball valves, pinch valves, sleeve valves, seat valves or disc valves. The embodiment illustrated in Figures 10 to 12 is a ball type valve which has a rotating element 69 located in a chamber 70 in the beverage outlet 37. The rotating element 69 is rotatable between preset positions to provide the required position. The diameter of the bore of the valve 60 in the unrestricted position is preferably at least 5mm which is required, for example, for cartridges 100 providing low pressure filter beverages.

An alternative suitable valve is a pinch valve illustrated in Figures 13 to 15 which comprises a flexible tube 71, preferably made of silicon rubber or an elastomeric material, and a clamping mechanism 72. In the unrestricted position (Figures 13a and 14) the beverage flows freely through the tube 71. The clamping mechanism 72 is activated

to provide a restricted position (Figures 13b and 15) and closed position.

The valve 60 is controlled automatically by the control processor of the machine 10. Once the type of cartridge 100 inserted into the machine 10 has been identified, by the decoding the barcode 40, the control processor selects the correct initial setting and, if appropriate, any subsequent operation of the valve 60 for the relevant beverage type.

The machine 10 can operate in a range of modes, with the valve 60 in one or more operating positions, some examples of which are:-

1. Valve Open Throughout The Brewing Cycle

When the valve 60 is in its open position the operating pressure is below 2 bar allowing a steady state through flow rate of up to 400 ml/min. The beverage is dispensed under similar conditions to those described in EP-A-1440644. This mode is particularly useful as it renders the machine 10 backwardly compatible with existing cartridges for preparing low pressure beverages, such as tea, foamed milk or chocolate.

2. Valve Restricted Throughout The Brewing Cycle

When the valve 60 is in its restricted position it creates a relatively high back pressure within the cartridge 100, which results in an operating pressure of up to 4, 6 or even 9 bar and provides a steady state through flow rate of

60 to 300 ml/min. This is sufficient to obtain the necessary solids extraction and emulsification of oils in the beverage ingredients 200 for an espresso beverage. The consequential restriction in the beverage outlet 37 provides a shearing and mixing action in the beverage flowing through the valve 60, giving rise to good air/liquid emulsification and resulting in an improved crema. This mode can advantageously be used for preparing higher pressure beverages, such as espressos and cappuccinos, from cartridges 100 which do not have means for entraining air to effect the mixing action, i.e. so called non-eductor cartridges.

3. Valve Closed Then Restricted

If the valve 60 is closed immediately at the start of the brewing cycle (before the pump 14 commences and during the pre-wet cycle), this enables a higher pressure to be developed within the cartridge 100 than when the valve 60 is in its restricted position.

Further combinations may be appropriate, such as valve closed then open or valve closed then restricted then open according to the desired effect to be achieved.

If required, the valve 60 can be pulsed between various positions during the brewing cycle, or a part thereof. This manner of valve operation during the delivery cycle enables beverages with a crema having a graduated colour and/or bubble size to be produced.

During the purge cycle the valve 60 is controlled by the control processor to divert the steam to a drain area rather than to the dispensing station 27 to preserve the appearance of the beverage and prevent contamination.

The second of the significant improvements to the known beverage preparation machines 10 referred to above is the addition to the brew control system of gas management. Surprisingly the applicant has now discovered that the characteristics of beverages prepared in this type of beverage preparation machine can be modified beyond boundaries hereto seen in prior art machines. The surprising effect is enacted by controlling the volume of gas in the delivery system during the preparation of the beverage to prescribe the amount of high quality crema on a beverage, varying from a delicate layer up to a surprisingly deep layer in the final beverage. The applicant has found a way to successfully use gases within the beverage machine to modify the gas:liquid ratio to produce a surprising volume of good stable crema in prepared beverages never seen before in prior art machines. Maintaining a greater volume of gas in the delivery system enables a much larger gas:liquid ratio to be achieved during brewing and dispensing and this produces a correspondingly larger volume of crema. Decreasing the volume of gas enables the ratio to be decreased to reduce the crema volume. The bubble size is also influenced by the gas:liquid ratio, so a lower ratio can be used to provide a tight and creamy crema and a higher ratio used to provide a more loose and bubbly crema. This improvement therefore provides the ability to optimise the crema volume and bubble size for each beverage dispensed. It

has been found that by manipulating the gas, good quality espressos can be brewed with a crema volume greater than 25% of the beverage volume whilst minimising the occurrence of bubbles having a diameter of more than 172 microns, which has not previously been seen to be possible in known beverage preparation machines of this type. In the prior art cartridge machines it has generally not been possible to brew espressos with a crema greater than 10% of the beverage volume.

The improvement is achieved by adapting the control of the brew cycle to provide means for managing the volume of gas within the delivery system which conveys the water from the tank 12 to the beverage ingredients 200 and to the dispensing outlet. All further references in this specification to the delivery system are intended to include any predetermined section thereof, for example the section extending from the water heater 13 to the cartridge 100 and may also include, if relevant, some gas contained within a headspace of the cartridge 100.

The "basic volume" of gas which can reside within the delivery system of any given machine 10 is dependant on its construction. The "actual volume" at any given time will vary according to whether the machine 10 has just been used to prepare a beverage, what type of beverage it was used for and whether a steam purge cycle has been run. Thus the improved brew cycle control incorporates means for varying the volume of gas in the delivery system according to the type of beverage to be dispensed (i.e. one requiring a crema with smaller and fewer bubbles or one which requires a

greater froth of larger bubbles) taking into account the actual volume of gas already present. The means for varying the volume of gas may be achieved by combinations of:-

1. purging the delivery system after a brewing cycle is complete, and prior to a subsequent high pressure brew, which will increase the gas:liquid ratio;
2. venting gas from the delivery system prior to high pressure brewing, which will decrease the gas:liquid ratio; and
3. inducting gas into the delivery system prior to high pressure brewing, which will increase the gas:liquid ratio.

Valve means are preferably provided to enable the volume of gas within the delivery system to be reduced and an air pump to enable gas (typically air) to be injected into the system. A separate, dedicated air valve may be incorporated in the delivery system, either upstream or downstream of the cartridge 100. Preferably the variable geometry valve 60 described above may be used as the valve means.

To enable this improved brew cycle control to be effected, additional parameters to those described in connection with the basic machine 10 may be stored in the memory of the control processor. These additional parameters include the basic volume of gas for the specific construction of machine 10 (which will apply to the machine 10 which is unused or after it has been purged) and the

volume required during high pressure brewing for optimising the crema for each specific beverage. Preferably the additional parameters also include the actual volume of gas which will remain in the delivery system after each type of brew operation which the machine 10 is capable of. However this is not wholly necessary if the machine 10 is programmed to run a steam purge cycle after every beverage is dispensed, which effectively resets the actual volume to the basic volume, because it flushes the dispensing system downstream of the water heater 13 of any remaining liquid.

The brew cycle will therefore include an additional step, namely a gas adjustment cycle before the pre-wet cycle. The gas adjustment cycle thus includes:-

1. An assessment of the required volume of gas for the type of beverage to be prepared. This will most conveniently be the selection from the processor memory of the required parameter associated with the cartridge code 120;

2. The determination of the actual volume of gas currently resident in the delivery means according to the last operation of the machine 10. This will be the basic volume for an unused machine or if a purge cycle has been run. If the machine has just been used to prepare a beverage and no purge cycle run, the processor ideally selects from the memory the parameter for the remaining gas according to the last beverage. Alternatively, means may also be provided to specifically monitor the volume of gas within the delivery system at any point in time;

3. A calculation of the volume of gas to be inducted into or vented from the delivery system to achieve the required volume;

4. The modification of the volume of gas, if required, by the induction of additional gas (typically air) or the venting of excess gas.

In one example the beverage preparation machine 10 has a basic volume of gas of 36ml in the section of the delivery means extending between the water heater 13 and the beverage ingredients 200.

There are a number of different modes of operation for step 4 depending on the outcome of step 3, depending on what type of valve means are used. If the valve means are downstream of the cartridge, i.e. an outlet valve, one way of controlling the volume of air upstream of the beverage ingredients 200 prior to high pressure brewing is by closing the outlet valve at different points in the brew cycle as follows:-

1. The Correct Volume of Gas is Present

If the processor calculates that it requires the full basic volume of gas (36ml) for the beverage to be dispensed, as determined from the reading of the code 120, it closes the outlet valve at the start of the brew cycle, before any water flows from the water heater 13. This means that the compression of the gas in the delivery system will commence

immediately the cartridge 100 will be subject to higher pressures during the pre-wet and soak cycles, with the valve only opening to dispense the resultant beverage. As the valve is closed before the pump 14 is started, all of the 36ml of trapped gas is mixed in to the resulting beverage and a larger volume of slightly coarser crema is obtained (Figure16a). In the example shown the volume of crema Y in a graduated, flat bottomed beaker was 20ml compared to the volume of liquid X, which was 50ml.

The chart shown in Figure 16b represents an example of brew cycle parameters used to produce a beverage in this mode with a large volume of crema under test conditions.

In this chart, a stop condition of 0 seconds (e.g. against the remove gas step) indicates that the step is not carried out.

2. Too Much Gas is Present

If, on the other hand, a beverage with a small volume of crema is indicated by the cartridge 100 inserted and there is an excess of gas present in the system, the outlet valve is closed after the pump 14 has operated for a short time until the excess gas in the delivery system has escaped through the open valve at low pressure. With the valve being closed later in the brew cycle, the required volume of gas is vented to atmosphere via the cartridge 100 and valve, so a smaller quantity of trapped gas is left to be compressed and mixed in to the resulting beverage during high pressure brewing and consequently a smaller volume of finer crema is

obtained (Figure 17a). In the example shown the volume of crema Y in a graduated, flat bottomed beaker was 5ml compared to the volume of liquid X, which was 50ml.

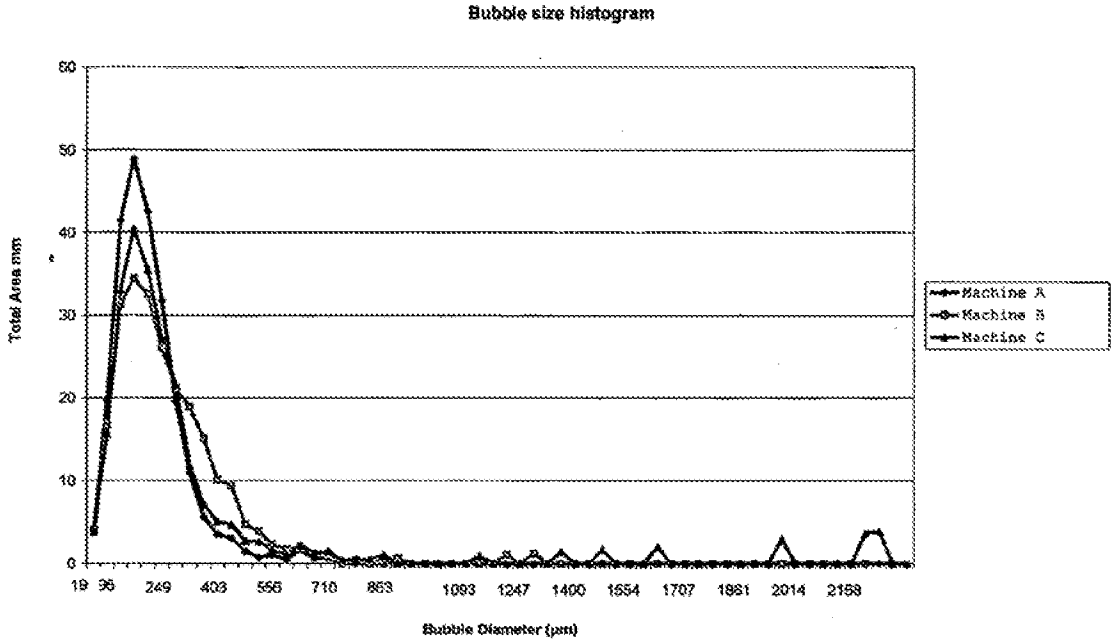
The chart shown in Figure 17b represents an example of brew parameters used to produce a beverage in this mode with a small volume of crema under test conditions.

3. Insufficient Gas Present

If step 3 indicates that more gas needs to be inducted, the outlet valve is closed immediately and the air pump operated until the deficit has been made up. Thereafter high pressure brewing commences.

The following graph is a digital image analysis showing a comparison of the crema characteristics produced by the present beverage preparation machine 10 (machine A) utilising the gas management system and two prior art machines (machines B and C) without such gas management system. Comparing the profiles for each machine from the peak (~172μm diameter) rightwards (increasing bubble size), it can be seen that machine A exhibits a very tight distribution of small bubbles within the crema. Machine C (the Nespresso Latissma (tm) which is a high pressure machine which has a pressure rating of around 19 bar and operates at a pressure between 9 and 15 bar) produces a broader/coarser distribution with a number of larger diameter bubbles, whilst machine B (the applicant's own Tassimo/Bosch Machine(tm) which is a low pressure machine operating at pressures below 2 bar) similar to that

described in EP-A-1440644) is coarser still, though without the larger bubbles seen for machine C.



The tail to the left of the chart (extremely small bubbles) is characteristic of the limits of the image analysis systems used to produce the graph, though is qualitatively similar.

Some elements of the control of the gas in the beverage machine 10 may also be effected manually by the use of suitable buttons for the user to press, to indicate the type of beverage being produced and the required crema characteristic.

Whilst this improvement has been described with reference to beverage machines 10 which use cartridges 100,

it may also be used in bulk brewers and other non-cartridge machines.

Embodiments of cartridges 100 which are suitable for use in the machine 10 having the improvements described above are shown in Figures 18 to 30.

The cartridge 100 generally comprises an outer member 102, an inner member 103 and a laminate 105. The outer member 102, inner member 103 and laminate 105 are assembled to form the cartridge 100 which has an interior 106 for containing one or more beverage ingredients, an inlet 107, an outlet 108 and a beverage flow path linking the inlet 107 to the outlet 108 and which passes through the interior 106. The inlet 107 and outlet 108 are initially sealed by the laminate 105 and are opened in use by piercing or cutting of the laminate 105. The beverage flow path is defined by spatial inter-relationships between the outer member 102, inner member 103 and laminate 105 as discussed below. Other components may optionally be included in the cartridge 100, such as a filter 104, as will be described further below.

A first version of cartridge 100 which will be described is shown in Figures 19 to 29. The first version of the cartridge 100 is particularly designed for use in dispensing espresso-style products such as roast and ground coffee where it is desirable to produce a crema. However, this version of the cartridge 100 may be used with other products such as chocolate, coffee, tea, sweeteners, cordials, flavourings, alcoholic beverages, flavoured milk, fruit juices, squashes, sauces and desserts.

As can be seen from Figure 23, the overall shape of the cartridge 100 is generally circular or disc-shaped with the diameter of the cartridge 100 being significantly greater than its height. A major axis X passes through the centre of the outer member as shown in Figure 19. Typically the overall diameter of the outer member 102 is 74.5 mm ±6mm and the overall height is 16 mm ±3mm. Typically the volume of the cartridge 100 when assembled is 30.2 ml ±20%.

The outer member 102 generally comprises a bowl-shaped shell 110 having a curved annular wall 113, a closed top 111 and an open bottom 112. The diameter of the outer member 102 is smaller at the top 111 compared to the diameter at the bottom 112, resulting from a flaring of the annular wall 113 as one traverses from the closed top 111 to the open bottom 112. The annular wall 113 and closed bottom 112 together define a receptacle having an interior 134.

A hollow inwardly directed cylindrical extension 118 is provided in the closed top 111 centred on the major axis X. As more clearly shown in Figure 20, the cylindrical extension 18 comprises a stepped profile having first, second and third portions 119, 120 and 121. The first portion 119 is right circular cylindrical. The second portion 120 is frusto-conical in shape and is inwardly tapered. The third portion 121 is another right circular cylinder and is closed off by a lower face 131. The diameter of the first, second and third portion 119, 120 and 121 incrementally decreases such that the diameter of the cylindrical extension 118 decreases as one traverses from

the top 111 to the closed lower face 131 of the cylindrical extension 118. A generally horizontal shoulder 132 is formed on the cylindrical extension 118 at the junction between the second and third portions 120 and 121.

An outwardly extending shoulder 133 is formed in the outer member 102 towards the bottom 112. The outwardly extending shoulder 133 forms a secondary wall 115 co-axial with the annular wall 113 so as to define an annular track forming a manifold 116 between the secondary wall 115 and the annular wall 113. The manifold 116 passes around the circumference of the outer member 102. A series of slots 117 are provided in the annular wall 113 level with the manifold 116 to provide gas and liquid communication between the manifold 116 and the interior 134 of the outer member 102. As shown in Figure 21, the slots 117 comprise vertical slits in the annular wall 113. Between twenty and forty slots are provided. In the embodiment shown thirty-seven slots 117 are provided generally equi-spaced around the circumference of the manifold 16. The slots 117 are preferably between 1.4 and 1.8 mm in length. Typically the length of each slot 117 is 1.6 mm representing 10% of the overall height of the outer member 102. The width of each slot 117 is between 0.25 and 0.35 mm. Typically, the width of each slot 117 is 0.3 mm. The width of the slots 117 is sufficiently narrow to prevent the beverage ingredients passing there through into the manifold 116 either during storage or in use.

An inlet chamber 126 is formed in the outer member 102 at the periphery of the outer member 102. A cylindrical wall 127 is provided, as most clearly shown in Figure 23,

which defines the inlet chamber 126 within, and partitions the inlet chamber 126 from, the interior 134 of the outer member 102. The cylindrical wall 127 has a closed upper face 128 which is formed on a plane perpendicular to the major axis X and an open lower end 129 co-planar with the bottom 12 of the outer member 102. The inlet chamber 26 communicates with the manifold 116 via two slots 130 as shown in Figure 19. Alternatively, between one and four slots may be used to communicate between the manifold 116 and the inlet chamber 126.

A lower end of the outwardly extending shoulder 133 is provided with an outwardly extending flange 135 which extends perpendicularly to the major axis X. Typically the flange 135 has a width of between 2 and 4 mm. A portion of the flange 135 is enlarged to form a handle 124 by which the outer member 102 may be held. The handle 124 is provided with an upturned rim 125 to improve grip.

The outer member 102 is formed as a single integral piece from high density polyethylene, polypropylene, polystyrene, polyester, or a laminate of two or more of these materials. A suitable polypropylene is the range of polymers available from DSM UK Limited (Redditch, United Kingdom). The outer member may be opaque, transparent or translucent. The manufacturing process may be injection moulding.

The inner member 103, as shown in Figures 25 to 28, comprises an annular frame 141 and a downwardly extending

cylindrical funnel 140. A major axis X passes through the centre of the inner member 103 as shown in Figure 25.

As best shown in Figures 26 and 27, the annular frame 141 comprises an outer rim 151 and an inner hub 152 joined by ten equi-spaced radial spokes 153. The inner hub 152 is integral with and extends from the cylindrical funnel 140. Filtration apertures 155 are formed in the annular frame 141 between the radial spokes 153. A filter 104 is disposed on the annular frame 141 so as to cover the filtration apertures 155. The filter is preferably made from a material with a high wet strength, for example a non-woven fibre material of polyester. Other materials which may be used include a water-impermeable cellulosic material, such as a cellulosic material comprising woven paper fibres. The woven paper fibres may be admixed with fibres of polypropylene, polyvinyl chloride and/or polyethylene. The incorporation of these plastic materials into the cellulosic material renders the cellulosic material heat-sealable. The filter 104 may also be treated or coated with a material which is activated by heat and/or pressure so that it can be sealed to the annular frame 141 in this way.

As shown in the cross-sectional profile of Figure 25, the inner hub 152 is located at a lower position than the outer rim 151, resulting in the annular frame 141 having a sloping lower profile.

The upper surface of each spoke 153 is provided with an upstanding web 154 which divides a void space above the annular frame 141 into a plurality of passages 157. Each

passage 157 is bounded on either side by a web 154 and on a lower face by the filter 104. The passages 157 extend from the outer rim 151 downwardly towards, and open into, the cylindrical funnel 140 at openings 156 defined by the inner extremities of the webs 154.

The cylindrical funnel 140 comprises an outer tube 142 surrounding an inner discharge spout 143. The outer tube 142 forms the exterior of the cylindrical funnel 140. The discharge spout 143 is joined to the outer tube 142 at an upper end of the discharge spout 143 by means of an annular flange 147. The discharge spout 143 comprises an inlet 145 at an upper end which communicates with the openings 156 of the passages 157 and an outlet 144 at a lower end through which the prepared beverage is discharged into a cup or other receptacle. The profile of the discharge spout 43 comprises a stepped profile with a distinct dog-leg 166 near an upper end of the tube 143.

As shown in Figure 25, the discharge spout 143 is provided with a partition 165 which extends part way up the discharge spout 143 from the outlet 144. The partition 165 helps to prevent the beverage spraying and/or splashing as it exits the discharge spout 143.

A rim 167 is provided upstanding from the annular flange 147 joining the outer tube 142 to the discharge spout 143. The rim 167 surrounds the inlet 145 to the discharge spout 143 and defines an annular channel 169 between the rim 167 and the upper portion of the outer tube 142. The rim 167 is provided with an inwardly directed shoulder 168. At

one point around the circumference of the rim 167 an aperture 170 is provided in the form of a slot which extends from an upper edge of rim 167 to a point marginally below the level of the shoulder 168 as most clearly shown in Figures 25 and 25a. The slot has a width of 0.64 mm.

An air inlet 171 is provided in annular flange 147 circumferentially aligned with the aperture 170 as shown in Figures 28 and 28a. The air inlet 171 comprises an aperture passing through the flange 147 so as to provide communication between a point above the flange 147 and the void space below the flange 147 between the outer tube 142 and discharge spout 143. Preferably, and as shown, the air inlet 171 comprises an upper frusto-conical portion 173 and a lower cylindrical portion 172. The air inlet 171 is typically formed by a mould tool such as a pin. The tapered profile of the air inlet 171 allows the mould tool to be more easily removed from the moulded component. The wall of the outer tube 142 in the vicinity of the air inlet 171 is shaped to form a chute leading from the air inlet 171 to the inlet 145 of the discharge spout 143. As shown in Figure 28a, a canted shoulder 174 is formed between the air inlet 171 and the chute to ensure that the jet of beverage issuing from the slot 170 does not immediately foul on the upper surface of the flange 147 in the immediate vicinity of the air inlet 171.

The inner member 103 may be formed as a single integral piece from polypropylene or a similar material as described above and by injection moulding in the same manner as the outer member 102.