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(54) RELATING TO COOLING

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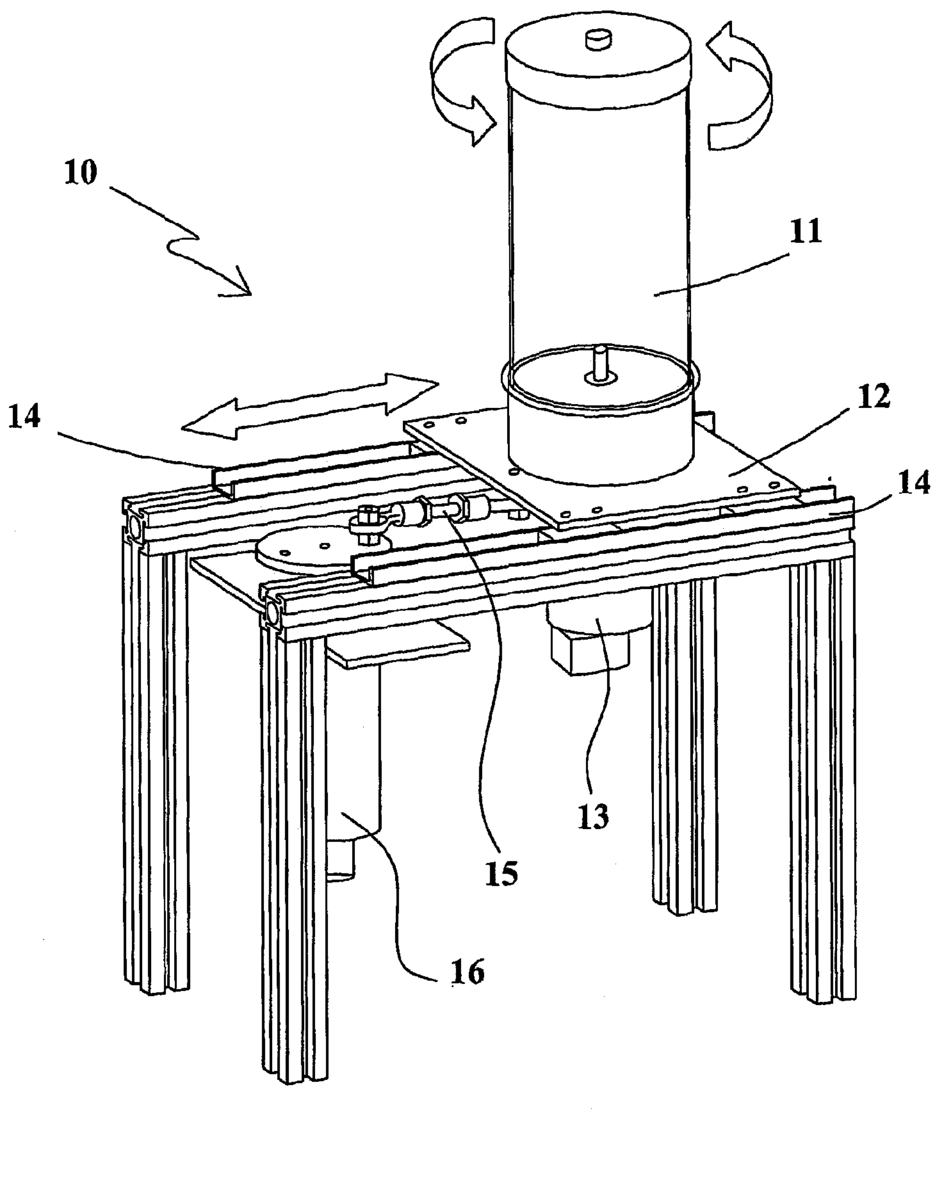
(57) **ABSTRACT**

A cooling apparatus includes a cavity for receipt of a product to be cooled. A rotation device rotates a product received in the cavity and a coolant supply provides a coolant to the cavity. The rotation device is adapted to rotate the product about two parallel non-coincident axes.



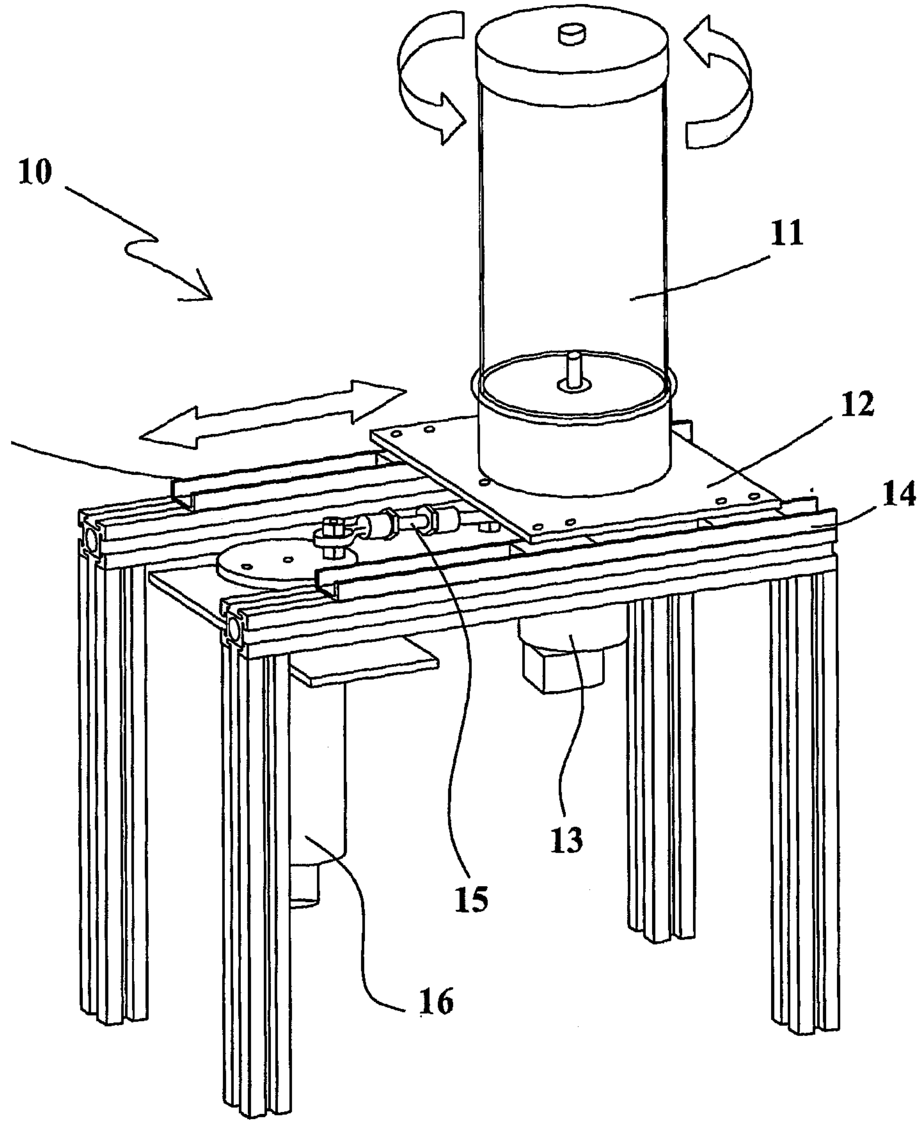
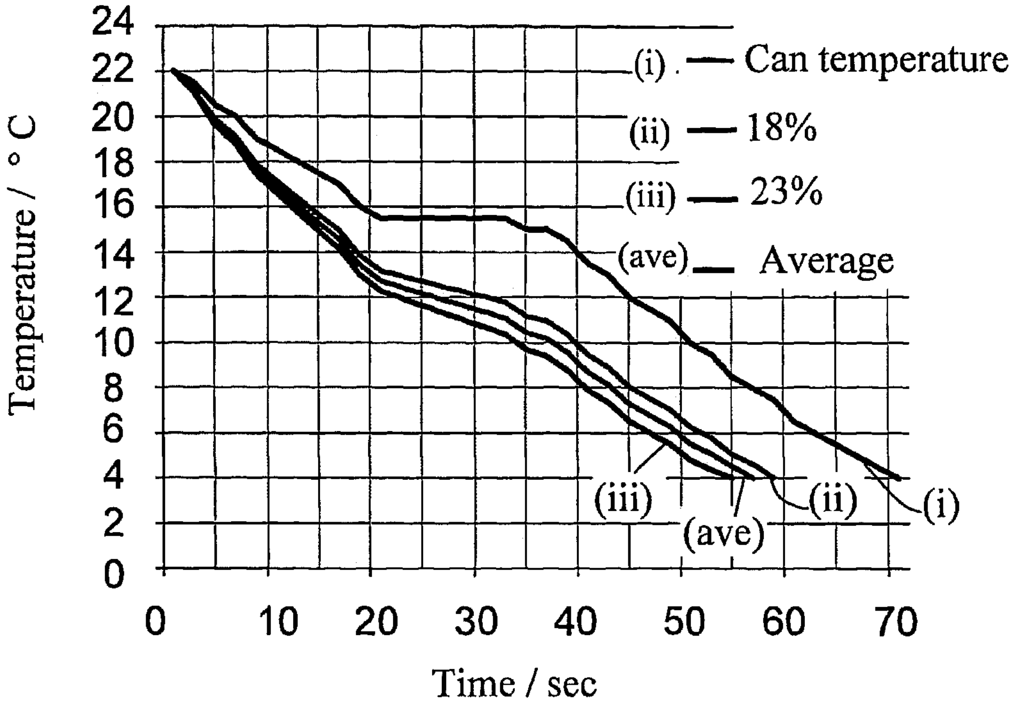


Fig. 1



Temperature / ° C
Time / sec
(i) Can temperature
(ii) 18%
(iii) 23%
(ave) Average
(iii)
(ave)
(ii)
(i)
24
22
20
18
16
14
12
10
8
6
4
2
0
0
10
20
30
40
50
60
70

Fig. 2

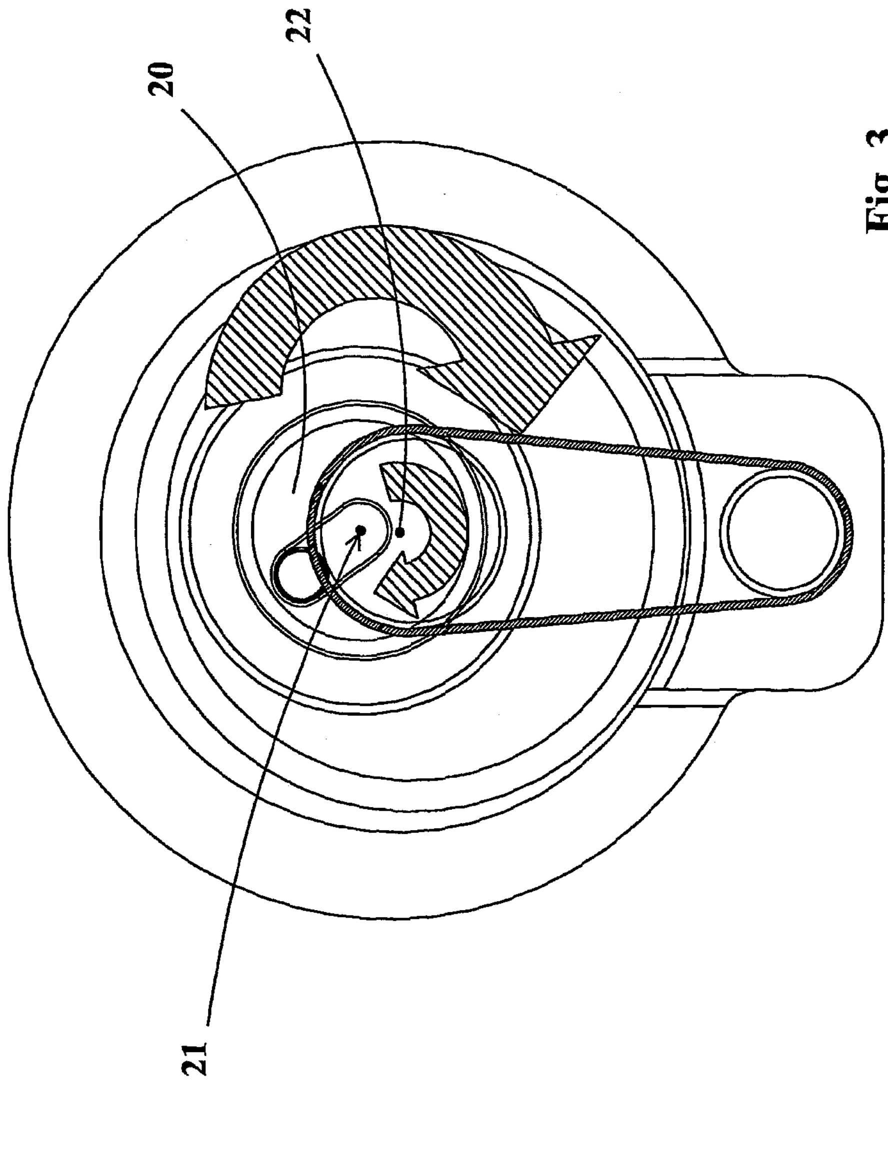


Fig. 3

RELATING TO COOLING

[0001] The present invention relates to improvements in or relating to cooling.

[0002] In catering, retail and entertainment sectors, various forms of vending devices are used in order to keep products chilled. For cold beverages these devices form two typical groups—commercial drinks refrigerators and cold beverage vending machines. Both types of device are essentially large glass-fronted refrigerators having hinged or sliding doors in the case of the first group (for manual dispensing) or a dispensing mechanism in the case of the second. They pre-cool and store drinks ready for purchase. In many cases, the drinks are maintained at low temperatures for long periods before they are eventually purchased. As a result, considerable energy is used potentially unnecessarily. Compounding the problem, both types of device operate inefficiently. In use, drinks refrigerators of the first group suffer substantial loss of cold air every time the large door is opened. Vending machines must provide easy passage to the vending tray where the item is collected by the user, resulting in poor sealing. Refrigeration systems generally have a requirement to be exercised through background running cycles to maintain efficiency, but this uses additional energy not directly contributing to chilling the contents.

[0003] It is also known for many beverage retailers to stock beverages in open-fronted refrigerated cabinets for ease of access and visibility of product. These cabinets obviously suffer even greater energy wastage.

[0004] The net result is high levels of wasted electrical energy used keeping drinks in a long-term cold state in readiness for purchasing, regardless of whenever that might occur.

[0005] Energy wastage is not confined to corporate sites hosting vending machines. Many small corner shops, petrol stations and café outlets host drinks chilling cabinets. For these operators, electrical energy costs will represent a high proportion of their operational overhead. Energy wastage is not the only issue. Since refrigeration systems generate heat, often the wasted heat energy by-product from the refrigeration system causes unwanted warming of the localised area around the machines. This creates an inconsistency in which users must drink their satisfactorily chilled drinks in unsatisfactorily warm areas.

[0006] Speed of cooling is also an issue, particularly in establishments having a high turnover of beverages, such as at special events—concerts, sporting eventings and so on. Often at the state of the event drinks are adequately cooled by having been in refrigerators for several hours. However, once the even it under way, the volume of drinks being sold exceeds the capacity of the refrigerators to chill further drinks. Drinks must then be sold only partially chilled or not chilled at all.

[0007] The present invention seeks to address these problems by providing an apparatus that allows cooling of beverages on demand. The apparatus can be a stand-alone device or may be incorporated into a vending machine.

[0008] Our earlier application, WO2011/012902, describes a cooling apparatus comprising a cavity for receipt of a product to be cooled. The apparatus comprises rotation means to rotate a product received in the cavity and cooling fluid supply means to provide a cooling fluid to the cavity. The reader is referred to that publication for further background. The rotation means is adapted to provide a pulsed or non-continuous rotation for a predetermined period.

[0009] We have developed an apparatus comprising a cavity for receipt of a can or other container for a beverage to be cooled. The cavity includes a motor-driven turntable to allow the can to be rotated at speed and also includes means to hold the can in position on the turntable whilst permitting rotation. The apparatus also includes supply means for a cooling liquid. The cavity itself may be rotated or the container can be rotated within the cavity.

[0010] A sealed can cooling rig was manufactured to use a salt water solution which is chilled down to approximately −16° C., in a cooling tank with a rotating agitator to reduce salt solidification. A diaphragm pump was used to fill the cooling vessel, at a rate of up to 5 litres/min. The cooling vessel has been designed to accept a standard can, which may be rotated up to 12 Hz/720 rpm. The flow rate of the pump and rotational speed of the can are controllable. The real-time cooling rates of the drink were recorded.

[0011] We have determined that, during rotation of a can, a forced vortex develops, the depth of which inside the can is dependent upon the speed of rotation. Forced convection takes place and creates artificially-induced convection currents inside the can. When the rotation is then stopped, a free or collapsing vortex forms and natural convection takes place, promoting mixing of the contents of the can but without incorporation of air bubbles which might lead to nucleation and excessive effervescing.

[0012] However, in a static can without this collapsing vortex, cooler beverages being denser, sinks to the base of the can. Mixing of the can contents is very poor leading to poor thermal uniformity, and also leading, in many cases, to ice formation or "slushing". In our previous work, we determined that intermittent or pulsed rotation overcame this problem. However, that introduces delays in cooling as the beverage container is slowed and brought back up to speed.

[0013] The present invention seeks to provide further enhanced cooling rates.

[0014] In its broadest sense, the present invention provides a cooling apparatus to cool a product characterised in that the apparatus is adapted to apply a motion to the product about at least two axes of freedom.

[0015] Accordingly, the present invention provides a cooling apparatus comprising a cavity for receipt of a product to be cooled. The apparatus comprises rotation means to rotate a product received in the cavity and a coolant supply means to provide a coolant in the cavity. The apparatus further comprises means to apply a supplementary motion to the cavity.

[0016] In one embodiment, the supplementary motion is a linear motion. Preferably, the linear motion is a reciprocating motion.

[0017] Preferably, the reciprocating motion is at a rate of at least 50 oscillations per minute, more preferably at least 80 oscillations per minute, even more preferably at least 100 oscillations per minute. Advantageously, the reciprocating motion is at a rate of about 120 oscillations per minute.

[0018] In an alternative embodiment, the rotation means is adapted to rotate the product about two parallel non-coincident axes. Preferably, one of the axes is an axis of the product.

[0019] Preferably, the rotation means is adapted to rotate the product at a rotational speed of 90 revolutions per minute or more, more preferably at least about 180 revolutions per minute, even more preferably at least about 360 revolutions per minute.

[0020] Optionally, the rotation means is adapted to rotate a product within the cavity. Alternatively, the rotation means is adapted to rotate the cavity.

[0021] Preferably, the coolant is a cooling fluid and the cooling fluid supply means is adapted to provide a flow of cooling fluid to the cavity.

[0022] Preferably, the cooling fluid is supplied to the cavity at a temperature of −10° C. or less, more preferably −14° C. or less, even more preferably −16° C. or less.

[0023] In certain embodiments, the apparatus comprises a plurality of cavities as defined above.

[0024] In typical embodiments, the apparatus is incorporated in a vending apparatus and the vending apparatus further comprises insertion and removal means for inserting the product to be cooled into the cavity and removing the cooled product therefrom.

[0025] Preferably, the vending apparatus further comprises storage means for storing a product or range of products and selection means for selecting a product from the storage means for insertion into the cavity.

[0026] The above and other aspects of the present invention will now be described in further detail, by way of example only, with reference to the accompanying drawings, in which

[0027] FIG. **1** is a perspective view of a first embodiment of an apparatus in accordance with the present invention;

[0028] FIG. **2** is a graph showing cooling rates obtained in several trials of the apparatus of FIG. **1**; and

[0029] FIG. **3** is a schematic plan view of a second embodiment of an apparatus in accordance with the present invention.

[0030] In its crudest form, the cooling liquid is simply poured into the cavity and then removed at the end of the cooling process. In preferred embodiments, a flow of cooling liquid through the apparatus is provided.

[0031] FIG. **1** shows the rig **10** comprising a cavity **11** for receipt of the beverage container mounted on a table **12**. Cavity **11** is rotatable by means of an electric motor **13** mounted underneath the table **12**. Table **12** is reciprocatable by means being slidably mounted on a pair of parallel tracks **14** and caused to reciprocate by means of a cam arrangement comprising an eccentrically mounted link rod **15** driven by a further motor **16**. Link rod **15** is adjustable to provide a variable stroke range of 5 to 25 mm. Alternative arrangements will be apparent to the skilled person, including gearing arrangements to allow the use of a single motor. Accordingly, the apparatus can apply a motion to a beverage container placed in cavity **11** about two degrees of freedom—a rotational motion about the rotational axis of cavity **11** and a linear motion about the direction of reciprocal movement of table **12**.

[0032] The cooling rates achieved for a 330 ml aluminium can at room temperature are shown in FIG. **2**. The rotational speed in all three cases was 350 revolutions per minute. The reciprocal movement was at a rate of 120 oscillations per minute with a single stroke length of 18.5 mm (equivalent to a motion of 74 mm/s) The coolant temperature was—14.5° C. flowing through cavity **11** at a rate of 4.25 l/min. The effective volume of the cavity was 650 ml, equating to a jacket of cooling fluid of about 20 mm around a standard diameter can.

[0033] As a control, the cooling rate achievable by the apparatus of WO2011/012902 (interrupted rotation only with no linear motion) is shown as line (i), showing cooling from an exemplary room temperature of 22° C. to 4° C. in a little over 70 seconds. In comparison, the rig of FIG. **1** achieved cooling to 4° C. within 54 seconds (line iii) and 58 seconds (line ii), an improvement of 18-23%.

[0034] It is suggested that the apparatus leads (at least in an idealised set-up) to the development of a Rankine vortex within the beverage container. Visual observation in a transparent cavity **11** and transparent beverage container confirms this to be the case.

[0035] Other techniques for generating a Rankine vortex or a Rankine-like vortex are possible, including epicyclic rotation, single plane agitation and multi-pane agitation; by introduction of asymmetry into the container, for example by a localised indentation, off-axis rotation or rotation of the container perpendicular to its axis; introduction of a shockwave to the container during rotation; or introduction of a centrapetal force, for example.

[0036] In essence, a vortex such as a Rankine-like vortex results in a tangential velocity that is not equal to the angular velocity multiplied by the radius across the entire radius. As a result beverage does not behave as a sold mass—shear is present and hence mixing occurs.

[0037] In typical embodiments, the apparatus is incorporated in a vending apparatus and further comprises insertion and removal means for inserting the product to be cooled into the cavity and removing the cooled product therefrom.

[0038] Preferably, the vending apparatus further comprises storage means for storing a product or range of products and selection means for selecting a product from the storage means for insertion into the cavity.

[0039] The vending apparatus will typically also include payment collection apparatus such as a coin-operated mechanism or a card-reading apparatus for deducting a charge from a card.

[0040] The beverage container of FIG. **3** shows one such arrangement in which the container is rotated in an epicylic manner. That is to say, the apparatus includes primary rotation means to rotate the container, such as a can **20**, about its own axis **21** and secondary rotation means to rotate the can axis about a non-coincident parallel secondary axis **22**. Such a rotational arrangement provides greater agitation of the beverage itself, thereby reducing temperature gradients with the container.

[0041] Convective heat transfer is largely governed by the fluid flow regime within the boundary layer. Increasing the velocity gradient within the boundary layer will increase convective heat transfer. Whilst the Reynolds number is a key parameter governing whether the boundary layer is laminar or turbulent, it may transition due to surface texture or roughness and the local pressure gradient. The more complex motion of the container and coolant provided by this arrangement gives more degrees of freedom to control the thickness and velocity gradient within the boundary layer. This enables the apparatus to maximise convective heat transfer whilst eliminating slushing or ice formation that has hampered past attempts to achieve rapid cooling.

[0042] The present invention also seeks to provide a vending machine incorporating the apparatus described above. In a conventional vending machine, the entire storage cavity must be insulated, but insulation for a cavity storing perhaps 400 cans can typically only be achieved using insulating foam or mats or other materials which trap air in order to prevent heat transmission. These materials are relatively inefficient thermal insulators.

[0043] In addition to providing a vending machine which chills beverages exclusively on demand, the present invention provides a vending machine in which most cans or other beverage containers are storable at ambient temperature and only a small number, perhaps 16 or so, are storable at a reduced or drinking temperature.

[0044] As a result, the cavity in which the reduced temperature containers are stored can be insulated by more effective means, such as vacuum insulation panels. The cooling apparatus is provided between the ambient storage cavity and the chilled storage cavity.

[0045] The use of two storage zones significantly reduces the overall energy consumption and will also reduce the power rating required for the rapid cooling apparatus.

[0046] Additional low level chilling to the chilled storage cavity can be provided to maintain the correct temperature, but the energy consumption to maintain the temperature in a small vacuum-insulated capacity cavity is substantially lower than in conventional machines.

1. A cooling apparatus comprising a cavity for receipt of a product to be cooled;

rotation means to rotate a product received in the cavity and coolant supply means to provide a coolant to the cavity; wherein the apparatus further comprises means to apply a supplementary motion to the cavity.

2. An apparatus as claimed in claim **1** wherein supplementary motion is a linear motion.

3. An apparatus as claimed in claim **2** wherein the linear motion is a reciprocating motion.

4. An apparatus as claimed in claim **3** wherein the reciprocating motion is at a rate of at least 50 oscillations per minute; more preferably at least 80 oscillations per minute; even more preferably at least 100 oscillations per minute.

5. An apparatus as claimed in claim **4** wherein the reciprocating motion is at a rate of about 120 oscillations per minute.

6. A cooling apparatus as claimed in claim **1** wherein the rotation means is adapted to rotate the product about two parallel non-coincident axes.

7. A cooling apparatus as claimed in claim **6** wherein one of the axes is an axis of the product.

8. A cooling apparatus as claimed in any preceding claim wherein the rotation means is adapted to rotate the product at a rotational speed of 90 revolutions per minute or more, more preferably at least about 180 revolutions per minute, even more preferably at least about 360 revolutions per minute.

9. A cooling apparatus as claimed in any preceding claim wherein the coolant is a cooling fluid and the cooling fluid supply means is adapted to provide a flow of cooling fluid to the cavity.

10. A cooling apparatus as claimed in any preceding claim wherein the cooling fluid is supplied to the cavity at a temperature of −10° C. or less, more preferably −14° C. or less, even more preferably −16° C. or less.

11. A cooling apparatus as claimed in any preceding claim wherein the rotation means is adapted to provide a pulsed or non-continuous rotation for a predetermined period.

12. A vending apparatus comprising a cooling apparatus as claimed in any one of the claims **1** to **11** and further comprising insertion and removal means for inserting the product to be cooled into the cavity and removing the cooled product therefrom.

13. A vending apparatus as claimed in claim **12** further comprising storage means for storing a product or range of products and selection means for selecting a product from the storage means for insertion into the cavity.

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