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(54) IMPINGEMENT APPARATUS FOR FREEZER

(57) In order to overcome the limitations and problems that earlier apparatus have experienced, an impingement apparatus (10) for a freezer is proposed, said apparatus (10) comprising:
- an impingement plate (16) having a first plurality of holes (14) therethrough; and
- at least one movable plate (12) having a second plurality of holes (18) therethrough, the at least one movable plate (12) positioned proximate to a surface of the impingement plate (16) and movable to align select ones of the second plurality of holes (18) in registration with select ones of the first plurality of holes (14) for providing a plurality of gas (20) flow passageways within the freezer.

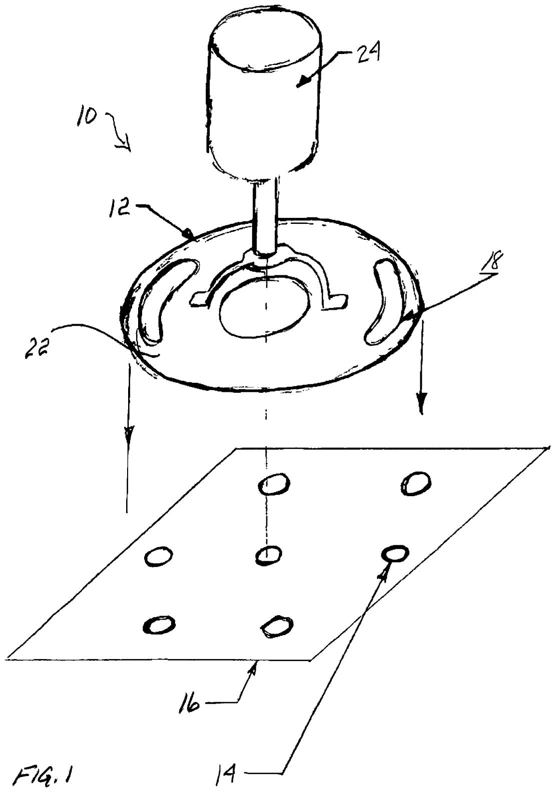

FIG. 1

Description

Technical field of the present invention

[0001] The present invention relates to impingement apparatus and processes for chilling and freezing at least one product, in particular at least one food product.

Technological background of the present invention

[0002] Known impingement freezing technologies use impingement plates, with holes drilled to sizes ranging from approximately 3/8 inch (approximately 0.95 cm) diameter to approximately 5/8 inch (approximately 1.59 cm) diameter suspended inside a pressurized space or enclosure to create jets or columns of gas or air which impact the product surface to be chilled or frozen and provide high heat transfer rates at the surface of the product.

[0003] The known apparatus use a constant flow of gas or air through each impingement hole to continuously impact the product surface as it passes in proximity to the impingement hole. The U-factor that has been achieved with the known impingement plates is approximately 18 Btu/(hr*ft^2*°F) (approximately 102.21 W/(m^2*K)) for an impingement pressure of approximately three inches (approximately 7.62 cm) water column in the pressurized space above the plates.

[0004] Utilizing higher pressures in the impingement hoods can increase heat transfer rates. However, there is a practical limit to the pressure that can be attained, due to required material thickness to achieve the strength needed, and the power required to deliver the desired pressure and flow rate of the impingement gas.

[0005] The maximum impingement heat transfer may be obtained upon initial gas impact with the product surface, but such heat transfer is reduced after a short duration to a lower heat transfer rate due to a resistance of gas flow along the product surface and impact of adjacent gas jet columns with each other.

[0006] Known impingement heat transfer process relies upon a constant flow of impingement gas through the impingement holes and therefore, the heat transfer achieved at the product surface is less than the maximum possible heat transfer which would otherwise be obtained.

Disclosure of the present invention: object, solution, advantages

[0007] Starting from the disadvantages and shortcomings as described above as well as taking the prior art as discussed into account, an object of the present invention is to overcome the limitations and problems that earlier apparatus have experienced.

[0008] This object is accomplished by an apparatus comprising the features of claim 1 as well as by an apparatus comprising the features of claim 10 as well as by an apparatus comprising the features of claim 11. Advantageous embodiments, expedient improvements and other optional features of the present invention are set forth herein and disclosed in the respective dependent claims.

[0009] There is basically provided a pulse impingement variable timing apparatus and methods, and more specifically there is provided herein an impingement apparatus for a freezer, comprising an impingement plate having a first plurality of holes therethrough and at least one movable plate having a second plurality of holes therethrough, the at least one movable plate positioned proximate to a surface of the impingement plate and movable to align select ones of the second plurality of holes in registration with select ones of the first plurality of holes for providing a plurality of gas flow passageways within the freezer.

[0010] Another embodiment of the present apparatus may include each one of the first plurality of holes having a first diameter, and each one of the second plurality of holes having a second diameter great than the first diameter.

[0011] Another embodiment of the present apparatus may include each one of the first plurality of holes comprising a circular shape, and each one of the second plurality of holes comprising a slot-like shape.

[0012] Another embodiment of the present apparatus may include the slot-like shape being longer than the circular shape.

[0013] Another embodiment of the present apparatus may include the at least one movable plate comprising a disc mounted for rotation in close proximity to the surface of the impingement plate.

[0014] Another embodiment of the present apparatus may include the at least one movable plate comprising at least one elongated planar member slidable into and out of position with respect to the impingement plate.

[0015] Another embodiment of the present apparatus may include the at least one movable plate comprising a plurality of elongated planar members slidable into and out of position with respect to the impingement plate.

[0016] Another embodiment of the present apparatus further may include a valve, in particular a solenoid valve, for moving the at least one elongated planar member in a first direction to cover at least a portion of the first plurality of holes; and a biasing member, in particular a spring, for moving the at least one elongated planar member in a second direction opposite to the first direction to align the first and second plurality of holes into registration for providing the gas flow passageways.

[0017] There is provided herein another impingement apparatus for a freezer, comprising an impingement plate having a plurality of holes therethrough and a valve assembly comprising a movable valve in registration with select ones of the plurality of holes for being pressurized to close a corresponding one of the holes; a biasing member, in particular a spring, mounted for coaction with the movable valve to bias the valve out of the corresponding one of the holes for providing gas passageways through the select ones of the plurality of holes; and a pressurized gas for providing a gas pulse to the valve assembly to close the valve at the select ones of the holes and the gas passageways.

[0018] There is provided herein still another impingement apparatus for a freezer, comprising an impingement plate having a plurality of holes therethrough; a piston assembly comprising a movable piston for select ones of the plurality of holes, each of the movable piston for being pressurized to close a corresponding one of the plurality of holes; a biasing member, in particular a spring, mounted for coaction with the movable piston to bias the piston out of the corresponding one of the plurality of holes for providing a gas passageway through each of the select ones of the plurality of holes; and a pressurized gas for providing a gas pulse to the piston assembly to close the piston and the gas passageways at the select ones of the impingement holes.

[0019] Another embodiment of the present apparatus may include pistons of the piston assembly moving concurrently with other of the pistons.

[0020] Another embodiment of the present apparatus may include pistons of the piston assembly moving at different time intervals from other of the pistons.

[0021] Another embodiment of the present apparatus may include each piston comprising an individual control valve for being energized separately or individually.

Brief description of the drawings

[0022] For a more complete understanding of the present embodiment disclosures and as already discussed above, there are several options to embody as well as to improve the teaching of the present invention in an advantageous manner. To this aim, reference may be made to the claims dependent on claim 1 as well as on claim 11; further improvements, features and advantages of the present invention are explained below in more detail with reference to the particular and preferred embodiments by way of non-limiting example and to the appended drawing figures taken in conjunction with the following description of exemplary embodiments, of which:

FIG. 1 shows a perspective view of a first illustrative embodiment of a pulse impingement variable timing apparatus according to the present invention, said embodiment working according to the method of the present invention;

FIG. 2 shows a top view of the first illustrative embodiment apparatus of FIG. 1;

FIG. 3 shows a cross-sectional side view of the first illustrative embodiment apparatus of FIG. 1 and FIG. 2;

FIG. 4 shows a schematic view of a second illustrative embodiment (with sliding plates attached to solenoid coils) of a pulse impingement variable timing apparatus according to the present invention, said embodiment working according to the method of the present invention;

FIG. 5A shows a schematic view of a third illustrative embodiment of a pulse impingement variable timing apparatus according to the present invention, said embodiment working according to the method of the present invention; and

FIG. 5B shows a schematic view of a fourth illustrative embodiment (with pulsed impingement hood with actuated valves) of a pulse impingement variable timing apparatus according to the present invention, said embodiment working according to the method of the present invention.

[0023] The accompanying drawings are included to provide a further understanding of the apparatus and method(s) provided herein and are incorporated in and constitute a part of this specification. The drawings illustrate various embodiments of the apparatus and method(s) provided herein and, together with the description, serve to explain the principles described herein but are not intended to limit the specification or any of the claims. In the accompanying drawings, like equipment is labelled with the same reference numerals throughout the description of FIG. 1 to FIG. 5B.

Detailed description of the drawings; best way of embodying the present invention

[0024] Before explaining the present inventive embodiments in detail, it is to be understood that the embodiments are not limited in its respective application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the present invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

[0025] In the following description, terms such a horizontal, upright, vertical, above, below, beneath and the like, are used solely for the purpose of clarity illustrating the present invention and should not be taken as words of limitation. The drawings are for the purpose of illustrating the present invention and are not intended to be to scale.

[0026] The present apparatus and method embodiments shown in FIG. 1 to FIG. 5B pulse an impingement gas flow through impingement holes at a frequency that maximizes heat transfer at the product surface by periodically impacting the product surface with gas flow, and then eliminating gas flow for a select or prearranged period of time to stop an increasing resistance to the flow. With the present embodiments, maximum heat transfer can be continuously maintained at the product surface.

[0027] In addition, by controlling pulses of gas flow so that adjacent holes will not flow gas (or gas columns) at the same time, the negating effect of flow from adjacent holes impacting each other is eliminated.

[0028] This present apparatus embodiments 10 of FIG. 1 to FIG. 3 include a rotating disc 12 or plate that is placed overtop of holes 14 in an existing impingement plate 16; discharging slots 18 being cut into the rotating disc 12 that are slightly wider than the diameter of the existing holes 14 in the impingement plate 16 and aligned with the impingement holes 18 as the disc 12 rotates, so that gas 20 flows through the slot 18 area and then through the impingement hole 14, but will prevent flow when the solid material 22 of the disc 12 covers and is in registration with the impingement holes 14.

[0029] This embodiment has slots 18 that vary the period of flow of the gas 20 versus non-flow of the gas 20, depending on the length of the slot 18 versus the solid material 22 length of the disc 12, and the speed of movement of the rotating disc 12.

[0030] This embodiment has a motor 24 to drive the disc 12 at variable revolutions per minute to control pulse duration, thereby varying rotation from a maximum of 1800 rounds per minute (rpm) to a minimum of 30 rpm.

[0031] The slots 18 of this embodiment are positioned so that adjacent holes 14 do not permit flow of the gas 20 at the same time, thereby eliminating interference of flow between adjacent holes 14, and maximizing heat transfer to the product.

[0032] This embodiment allows impingement holes 14 to be spaced for maximum heat transfer coverage of for example food product, while allowing flow through only half of the holes 14 at any one time, thereby increasing heat transfer due to higher hood pressure at only slightly increased power rate for the blowers.

[0033] In this embodiment according to FIG. 1 to FIG. 3, the movable plate 12 may comprise at least one elongated planar member, in particular a plurality of elongated planar members, slidable into and out of position with respect to the impingement plate 16.

[0034] Solenoid valves may be provided for moving each elongated planar member in a first direction to cover at least a portion of the first plurality of holes 14, and a biasing member, in particular a spring, may be provided for moving each elongated planar member in a second direction opposite to the first direction to align the first plurality of holes 14 and the second plurality of holes 18 into registration for providing the gas flow passageways.

[0035] Another apparatus embodiment 110 shown at FIG. 4 includes sliding plates 112 which coact with the impingement plate 114 to open and close the impingement holes 116 to allow pulsing of gas flow therethrough. The sliding plates 112 can be actuated by a solenoid valve 118 to close the holes 116, with a spring 120 that would bias the plate 112 back to its original position and align holes 122 in the plates 112 to be in registration with the impingement holes 116 to open the holes 116 again to gas flow.

[0036] Further apparatus embodiments 210, 310 are shown at FIG. 5A and at FIG. 5B, respectively:

In the embodiment 210 according to FIG. 5A, an individual piston 212 for each impingement hole 214 or port uses a high pressure gas pulse or burst to close the hole 214, with the piston 212, and a spring 216 to bias the piston 212 in a reverse direction to open the hole 214 again to allow gas flow through the hole 214. The burst delay 222 to the pistons 212 is approximately 90 psig (approximately 620.53 kPa).

[0037] This embodiment with the piston 212 also acts to keep the impingement hole 214 free of ice, and an additional benefit of knocking ice free from the entire impingement plate 218 due to the impact of the pistons 212 on the impingement plate 218.

[0038] In the embodiment 210 according to FIG. 5A, all pistons 212 open and close at the same time, so all impingement ports 214 produce columns of high velocity gas flow at the same time. An impingement hood 220 contains the impingement plate 218 and the pistons 212. The impingement pressure is approximately four inches (approximately 10.16 cm) water column.

[0039] In the embodiment 310 according to FIG. 5B, each individual piston 312 can be energized separately or individually, because each piston 312 has its own control valve 322 (provided with gas 324 with approximately 90 psig (approximately 620.53 kPa)). This allows to open and close adjacent impingement holes 314 separately with the pistons 312 at select, different time intervals in order to control the interaction of adjacent impingement holes 314.

[0040] An impingement hood 320 contains the impingement plate 318 and the pistons 312. The springs 316 are constructed and function similar to the springs 216. The impingement pressure 326 is approximately six inches (approximately 15.24 cm) water column to approximately ten inches (approximately 25.4 cm) water column.

[0041] In the embodiment of FIG. 5A, opening and closing all holes at the same time will cause adjacent holes to produce jets at the same time. This produces columns of high velocity gas that will impact the food product at the same time, and then the gas will radiate outward. As the gas flow does so, the adjacent gas streams will impact each other and create a certain amount of turbulence at the product surface in between each column of gas.

[0042] In the embodiment of FIG. 5B, a user can select when to open and close adjacent holes and columns of gas and therefore, the user can control the interaction of adjacent gas streams. This is beneficial to allow each gas column to spread radially somewhat before the gas impacts with another radiating column of gas.

[0043] The present embodiments provide combinations of open time and closed time for each impingement hole and adjacent impingement holes in order to create the optimal combination that produces the maximum heat transfer by eliminating resistance at the product surface.

[0044] The foregoing apparatus embodiments 10, 110, 210, 310 of FIG. 1 to FIG. 5B:

- increase impingement heat transfer rates by creating and using pulsed impingement gas flows;
- reduce freezing times in view of the increased heat transfer rate achieved;
- create smaller ice crystals in the food product, thereby resulting in less product damage during the freezing process;
- reduce product dehydration due to the faster freezing process resulting in higher overall production yield of the product;
- provide a variable impingement duration, thereby resulting in an optimal pulse duration for each product and its particular surface; and
- reduce the number of holes that flow gas therethrough at any given time, resulting in reducing total flow requirement, but still using only slightly more power due to higher pressure requirement.

[0045] It will be understood that the embodiments described herein are merely exemplary, and that one skilled in the art may make variations and modifications without departing from the spirit and scope of the present invention. All such variations and modifications are intended to be included within the scope of the present invention as described and claimed herein. Further, all embodiments disclosed are not necessarily in the alternative, as various embodiments of the present invention may be combined to provide the desired result.

List of reference signs

[0046]

10	impingement apparatus (first embodiment; cf. FIG. 1 to FIG. 3)
12	movable disc, in particular rotating disc, or movable plate, in particular rotating plate
14	hole, in particular impingement hole, or port, in particular impingement port
16	impingement plate or stationary plate
18	discharging slot or gas pulse slot, in particular rotating gas pulse slot
20	gas
22	solid material of movable disc or movable plate 12
24	motor, in particular drive motor, for example variable speed drive motor
26	drive motor, in particular blower drive motor, for example impingement blower drive motor
28	blower wheel
30	impingement hood
110	impingement apparatus (second embodiment; cf. FIG. 4)
112	sliding plate
114	impingement plate
116	hole, in particular impingement hole, or port, in particular impingement port
118	valve, in particular movable valve, for example solenoid valve
120	biasing member, in particular spring
122	hole in sliding plate 112
210	impingement apparatus (third embodiment; cf. FIG. 5A)
212	piston, in particular movable piston
214	hole, in particular impingement hole, or port, in particular impingement port
216	biasing member, in particular spring
218	impingement plate
220	impingement hood
222	burst delay to piston 212
310	impingement apparatus (fourth embodiment; cf. FIG. 5B)
312	piston, in particular movable piston
314	hole, in particular impingement hole, or port, in particular impingement port
316	biasing member, in particular spring
318	impingement plate
320	impingement hood
322	control valve
324	gas, in particular pressurized gas
326	impingement pressure

Claims

1. An impingement apparatus (10) for a freezer, comprising:

- an impingement plate (16) having a first plurality of holes (14) therethrough; and
- at least one movable plate (12) having a second plurality of holes (18) therethrough, the at least one movable plate (12) positioned proximate to a surface of the impingement plate (16) and movable to align select ones of the second plurality of holes (18) in registration with select ones of the first plurality of holes (14) for providing a plurality of gas (20) flow passageways within the freezer.

2. The apparatus according to claim 1, wherein each one of the first plurality of holes (14) have a first diameter, and each one of the second plurality of holes (18) have a second diameter greater than the first diameter.

3. The apparatus according to claim 1 or 2, wherein each one of the first plurality of holes (14) comprise a circular shape, and each one of the second plurality of holes (18) comprise a slot-like shape.

4. The apparatus according to claim 3, wherein the slot-like shape is longer than the circular shape.

5. The apparatus according to at least one of claims 1 to 4, wherein the at least one movable plate (12) comprises a disc mounted for rotation in close proximity to the surface of the impingement plate (16).

6. The apparatus according to at least one of claims 1 to 5, wherein the at least one movable plate (12) comprises at least one elongated planar member slidable into and out of position with respect to the impingement plate (16).

7. The apparatus according to claim 6, wherein the at least one movable plate (12) comprises a plurality of elongated planar members slidable into and out of position with respect to the impingement plate (16).

8. The apparatus according to claim 6 or 7, further comprising:

- at least one valve for moving the at least one elongated planar member in a first direction to cover at least a portion of the first plurality of holes (14); and
- at least one biasing member for moving the at least one elongated planar member in a second direction opposite to the first direction to align the first plurality of holes (14) and the second plurality of holes (18) into registration for providing the gas (20) flow passageways.

9. The apparatus according to claim 8, wherein the at least one valve is at least one solenoid valve.

10. An impingement apparatus (110) for a freezer, comprising:

- an impingement plate (114) having a plurality of holes (116) therethrough;
- a valve assembly comprising at least one movable valve (118) in registration with select ones of the plurality of holes (116) for being pressurized to close a corresponding one of the holes (116);
- at least one biasing member (120) mounted for coaction with the at least one movable valve (118) to bias the at least one movable valve (118) out of the corresponding one of the holes (116) for providing gas passageways through the select ones of the plurality of holes (116); and
- a pressurized gas for providing a gas pulse to the valve assembly to close the at least one movable valve (118) at the select one of the holes (116) and the gas passageways.

11. An impingement apparatus (210; 310) for a freezer, comprising:

- an impingement plate (218; 318) having a plurality of holes (214; 314) therethrough;
- a piston assembly comprising at least one movable piston (212; 312) for select ones of the plurality of holes (214; 314), each of the movable pistons (212; 312) for being pressurized to close a corresponding one of the holes (214; 314);
- at least one biasing member (216; 316) mounted for coaction with the at least one movable piston (212; 312) to bias the at least one movable piston (212; 312) out of the corresponding one of the plurality of holes (214; 314) for providing a gas passageway through each of the select ones of the plurality of holes (214; 314); and
- a pressurized gas (324) for providing a gas pulse to the piston assembly to close the at least one movable piston (212; 312) and the gas passageways at the select ones of the impingement holes (214; 314).

12. The apparatus according to claim 11, wherein pistons (212) of the piston assembly move

- concurrently with other pistons (212) of the piston assembly, or
- at different time intervals from other pistons (312) of the piston assembly.

13. The apparatus according to claim 11 or 12, wherein each piston (312) comprises an individual control valve (322) for being energized separately or individually

14. The apparatus according to at least one of claims 8 to 13, wherein the at least one biasing member (120; 216; 316) is at least one spring.

15. The apparatus according to at least one of claims 1 to 14, provided for chilling and/or freezing at least one product, in particular at least one food product.

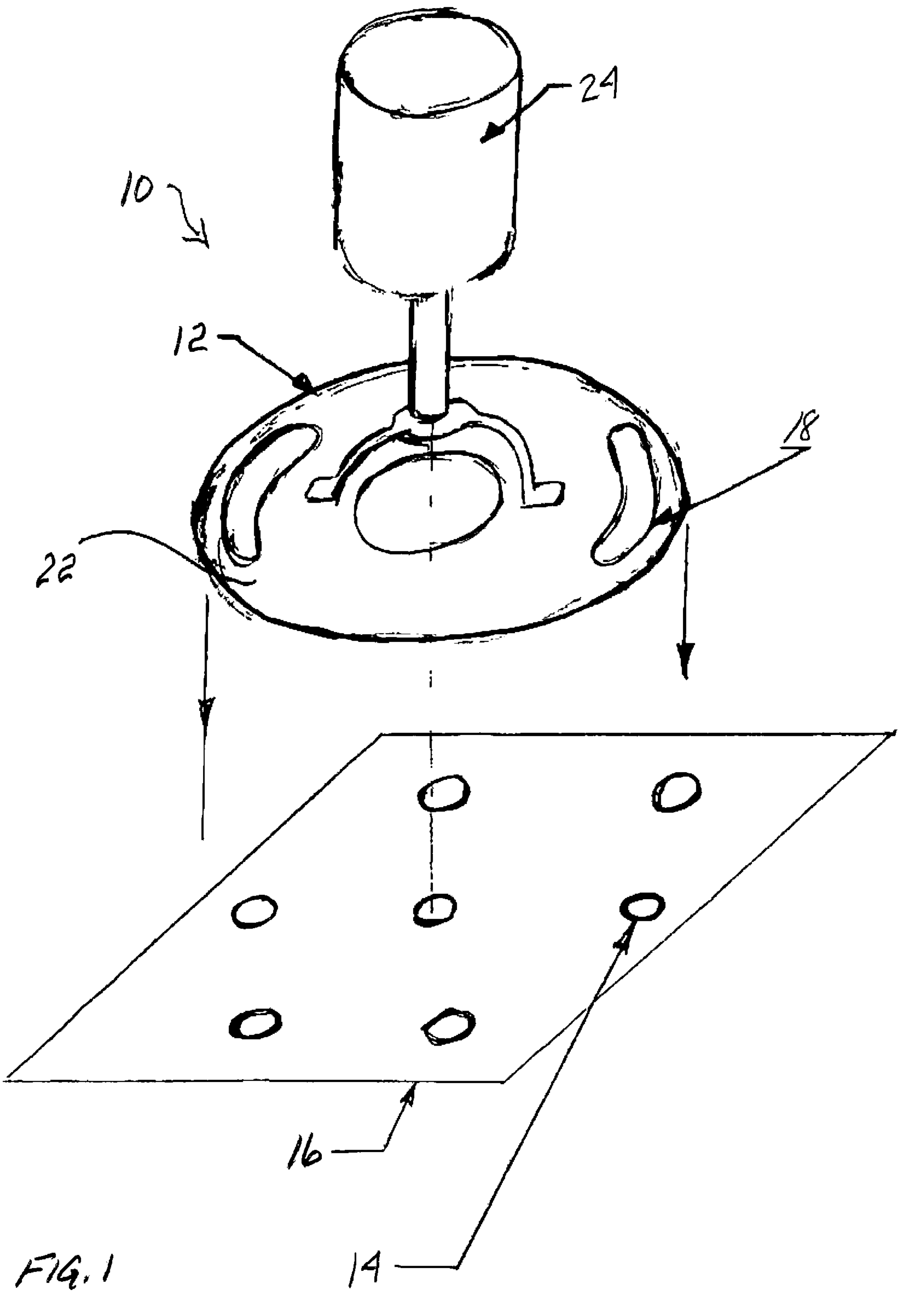

FIG. 1

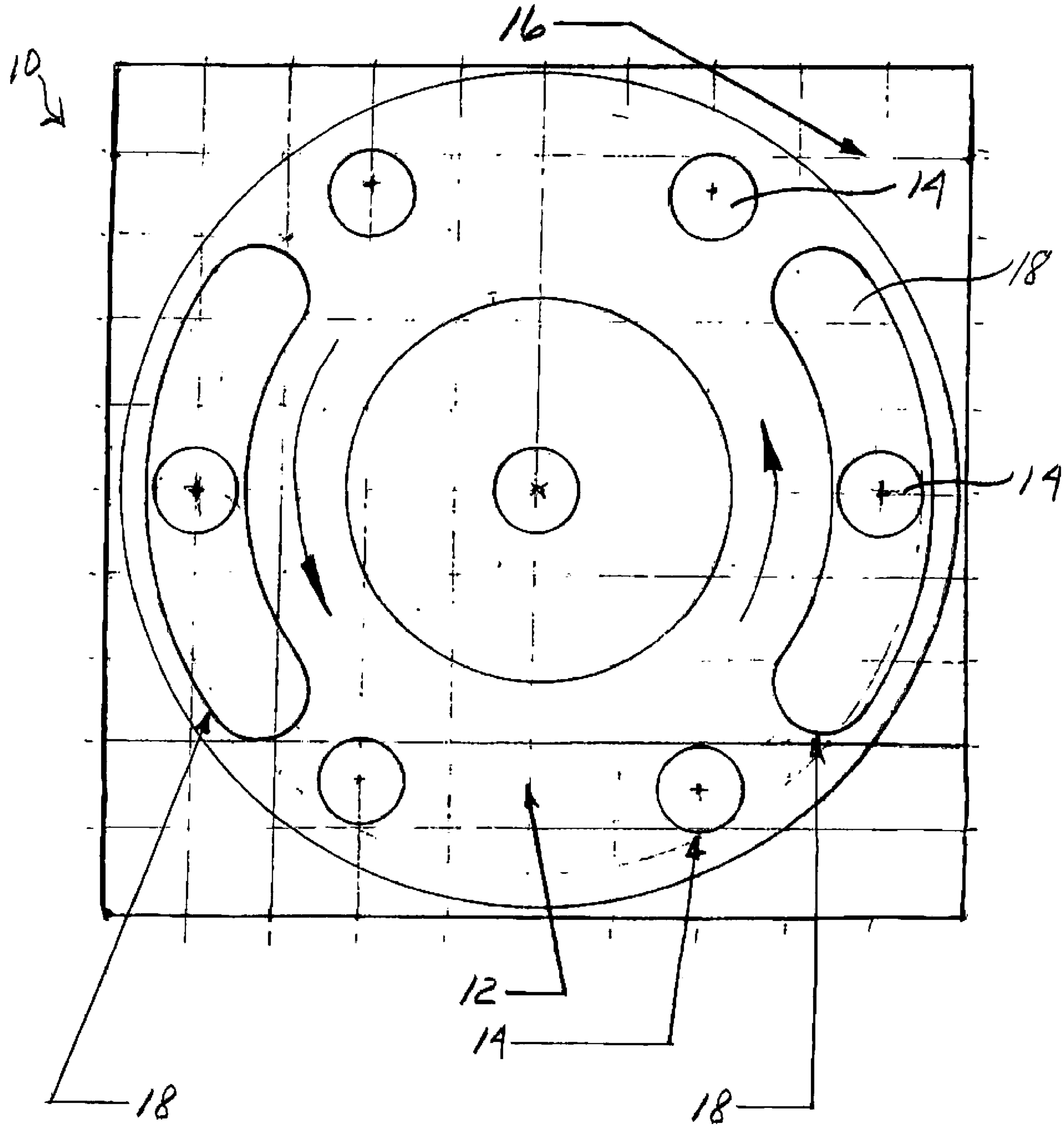

FIG. 2

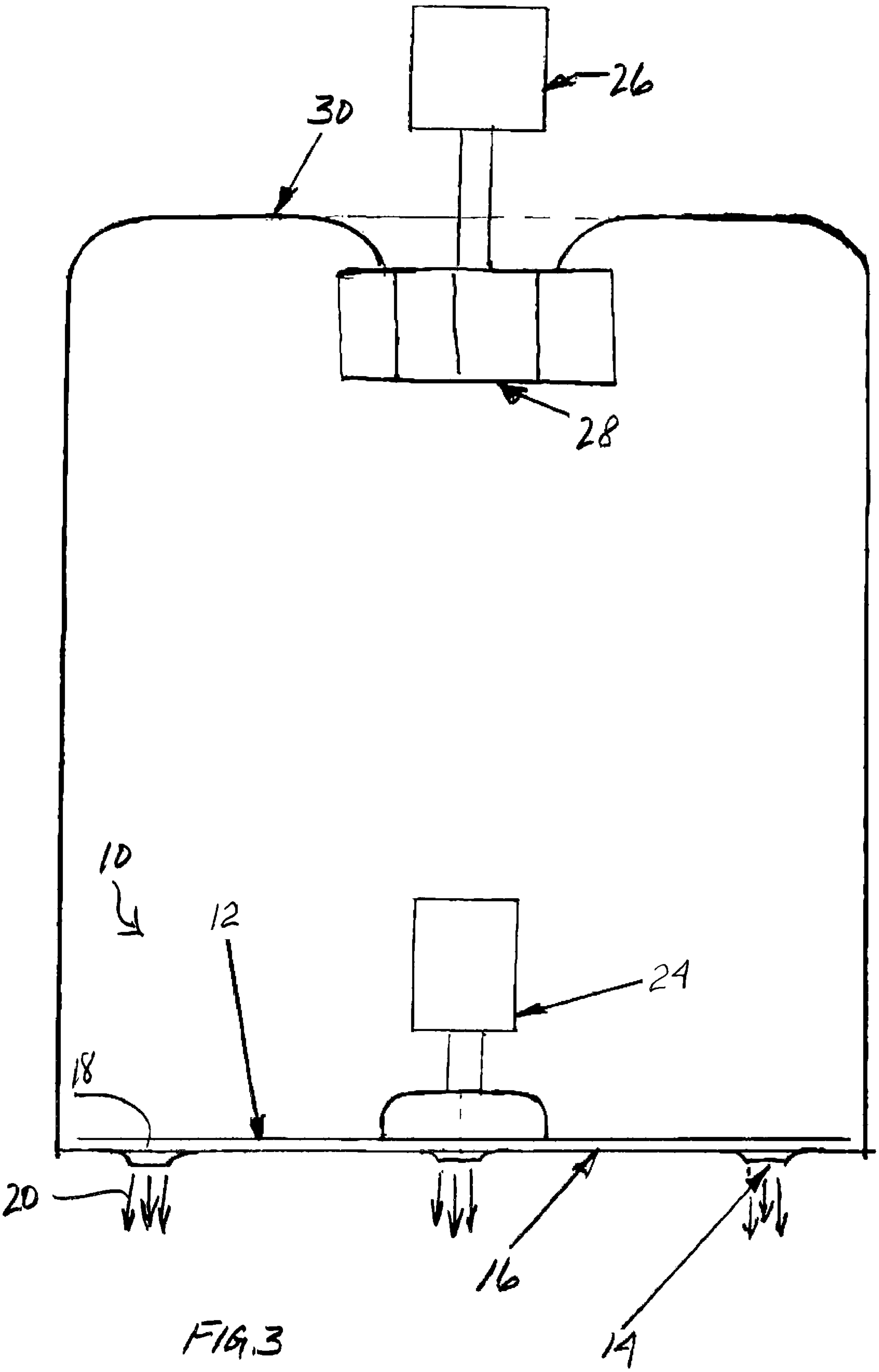

FIG.3

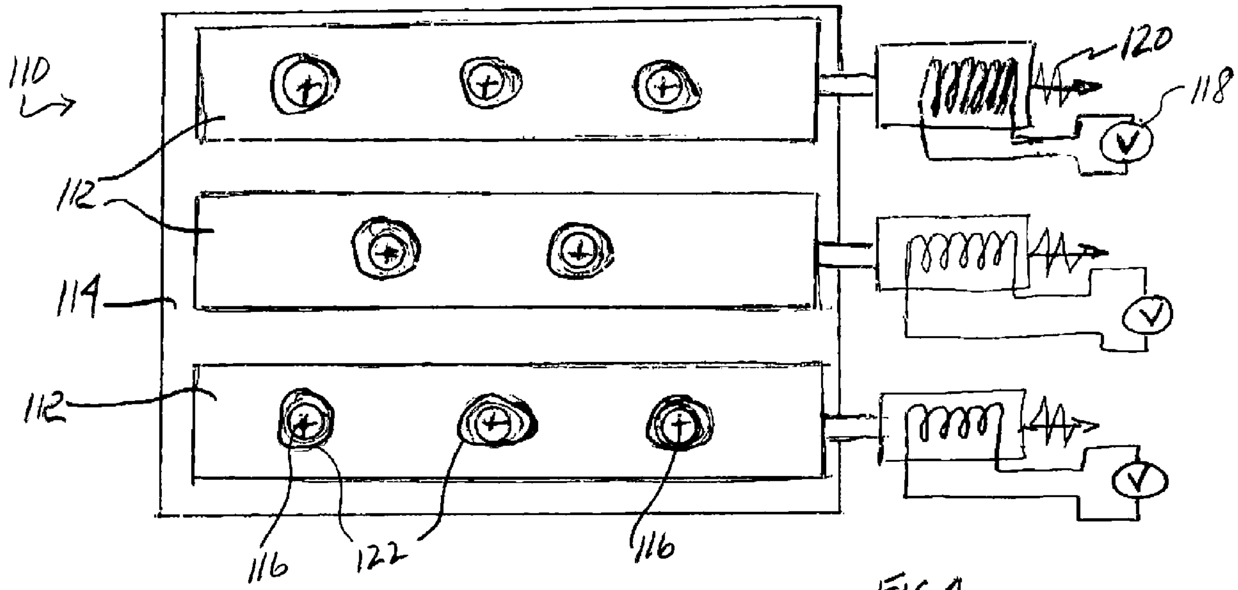
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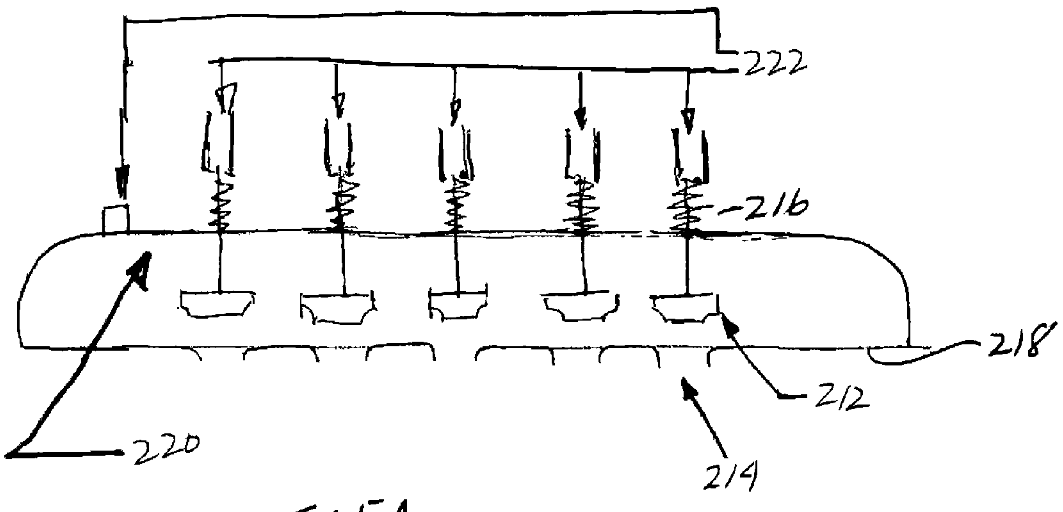
FIG.4


222
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216
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212
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214

FIG.5A

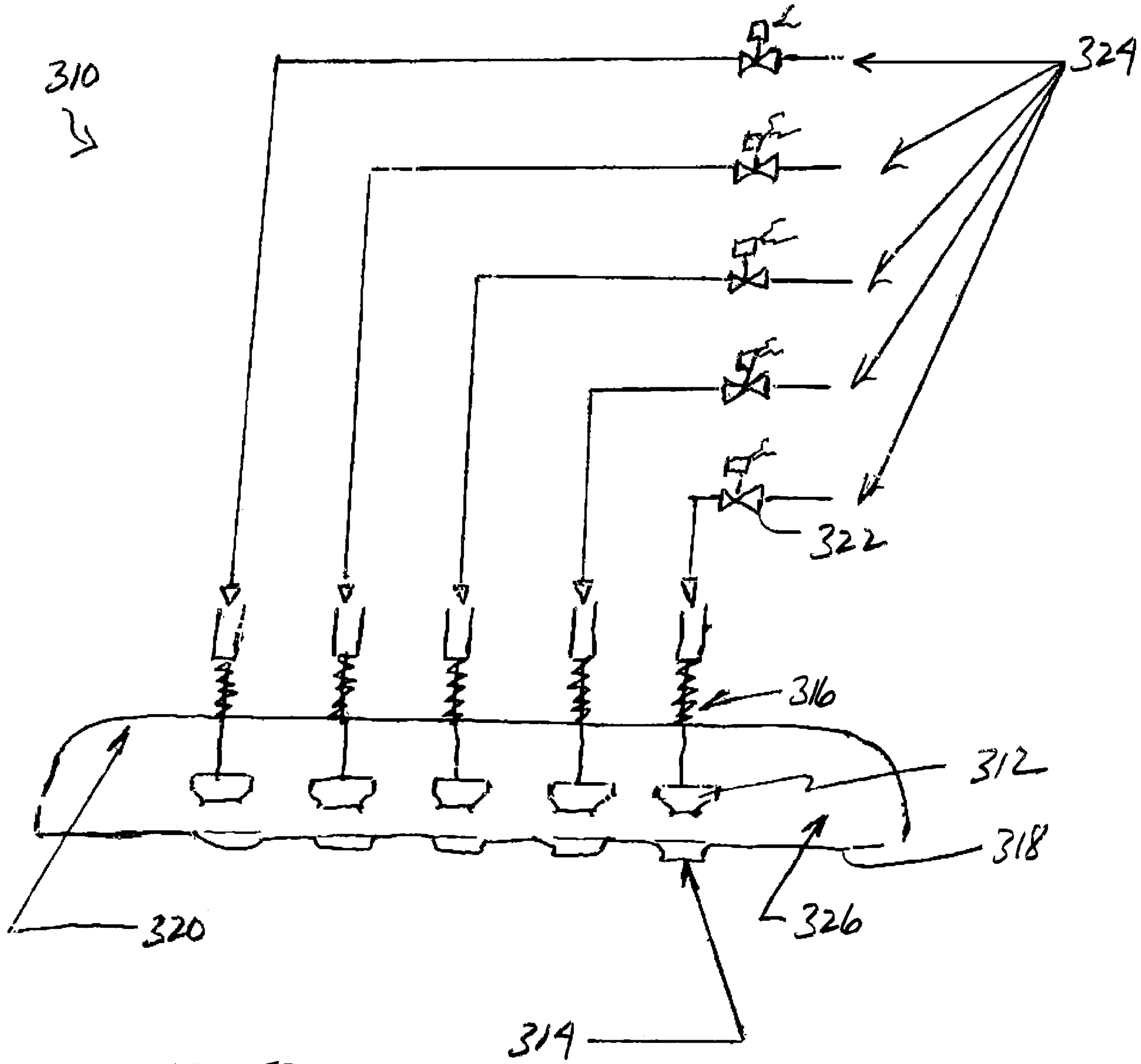

FIG.5B

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EUROPEAN SEARCH REPORT

Application Number
EP 17 17 5602

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The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	7 December 2017	Léandre, Arnaud

CATEGORY OF CITED DOCUMENTS

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