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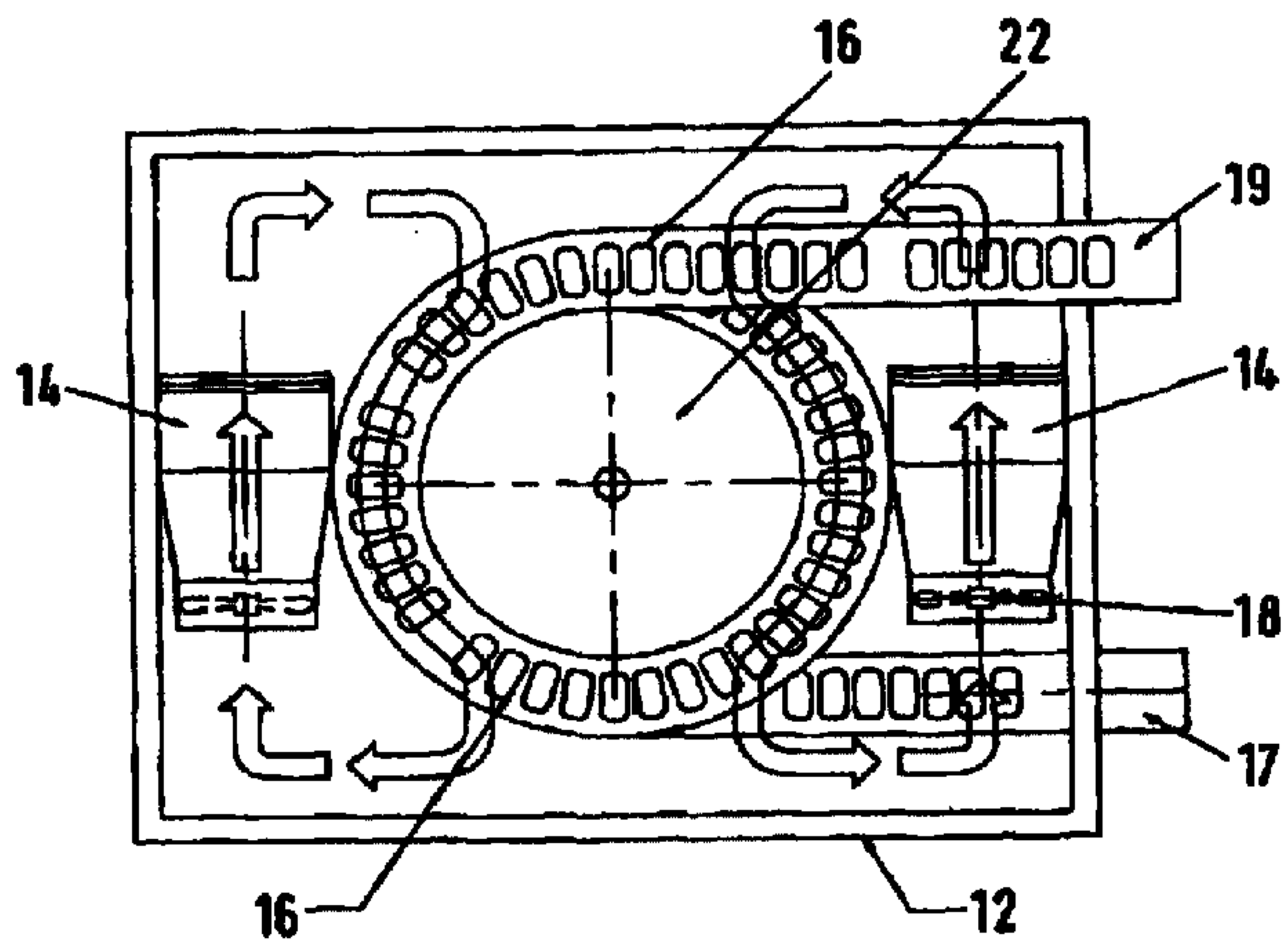
(54) **PROCEDE DE REFROIDISSEMENT**
(54) **COOLING METHOD**



(57) L'invention se rapporte à un procédé de refroidissement de produits cuits au four, tels que le pain, consistant à faire passer les produits sur une bande transporteuse dans une unité de refroidissement, à refroidir l'air jusqu'à une température inférieure ou égale à 15 °C environ, ce qui accroît son humidité relative, et à faire passer l'air froid sur les produits cuits au four de manière à les refroidir, les bobines de refroidissement étant disposées dans l'unité de refroidissement de telle sorte que la température de l'air ne dépasse pas 8 °C au moment où il passe sur les produits. L'air à une température inférieure ou égale à 15 °C environ possède une humidité relative bien supérieure à celle de l'air à température ambiante. Ainsi, le passage d'air froid sur les produits cuits au four permet de réguler la perte d'humidité des produits sans recours à des dispositifs d'humidification, tels que des laveurs d'air. Ce procédé, qui s'avère par ailleurs avantageux du point de vue sécurité, permet de réduire le coût des installations nécessaires ainsi que les durées de refroidissement.

(57) A method of cooling baked products, such as bread, is provided comprising the steps of moving the products on a conveyor belt through a cooling unit, cooling air to about 15 °C or less, thereby increasing its relative humidity, and then passing the cold air over the baked products to cool the products, the cooling coils in the cooling unit being arranged such that the temperature of the air does not rise by more than 8 °C as it passes over the products. Air having a temperature of about 15 °C or less has a much higher relative humidity than air at ambient temperatures. Thus by passing such cold air over the baked products, the moisture loss from the products can be controlled without the use of humidification devices, such as air washers. This reduces the cost of the equipment needed, reduces cooling times, and is safer.

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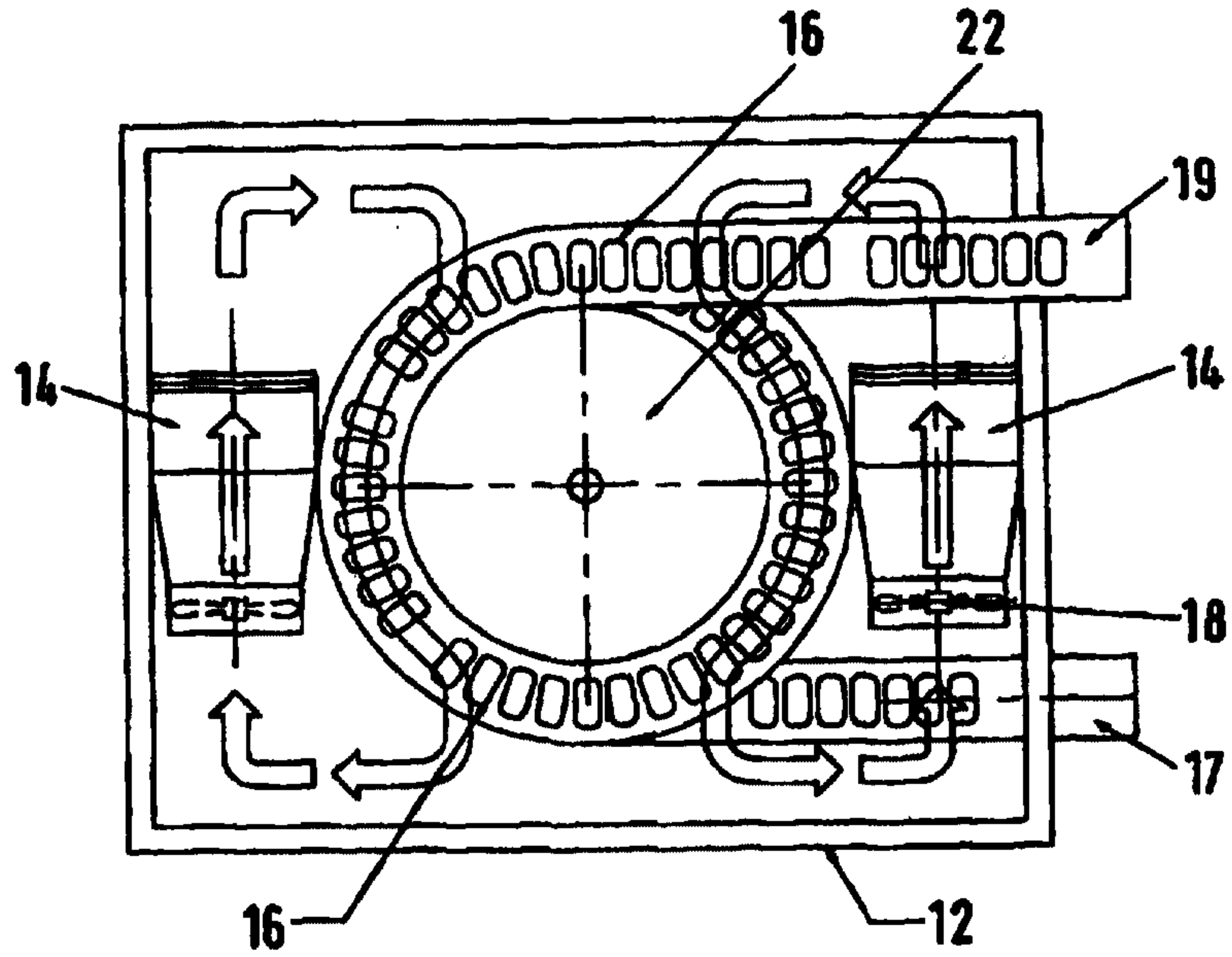


(57) Abstract

A method of cooling baked products, such as bread, is provided comprising the steps of moving the products on a conveyor belt through a cooling unit, cooling air to about 15 °C or less, thereby increasing its relative humidity, and then passing the cold air over the baked products to cool the products, the cooling coils in the cooling unit being arranged such that the temperature of the air does not rise by more than 8 °C as it passes over the product s. Air having a temperature of about 15 °C or less has a much higher relative humidity than air at ambient temperatures. Thus by passing such cold air over the baked products, the moisture loss from the products can be controlled without the use of humidification devices, such as air washers. This reduces the cost of the equipment needed, reduces cooling times, and is safer.

Cooling Method

The invention relates to a method for cooling dough based products after baking, particularly bread.

In the process of cooling baked products, it is necessary to control the loss of moisture from the products as far as possible. This is for several reasons. If too much moisture is lost then the products will be underweight and will require the addition of more water to the dough during mixing which results in handling problems. Also, a dry crust may be produced which can lead to difficulties when packaging the product.

The most common, traditional method of cooling products after baking has been to pass cool air over the products. However, as the air passes over the hot products it warms up and dries out. To counteract this effect and increase the humidity of the air so that the products do not lose too much moisture, the air is passed through an air washer (water spray curtain) or some other humidification device, such as a Spinning Disc Humidifier. This cools the air to close to the wet bulb temperature of the local environment before passing it over the baked product. Such systems typically produce air with initial relative humidity levels in the region of 90 to 95%.

This method has several disadvantages however:-

1) the minimum air temperature achievable is entirely dependent on the current climatic wet bulb temperature;

2) it may not be possible to recirculate all the air due to the large amount of heat picked up from the product;

3) the air wash system uses large quantities of water;

4) the system is liable to bacterial contamination;

5) the system requires continual maintenance and hygiene checks; and

6) the efficiency of these systems and their ability to closely control desired parameters are limited.

The present invention aims to provide an improved method for cooling baked products. The invention is defined in the appended claims to which reference should now be made.

The method of the present invention differs from the traditional methods in that no humidification equipment is necessary. The moisture loss of the baked dough products is controlled by using cold air at temperatures of less than 15°C, which takes up less moisture at any given relative humidity (kg/kg of dry air) because it is closer to its saturation temperature than air at ambient temperatures and is therefore closer to saturated conditions.

The cooling coils are arranged in the cooler such that the air path within the cooler is kept short, and the air does not dry out too much before passing back to a cooling coil. By keeping the air path short the temperature of the air does not rise by more than 8°C as it passes over the product and thus it remains sufficiently humid that no humidification apparatus is required. This has several other advantages. For example, the cooling time is reduced which means that a smaller, and therefore cheaper, cooler can be used.

A rise in temperature of more than about 8°C would cause a reduction of the relative humidity of more than about 20%, even when additional moisture that could be input to the air from the products is taken into account.

The use of a spiral conveyor allows a short air path to be achieved, usually in combination with multiple cooling coils, in a large scale cooling unit, such as could be used for cooling bread commercially.

The term "cooling coils" is a well known ter min the art and covers cooling arrangements other than spiral coils.

According to a second aspect of the invention, the cooling coils are arranged so that the relative humidity of the air does not fall below 70% as it passes over the products.

According to a third aspect of the invention, the system, in operation, uses recirculated air moving around in closed loop. No inlet or outlet ducts to the outside of the system need to be opened to draw in or expel air to control the temperature and/or humidity of the system.

The results which have been achieved using the system of the present invention show a vast improvement over other known bread coolers. When cooling bread, temperatures of 31°C inside the bread have been obtained in 65 minutes with weight losses of 12g.

Figure 6 shows the temperature/humidity characteristics of a traditional block type cooler, as opposed to a spiral mechanism. In the block type cooler, products are loaded onto long, flat racks which are circulated through the cooler. In the system shown in Figure 6 the bread and cool air pass through the cooling "tunnel" in the same direction, thus the cool air passes over the hottest bread first. The air quickly warms up as it passes over the hot bread, causing the relative humidity to fall rapidly to below 50%. Thus weight loss occurs because warm, dry air is being passed over the bread.

Attempts to improve the situation have been made by feeding the air into the central portion of the machine, passing the air over the coolest racks first and then over the hottest racks of products before being recooled. The temperature/humidity characteristics of this system are shown in Figure 7. The situation is somewhat improved as the humidity of the air is higher over the cooler products, but rapidly drops off when passed over the warm products.

Figure 8 shows the typical characteristics of the system of the preferred embodiment of the present invention using a spiral conveying mechanism with air being fed from a number of sources within the cooling unit. As the product moves around the spiral away from the cold air source, the air around the product becomes warmer and less humid but, because of the design of the system, it is quickly brought back into the freshly conditioned air supply. Thus the air conditions around the bread are maintained within close limits with the temperature of the air not rising by more than 8°C between cooling coils, and the relative humidity of the air not becoming less than 70%.

An apparatus using a spiral conveying mechanism within an isolated enclosure is ideal for carrying out this method.

In the system of the present invention humidity is provided by the moisture from the product as the small amount of moisture released from the product into the air is enough to ensure that a relative humidity of above 90°C is maintained. The air used is recirculated and its temperature is reduced to less than 15°C. Because such low temperatures are used, the system quickly reaches equilibrium once the baked product has been fed into the apparatus. Excess moisture is removed from the circulating air by the effect of condensation as it passes through the cooling coils.

A preferred embodiment of the invention will now be described with reference to the drawings in which:

Figures 1a & 1b show a cooler according to one embodiment of the invention in plan and side view respectively;

Figure 2 shows a plan view of a modified cooler according to an embodiment of the invention;

Figures 3a and 3b show plan and side views respectively of a tall cooling unit according to one embodiment;

Figures 4a & 4b show plan and side views respectively of another modified cooler according to an embodiment of the invention;

Figures 5a & 5b show plan and side views respectively of a cooler similar to the one shown in Figure 1;

Figure 6 shown the temperature/humidity characteristics of a traditional block type cooler;

Figure 7 shows the temperature/humidity characteristics of another traditional block type cooler; and

Figure 8 shows the temperature/humidity characteristics of the cooling system according to a preferred embodiment of the present invention.

Referring to Figures 1a and 1b, a cooler comprising a spiral conveying mechanism 10 arranged within an insulated enclosure 12 is shown. The spiral conveying mechanism 10 comprises a central drum 22 around which a conveyor belt 16 moves along a spiral path. The belt 16 forms a plurality of tiers, one above the other, as it moves up the drum and comprises a supporting surface 13 on which products may be conveyed. The belt is driven by an electric motor (not shown). The cooler comprises heat exchangers 14 which are mounted around the periphery of the spiral conveyor. The heat exchangers comprise cooling coils where heat is transferred from the air to the primary refrigerant or secondary inside the coils, and may be in the form of evaporators. The heat exchangers 14 are arranged in two sets, with three heat exchangers arranged one on top of the other in each set. Each heat exchanger houses a fan 18 at its inlet, and an eliminator system 20 for removing water droplets at its outlet. The two sets of heat exchangers are arranged on opposite sides of the spiral conveyor with their inlets facing the same direction.

As an example of the invention, the process of cooling bread will be described.

Bread is fed into the cooler on the conveyor belt. The fans 18 of the heat exchangers 14 are driven by an electric motor (not shown)and this causes air to pass through the cooling coils of the heat exchangers 14 where the temperature of the air is reduced to less than 15°C.

The flow of the cool air inside the cooler is shown in figure 2a by the hollow arrows. As the sets of heat exchangers 14 on either side of the spiral conveyor direct air in the same direction, the airflow through the central drum 22 caused by one set of heat exchangers 14 is opposed by the direction of movement of the air moving through the other set of heat exchangers. Thus the chilled air is constrained to pass over only part of the spiral system before returning to the fans 18. By keeping the air path relatively short, the temperature rise of the air, and hence its ability to remove moisture from the product, is kept to a minimum, and to less than 8°C.

The preferred temperature of air passing over the bread is 15°C. As the air will heat up a little while passing over the bread, the heat exchangers may be set to cool the air to about 12°C or less, so that the average temperature of the air while passing over the bread is around 15°C.

As no humidification system is used there are no water pumps or filters to maintain and no chemical water treatment is required. There will only be a relatively small amount of condensate which will be sent to drain. There are several other advantages of an apparatus and process that does not require a high water usage. Namely, the danger of water-borne diseases, such as legionnaires disease, is significantly reduced, and, because the air is recirculated, spores and other undesirable particles are not drawn into the system from the outside. Also, there are no inlet or discharge filters to maintain.

Referring to Figure 2, a modified version of the cooler comprises a double drum spiral system. The two drums are arranged in first and second chambers 36,38 , side by side, separated by a partition 34 which prevents air moving from one chamber of the cooler to the other. The first spiral conveyor is arranged in the first chamber 36 and is surrounded by four sets of heat exchangers 14 positioned around the outside of the conveyor. They are arranged so that adjacent sets are at 90° to each other and so that along a path taken around the outside of the spiral conveyor one would pass inlet/outlet outlet/inlet inlet/outlet outlet/inlet of the heat exchangers. Thus, each set of heat exchangers 14 works against adjacent sets of heat exchangers to direct air in an opposing direction to those in which it is driven by the adjacent sets of heat exchangers.

The second chamber 38 has only two sets of heat exchangers arranged in a similar manner to the system shown in Figures 1a and 1b.

In use, a hot product enters the cooler on the belt at the inlet 17 to the first chamber, spirals up to the top of the first drum 30 and transfers at the level of the top of the drum to the second drum 32 from which the belt is discharged at a lower level at the output 19.

By using four sets of heat exchangers in the first chamber 36, rather than two sets, the length of the air path is reduced by almost half. In the second chamber 38 the partially cooled products enter from the first chamber at a high level and then move down the spiral conveyor. As the products are already partially cooled fewer sets of heat exchangers are needed to maintain a steady air temperature.

Referring to Figures 3a and 3b, if a taller spiral conveyor is used, the unit can be partitioned into two chambers one above the other by a baffle 40 extending vertically across the unit at about half the height of the spiral conveyor. The heat exchangers in the two chambers can be arranged in a similar manner as in the embodiment shown in Figure 2 with the chamber 36' into which the hot product enters (which in this embodiment is the lower chamber) having four sets of heat exchangers and the second chamber 38' having two sets of heat exchangers.

Figures 4a and 4b show another cooler in which the drum 22' of the spiral conveyor is perforated. A set of heat exchangers 14 is arranged to direct air vertically upwards into an L-shaped duct 50 which directs the air through the top of the drum to the inside of the drum which then forms a plenum chamber. As shown in Figure 3a the air then flows out of the drum radially across the baked products. The fans 18 draw the used air back into the heat exchangers 14 where excess moisture is removed by the eliminator system 20.

In an alternative arrangement the duct 50 could be configured to feed the drum through its base to the same effect. In another alternative, the fan 18 may be reversed so that the drum 22' is used to collect the return air which then passes along the duct 50 to the heat exchangers 14.

Figures 5a and 5b show a further modified cooler in which the fans 60 are separate from the heat exchangers 70,72, and are mounted vertically so that air is drawn radially away from the spiral conveyor into a vertical duct 62 from which it is drawn through a heat exchanger 72 and then passed back through the spiral conveyor 10. The use of two sets of heat exchangers, rather than only one, reduces the length of the path of the air between heat exchangers.

The cooler unit is partitioned into two sections, an upper 76 and a lower 78 section by a baffle 68 which passes around the circumference of the spiral conveyor 10 , approximately halfway up. Heat exchangers 70,72, comprising cooling coils and eliminator systems 20, and fans 60 are arranged so that the chilled air 64 is expelled towards the centre of the spiral conveyor.

The fans 60 are arranged below the baffle plate on the side opposite the infeed 17 to the cooling unit and draw air into a vertical duct 62 at the side of the cooling unit. On the side of the spiral conveyor 10 adjacent the infeed section of the conveyor belt 16, one heat exchanger 70 is arranged below the baffle plate 68. This heat exchanger 70 cools air 74 after it has passed through the upper section 76 of the cooling unit. The air is drawn into a duct 66 behind the heat exchanger, through its cooling coils and eliminator system 20, and then substantially horizontally through the lower tiers of the spiral conveyor 10.

A second heat exchanger 72 is arranged above the baffle plate on the side opposite the infeed 17 of the cooling unit, almost directly above the fans 60. This heat exchanger cools the air 64 that has been drawn into the vertical duct 62. This chilled air is driven through the heat exchanger 72 and then substantially horizontally through the upper tiers of the spiral conveyor 10.

In a modified system, a secondary refrigerant may be used in the cooling coils. Such a secondary refrigerant could for example be cold water which is chilled outside the cooling unit, and then pumped through the cooling coils. This has the advantages that it is cheaper and safer. Conventional commercial refrigerants such as ammonia and Freon-22 are highly corrosive and require special pipes to be used, whereas no special pipes are required when using water. Also, Freon-22 and ammonia are both very toxic, unlike water.

A system embodying the invention would typically be expected to cool standard 800 gram loaves of bread after baking to a point where slicing and wrapping can take place in 75 minutes or less, with weight losses occurring during the process in the region of 13 grams per loaf when cooling to 27°C to 32°C. The results typically obtained are shown in Figure 8.

In such a system moisture loss from the products is reduced as the air is closer to saturation than when warmer air is used. As the temperature of the air does not rise by more than 8°C, the air does not become hot and dry. Thus no humidification systems are needed in order to reduce the moisture loss of the baked products.

The system thus provides a much more economical, safe and efficient method for cooling baked products such as bread. In particular, because no humidification system is required there are less parts to maintain, the cooling time is reduced and also there is less likelihood of contamination.

Claims

1. A method for cooling bread after baking comprising the step of:

circulating air over the bread in a closed loop and cooling the air as it circulates, whereby moisture introduced into the air from the bread as it cools is used to maintain the relative humidity of the circulating air thereby controlling loss of moisture from the bread.

2. A method according to claim 1 in which the air is cooled to 15°C or less.

3. A method according to claim 2 in which the closed loop is arranged such that the temperature of the air does not rise by more than 8°C as it passes over the bread.

4. A method according to claims 1, 2 or 3 in which the closed loop is arranged such that the relative humidity of the air does not fall below 70% as it passes over the bread.

5. A method according to any preceding claim in which the cooling step increases the relative humidity of the air to 90% or greater than this.

6. A method according to any preceding claim including the step of moving the bread on a spiral conveyor through a cooling zone.

7. A method according to any preceding claim in which the cooling of the air is performed by a plurality of cooling coils.

8. Apparatus for cooling bread comprising:

means for circulating air over the bread in a closed loop; and

means for cooling the air as it circulates such that moisture introduced into the air from the bread as it cools is used to maintain the relative humidity of the circulating air thereby controlling loss of moisture from the bread.

9. Apparatus according to claim 8 in which the air is cooled to 15°C or less.

10. Apparatus according to claim 9 in which the closed loop is arranged such that the temperature of the air does not rise by more than 8°C as it passes over the bread.

11. Apparatus according to claims 8, 9 or 10 in which the closed loop is arranged such that the relative humidity of the air does not fall below 70% as it passes over the bread.

12. Apparatus according to claims 8, 9, 10 or 11 in which the cooling means increases the relative humidity of the air to 90% or greater.

13. Apparatus according to any of claims 8 to 12 including a spiral conveyor for moving bread through a cooling zone.

14. Apparatus according to any of claims 8 to 13 in which the cooling means comprises a plurality of cooling coils.

15. A method of cooling baked products comprising the steps of:

moving the products on a spiral conveyor through a cooling unit;

circulating air through a closed loop which includes a plurality of cooling coils, arranged adjacent the conveyor, to cool the air to about 15°C or less, thereby increasing it relative humidity;

passing the cooled air over the baked products to cool the products; and

arranging the cooling coils such that the temperature of the air does not rise by more than 8°C as it passes over the products.

16. A method according to claim 15 in which the cooling coils are arranged such that the relative humidity of the air does not fall below 70% as it passes over the products.

17. A method of cooling baked products comprising the steps of:

moving the products on a spiral conveyor through a cooling unit;

circulating air through a closed loop which includes a plurality of cooling coils, arranged adjacent the conveyor, to cool the air to about 15°C or less, thereby increasing its relative humidity;

passing the cooled air over the baked products to cool the products; and

arranging the cooling coils such that the relative humidity of the air does not fall below 70% as it passes over the products.

18. A method of cooling baked products comprising the steps of:

moving the products on a spiral conveyor through a cooling unit;

circulating air through a closed loop which includes a plurality of cooling coils arranged adjacent the conveyor to cool the air to about 15°C or less, thereby increasing its relative humidity; and

passing the cooled air over the baked products.

19. A method as claimed in any of claims 15 to 18 in which the cooling coils increase the relative humidity of the air to 90% or greater, by cooling it.

20. A method according to any of claims 15 to 19 in which the humidity within the cooling unit is provided by the moisture removed from the products.

21. A method according to any of claims 15 to 20 in which the baked products comprise bread.

22. An apparatus for cooling baked products according to the method of any preceding claim comprising:

a cooling unit including a plurality of cooling coils for cooling the air to about 15°C or less, and means for circulating the cooled air over the baked products in a closed loop; and

a spiral conveyor for supporting the products and moving them through the cooling unit; and

the cooling coils of the cooling unit being arranged such that the temperature of the air does not rise by more than 8°C as it passes over the products.

23. A method for cooling baked products substantially as described herein.

24. A method for cooling bread substantially as described herein.

25. An apparatus for cooling bread products substantially as described herein with reference to the drawings.

FIG.1A.

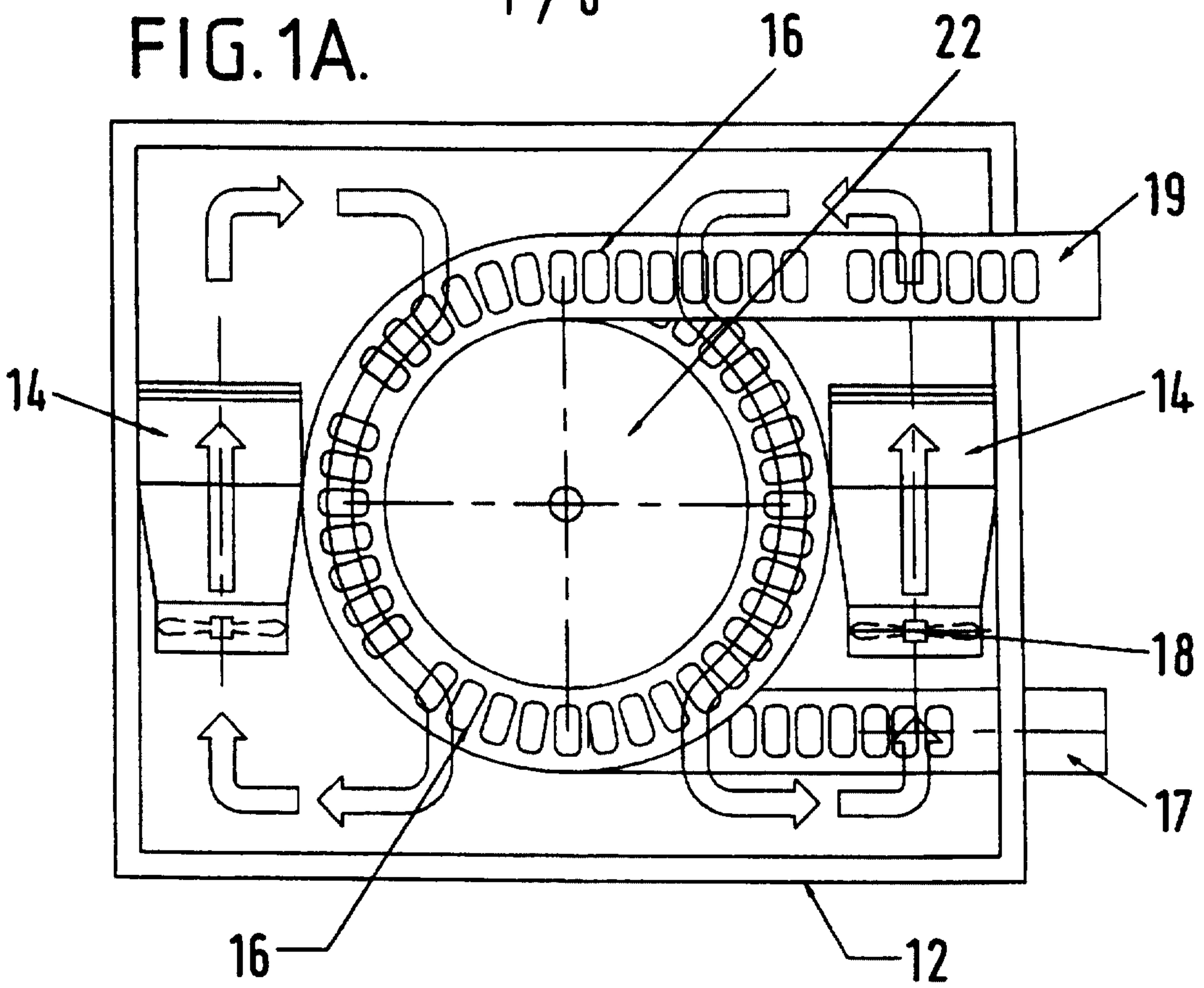


FIG.1B.

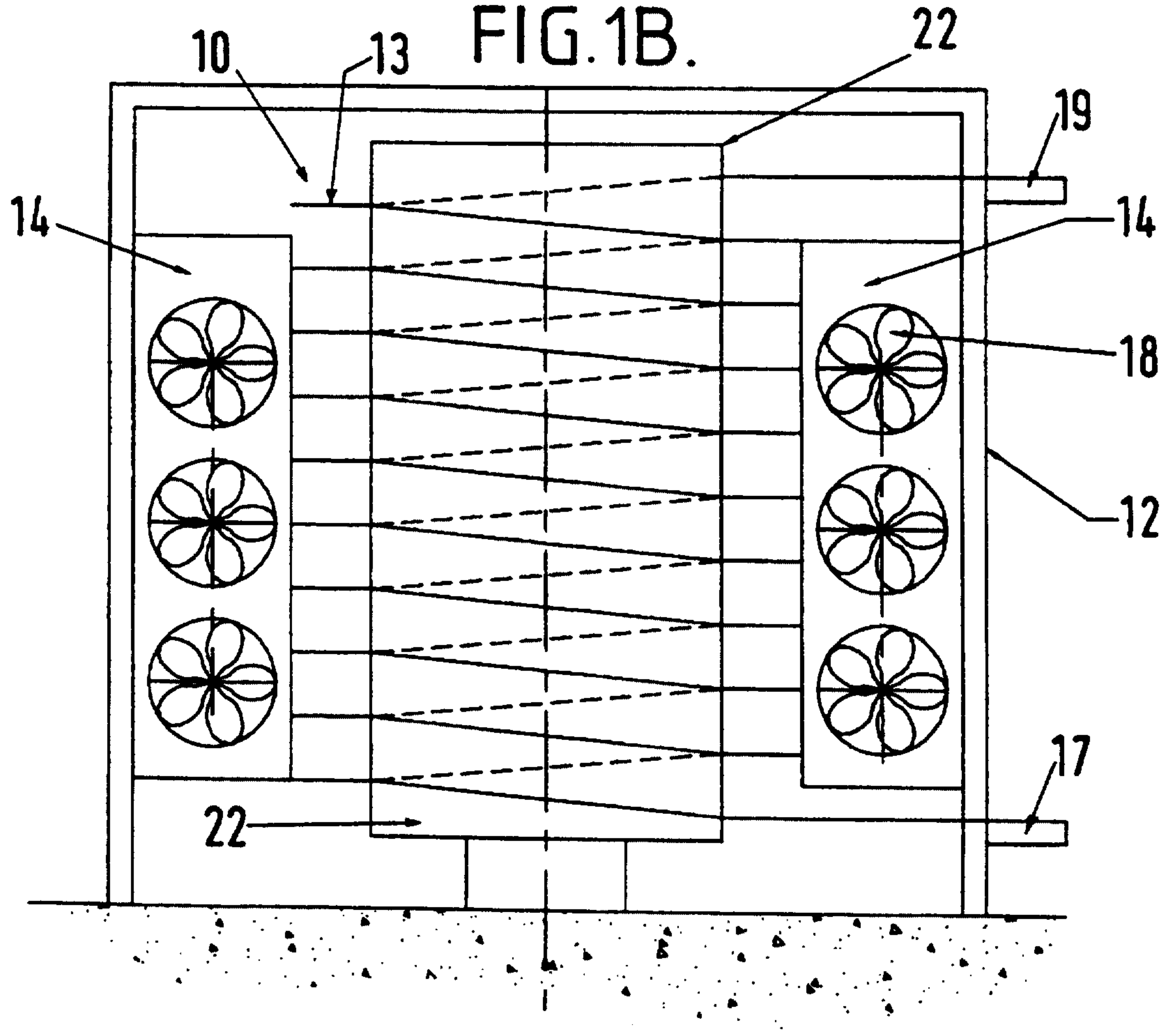


FIG. 2.

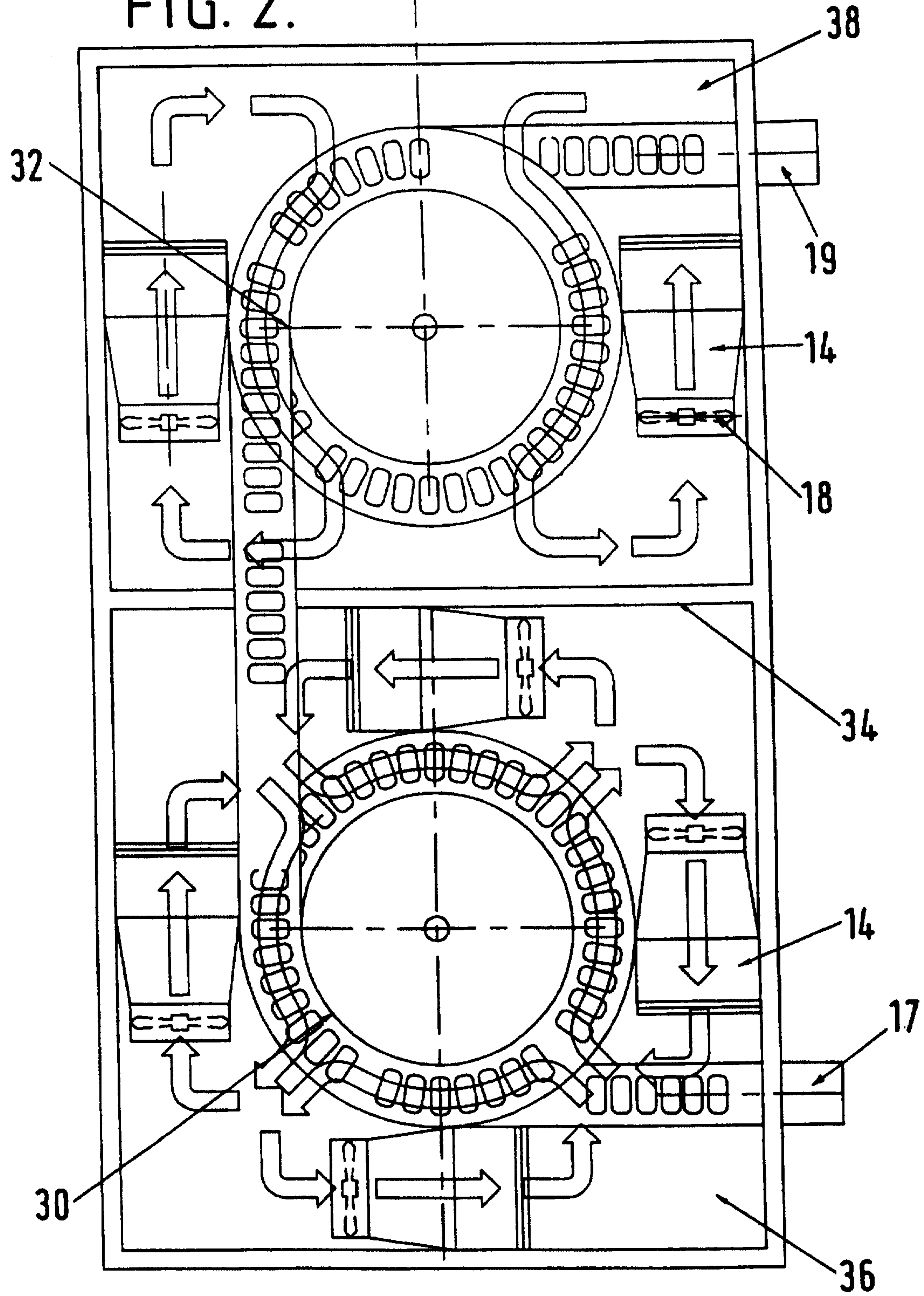


FIG. 3B.

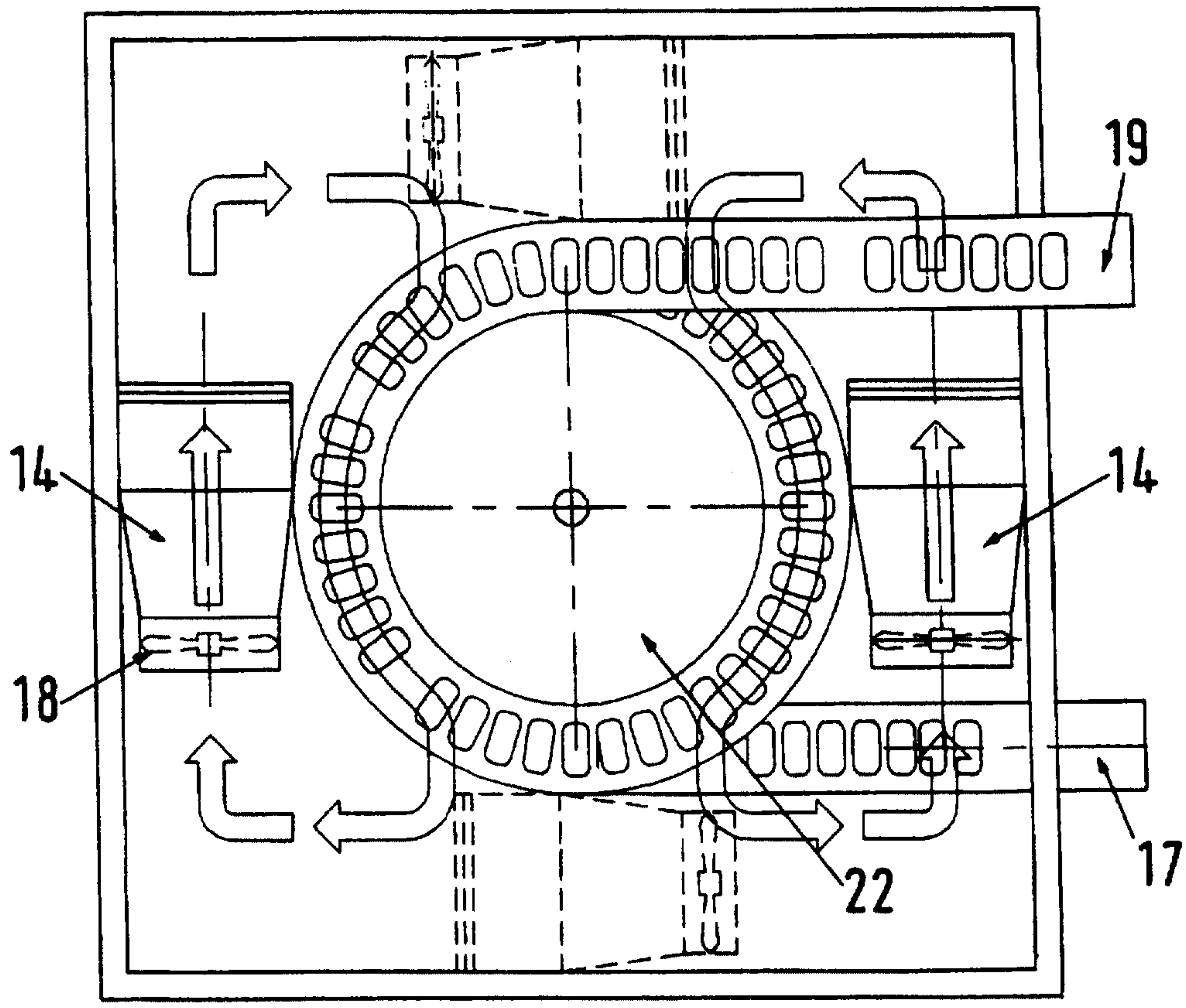


FIG. 3A.

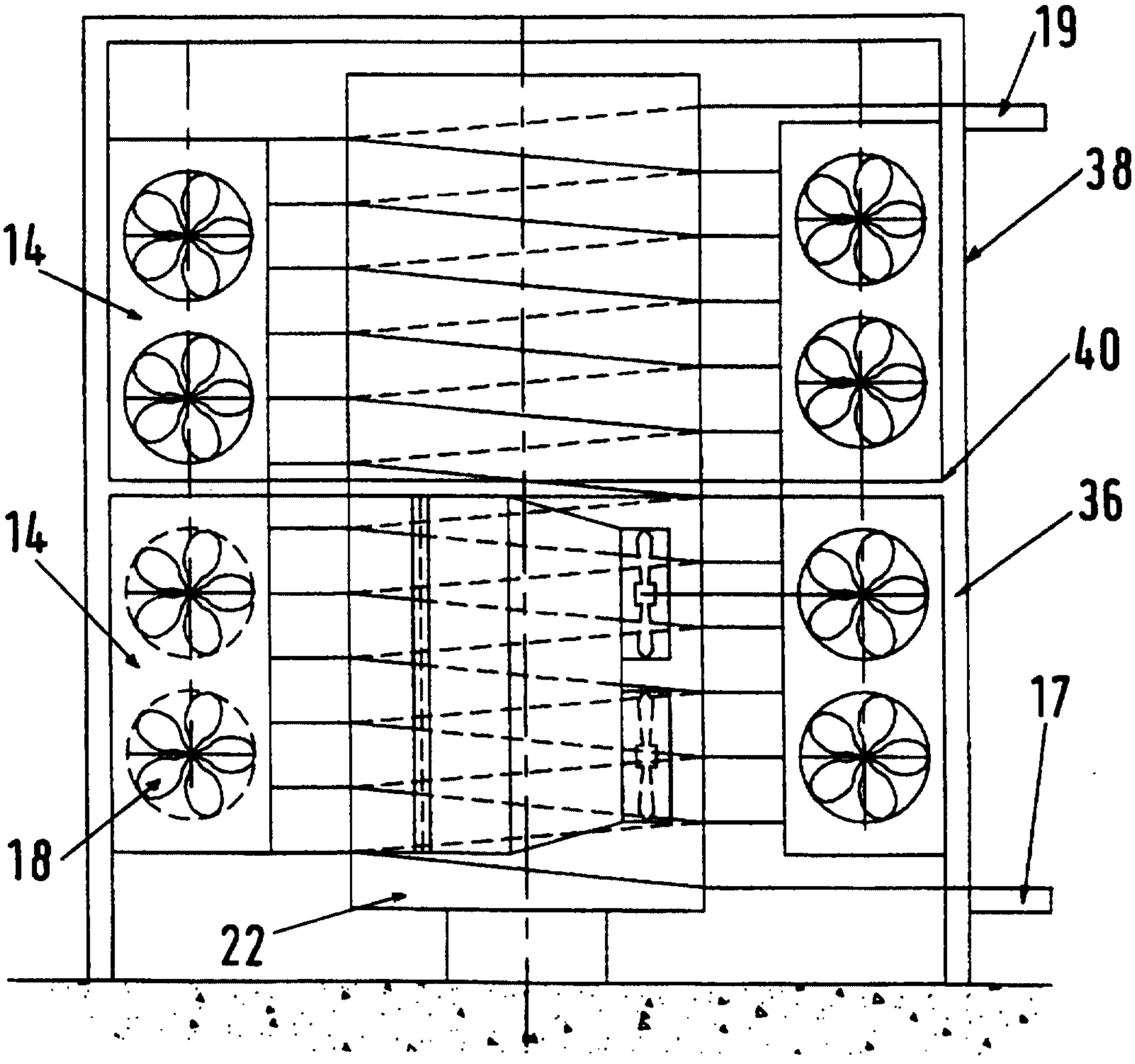
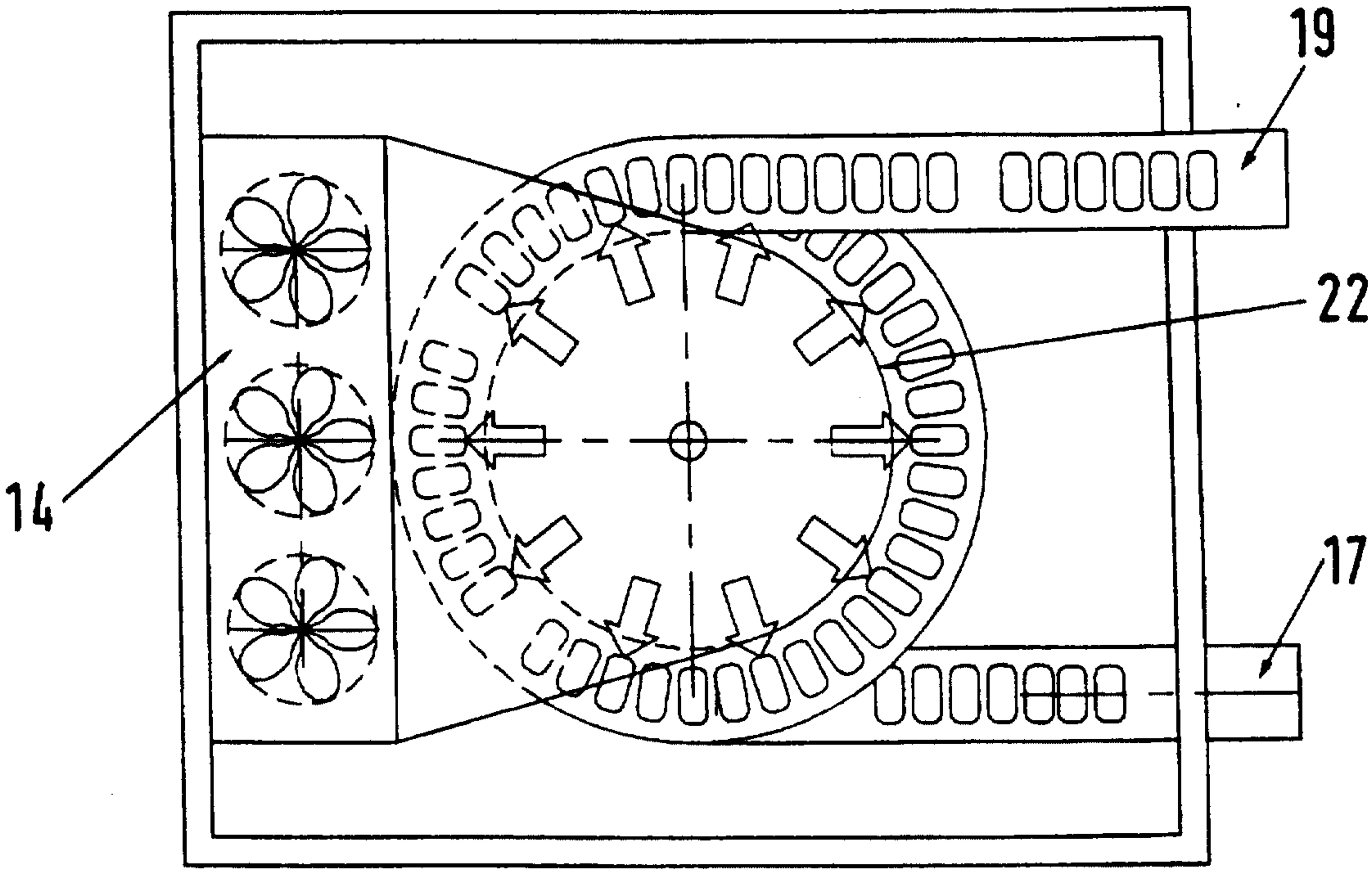


FIG. 4A.



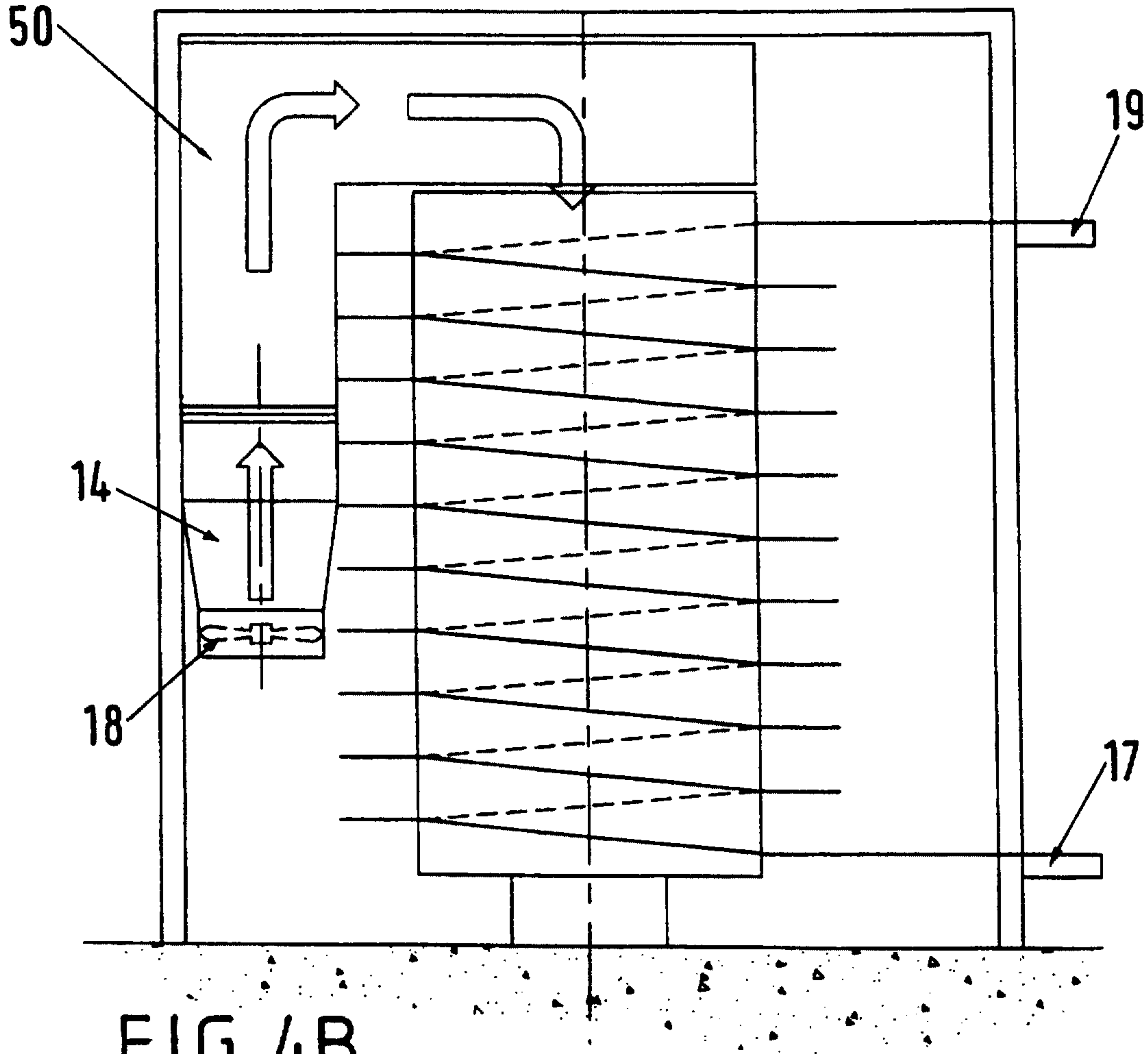


FIG. 4B.

FIG. 5A.

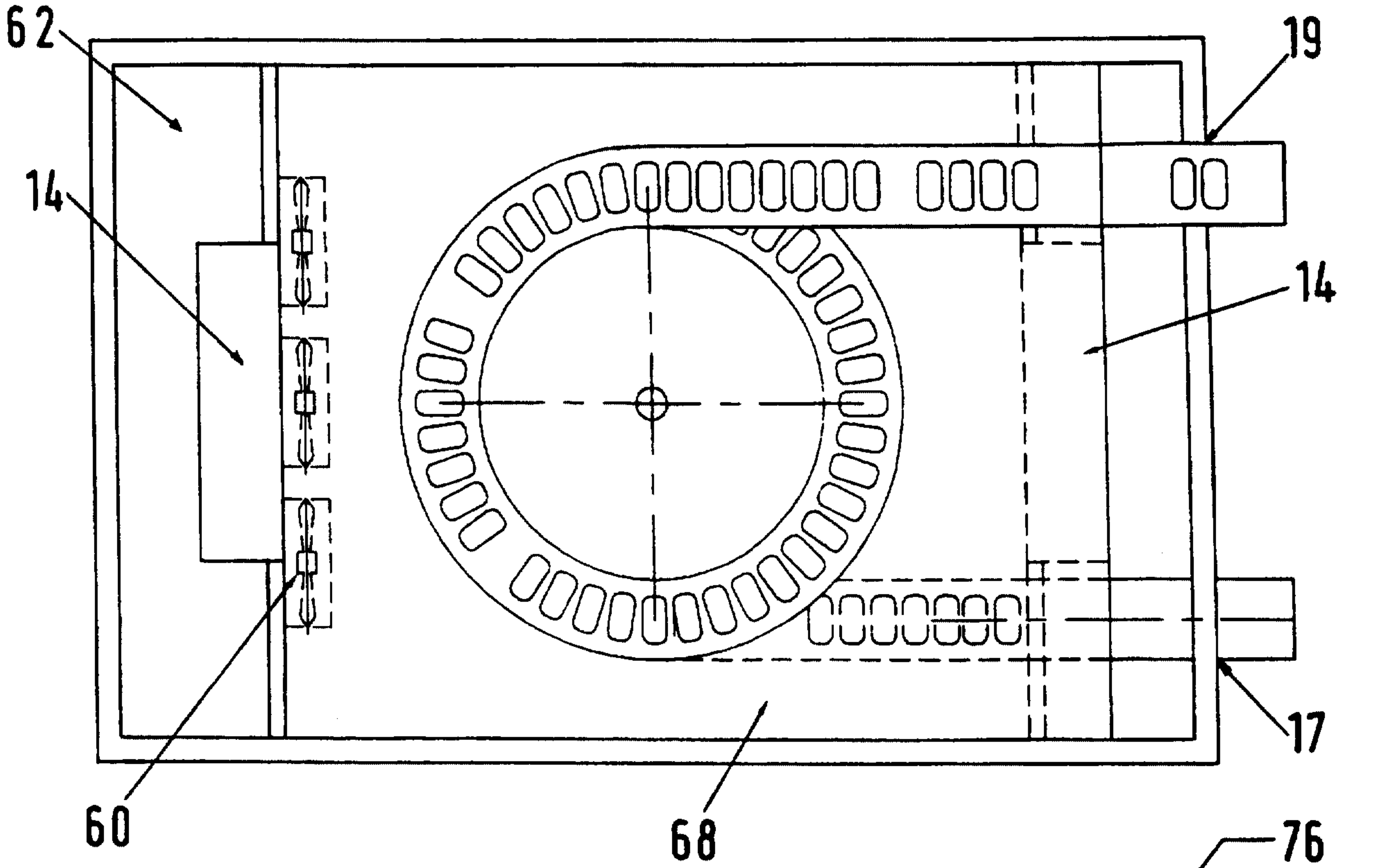
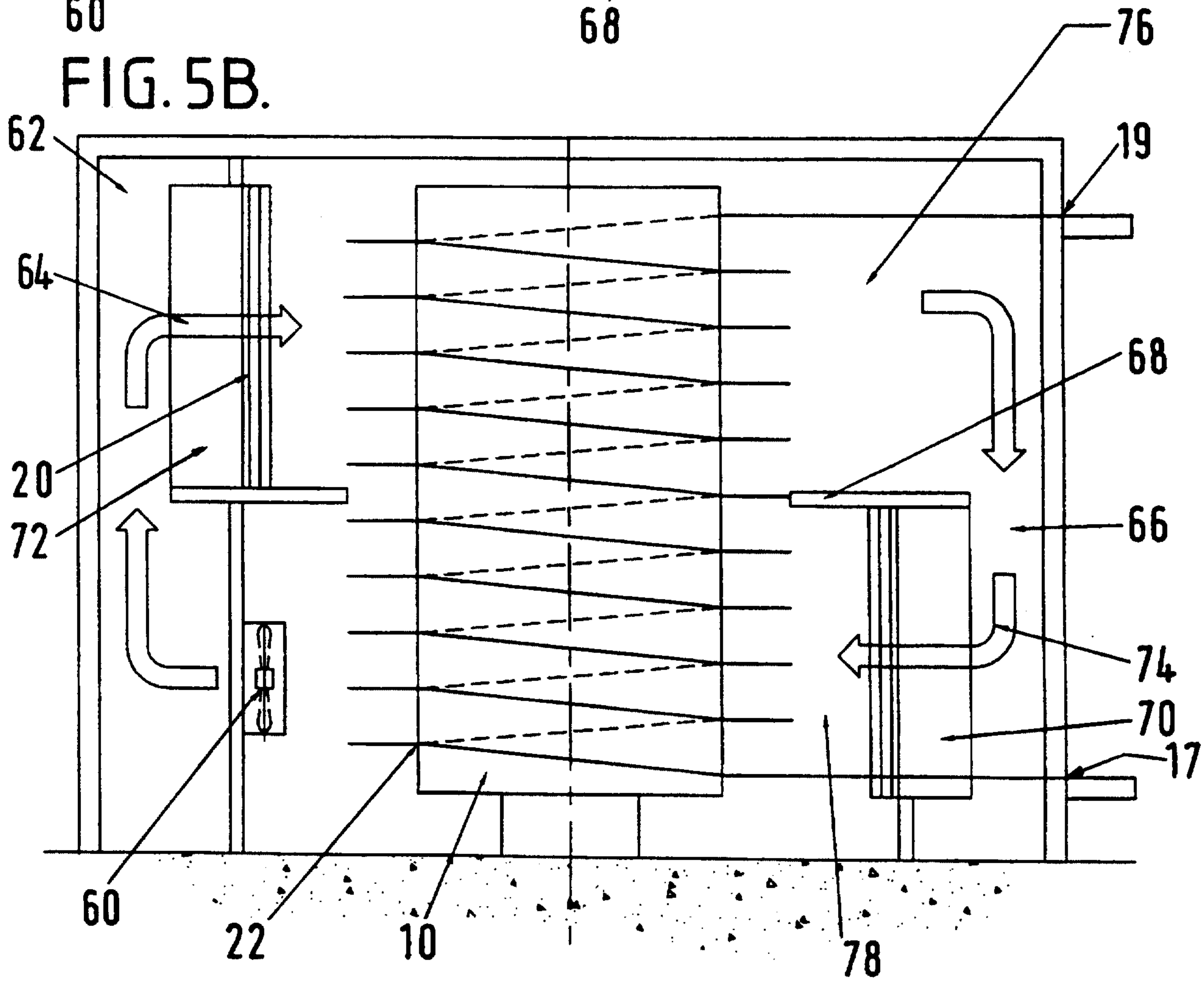


FIG. 5B.



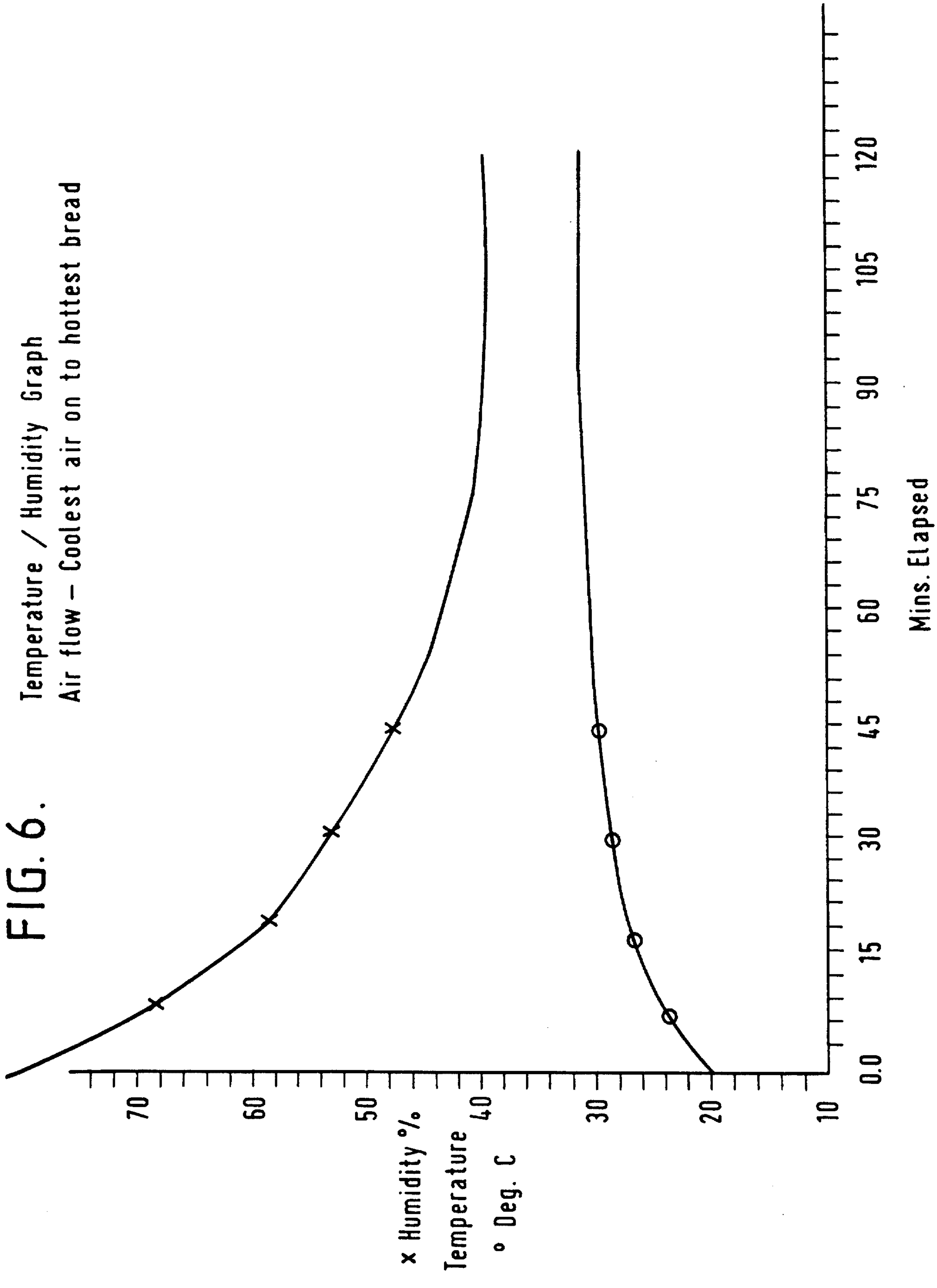
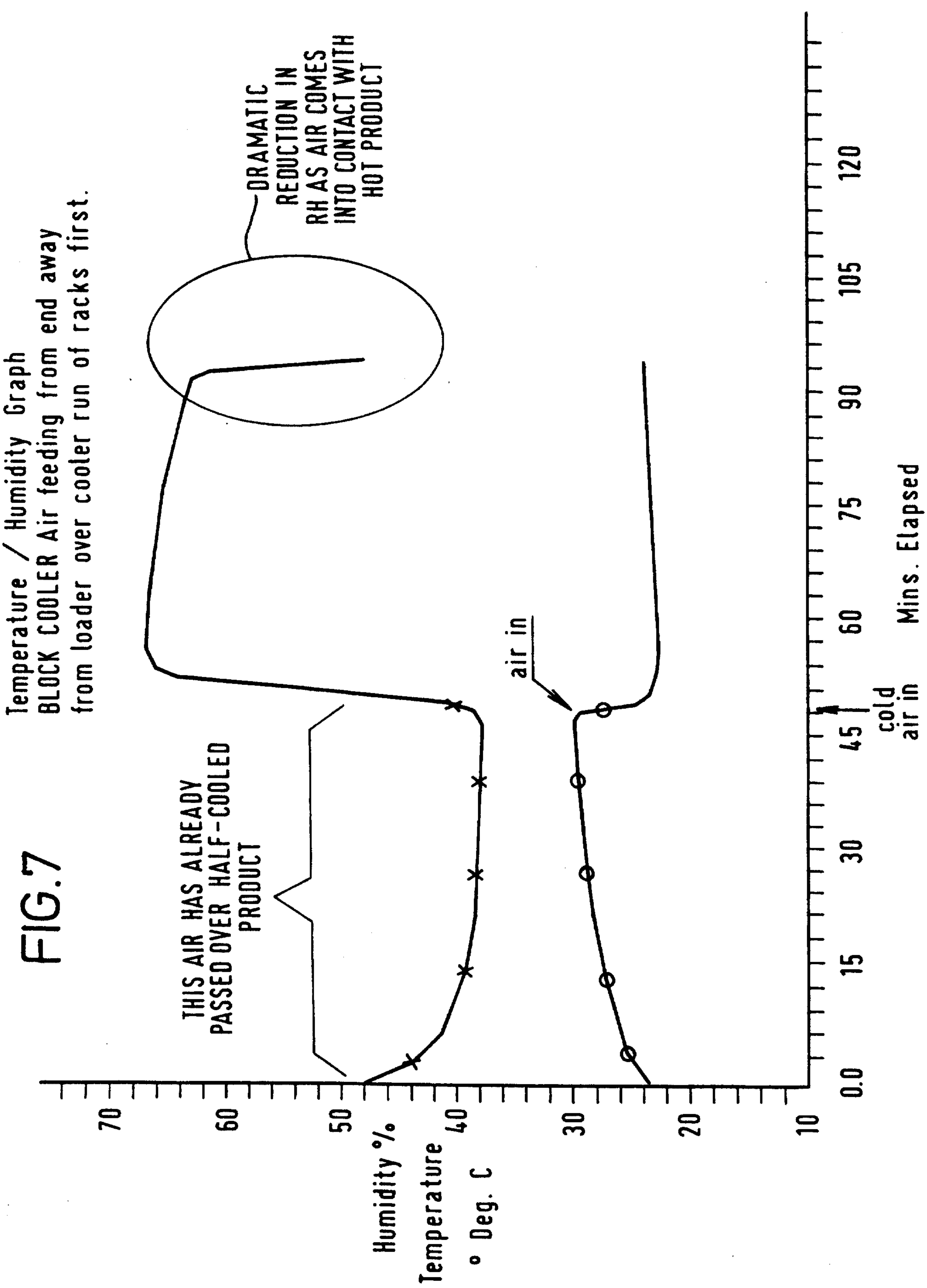

Temperature / Humidity Graph
Air flow - Coolest air on to hottest bread
x Humidity %
Temperature
° Deg. C
70
60
50
40
30
20
10
0.0
15
30
45
60
75
90
105
120
Mins. Elapsed

FIG. 6.

FIG.7



Temperature / Humidity Graph
BLOCK COOLER Air feeding from end away
from loader over cooler run of racks first.
ORAMATIC
REDUCTION IN
RH AS AIR COMES
INTO CONTACT WITH
HOT PRODUCT
THIS AIR HAS ALREADY
PASSED OVER HALF-COOLED
PRODUCT
air in
cold
air in
Humidity %
Temperature
° Deg. C
Mins. Elapsed
70
60
50
40
30
20
10
0.0
15
30
45
60
75
90
105
120

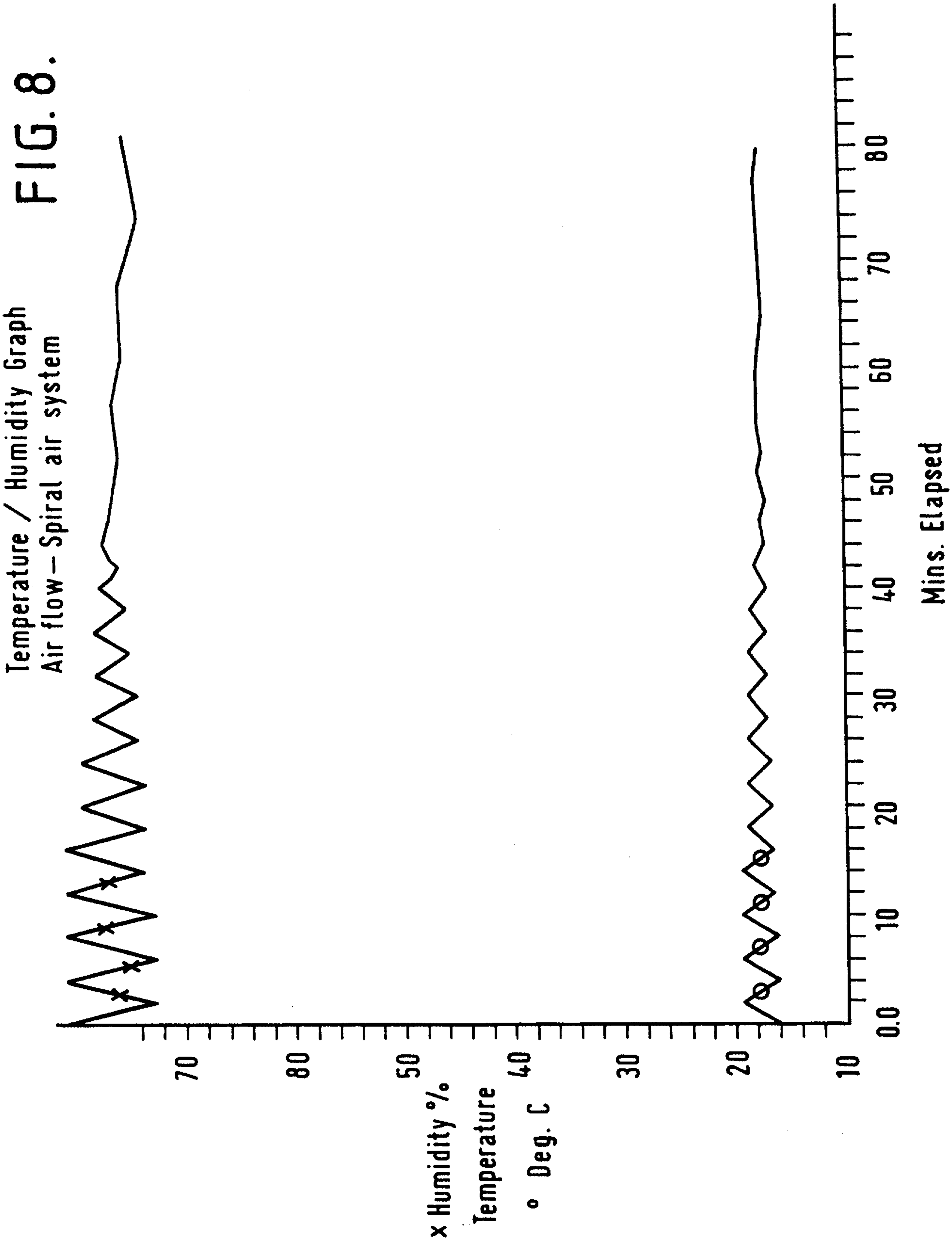

Temperature / Humidity Graph
Air flow – Spiral air system
x Humidity %
Temperature
o Deg. C
70
80
50
40
30
20
10
0.0
10
20
30
40
50
60
70
80
Mins. Elapsed

FIG. 8.