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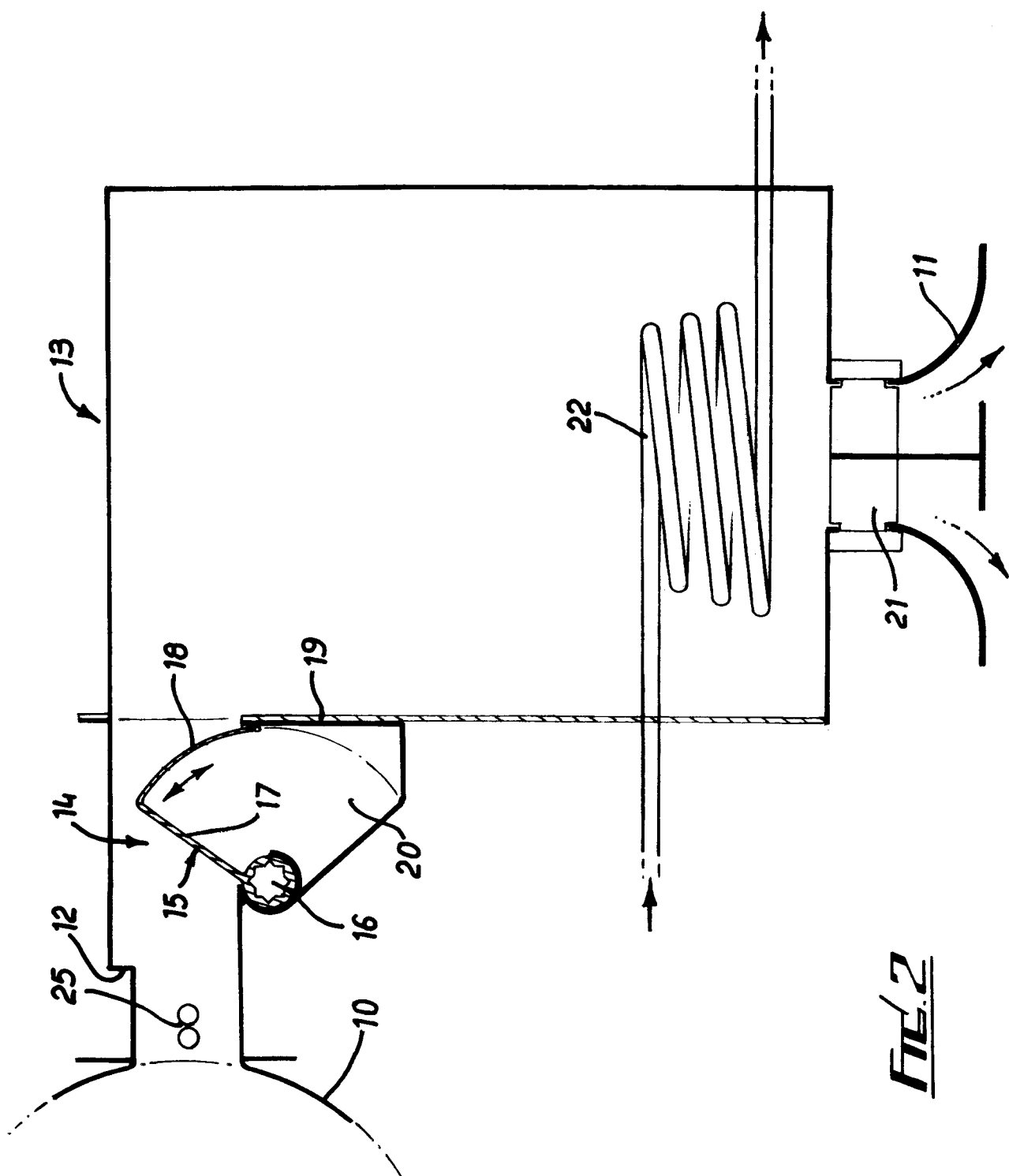
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(54) **Ventilation apparatus.**

(57) A ventilation duct (10) discharges air through a diffuser (11) into a room. The diffuser (11) is connected to the duct (10) via a plenum chamber (13) and a variable constriction valve (14). The valve (14) is located between the duct (10) and the plenum chamber (13). The valve (14) may have a flap with a flat upstream surface (17) and a downstream surface (18) which is convexly curved away from the upstream surface (17). An automatic control system (42) may be provided to adjust the valve in dependence on temperature or pressure. Two ducts (100, 110) may be connected to the same diffuser (101), one duct supplying cold air and the other hot air so that the ventilation temperature can be adjusted.



This invention relates to ventilation apparatus, and in particular to ventilation apparatus adapted to the regulation of air temperatures in rooms or other spaces served by the apparatus.

In ventilation and air conditioning apparatus, air which has been cooled or heated by passing through a central refrigeration or heating installation, is circulated by ducts, usually located in a space above the ceilings of the respective spaces. The air is then fed to diffusers which are supplied by branches from the duct, into the respective spaces.

In order to control the ambient temperatures in the rooms etc., it is usual to regulate the flow of air through the diffusers rather than for example the temperature of the cooling or heating apparatus which conditions the air before circulation. This can be achieved with known apparatus by controlling the feed of air to the duct. However, this is not always satisfactory in so far as it does not allow for different requirements in the vicinity of different diffusers. It is also known to control each diffuser separately, with a flow restricting device immediately upstream of the diffuser. However, this latter arrangement can cause an unacceptable level of noise, including high frequency tones (whistling) which may cause disturbance even distress to occupants of the room.

An object of the present invention is to provide ventilation apparatus which can overcome the aforementioned disadvantages of known apparatus.

According to the invention therefore, there is provided ventilation apparatus comprising at least one duct for supplying air to at least one diffuser wherein a plenum chamber is provided between the diffuser and the duct and a variable constriction valve is provided for controlling air flow to the diffuser, characterised in that the valve is provided between the duct and the plenum chamber.

With this arrangement, satisfactory control of ventilation in the vicinity of the respective diffuser can be achieved in an acceptable manner.

With regard to the plenum chamber, this preferably has a greater cross-sectional area than said duct or said diffuser.

In a preferred embodiment the valve has an inlet containing a constriction member having a first surface which faces towards the duct and a connecting second surface which faces towards the diffuser in the normal direction of air flow, the member being pivotable to adjust the angle of the first surface to the air flow and hence the constriction of the inlet.

Preferably the first surface of the constriction member is provided by a substantially flat flap which is pivotally mounted at one end, and the second surface is provided by an extension part at the opposite end of the flap which is curved convexly away therefrom. With this arrangement, turbulent inflow of air behind the constriction member can be prevented or reduced thereby to minimise noise.

Preferably also, the inlet may be elongate and the constriction member may be mounted on an axis which is driven by a motor, extending longitudinally of the longest dimension of the inlet, which is preferably parallel to the axis of the duct. The surfaces of the constriction member may be presented by a solid body, but preferably are of a suitable sheet material.

An automatic control system is preferably provided to effect automatic operation of the valve in response to a sensed parameter.

Thus, the aforesaid motor operating the constriction member is preferably controlled e.g. by a microprocessor based control system, which obtains data concerning ambient temperatures and flow rates of air to the respective diffuser, and effects variations to achieve or maintain a predetermined temperature.

In one embodiment, a pressure sensor may be provided to provide the aforesaid sensed parameter, said sensor being arranged to sense pressure between the duct and the plenum chamber. This sensor may be arranged to monitor the pressure averaged over a length and, in a particularly preferred embodiment the sensor comprises a pair of parallel tubes an upstream one of said tubes having a plurality of holes facing towards the air flow, and the downstream one of said tubes having a plurality of holes facing away from the air flow, and a respective pressure measuring device being applied to each said tube. This is advantageous compared with known arrangements where measurements are taken at a series of points. As an alternative to this kind of pressure sensor, a hot wire air velocity sensor may be used.

It is also possible to use a temperature sensor to provide said sensed parameter, said sensor being arranged to sense ambient temperature.

A temperature adjusting device may be provided within the plenum chamber for supplying heat to or for removing heat from air in the plenum chamber.

Other factors such as humidity may also be taken into account, and apparatus such as humidifiers and desiccators may be used.

In a further preferred embodiment one said diffuser is arranged to be supplied with air from two said ducts via a common said plenum chamber and via respective said variable constriction valves, said ducts being arranged to supply air at different respective temperatures.

A preferred embodiment of ventilation apparatus according to the invention will now be described by way of example, with reference to the accompanying drawings, wherein: -

Fig. 1 is a perspective view of a ventilation apparatus according to the invention;

Fig. 2 is a sectional view of the apparatus of Fig. 1;

Fig. 3 is a cross-section of a pressure differential detection device used in the apparatus;

Fig. 4 illustrates diagrammatically a space e.g. an

office housing ventilation system with a plurality of individual apparatus of the invention;

Fig. 5 is a flow diagram illustrating the functions of detection and control devices in the operation of the apparatus of the invention; and

Fig. 6 is a perspective view of a second embodiment of ventilation apparatus according to the invention enabling the variable mixing of air supplies of different temperatures.

Fig. 1 shows a duct 10 for the distribution of, for example, cooled air to rooms or other spaces in an air conditioned building. This duct may be housed in a ceiling space, and is connected to a plurality of diffusers such as 11, located at spaced apart intervals along the duct 10, for example, one, two or more in each room, depending on the size of the room.

The air intake from the duct 10 for each diffuser 11 is in the form of an elongate rectangular housing 12, opening into the duct at one side, and into a plenum chamber 13, parallel to the duct 10 and equal in length to the diffuser 11, which plenum chamber 13 is of substantially greater cross-sectional area than the intake housing 12.

The intake 12 as shown in Fig. 2 contains a valve or variable constrictor means 14, which includes a movable element 15 and a shaft 16 which is driven by a pneumatic or electric actuator which may be a stepping motor or an analogue (continuously variable) equivalent, under the control of a controller (to be described below). The shaft 16 causes rotational displacement of the element 15, which has a rectilinear or flat face 17 directed towards the direction of flow of air into the housing 12 from duct 10, and a curved trailing face 18, the free edge of which slidingly abuts a wall 19 to prevent inflow of air into a space 20 provided to accommodate the movable element 15. The trailing face 18 prevents turbulent flow of air into the space behind the face 17 of the element 15, thereby reducing noise, and encourages laminar flow of air past the element 15, with enhanced intake efficiency as well as reduced noise.

The element 15 can be moved between positions respectively fully opening and fully closing the passage through the intake housing 12.

After passing through housing 12, and the variable constriction valve 14, air from the duct 10 enters the plenum chamber 13. The air is fed from the chamber 13 through the diffuser 11, which is of known type, and includes for example filters 21.

In the plenum chamber, the air from the duct 10 may be mixed with air of different temperatures from other sources, or subject to direct heating by e.g. a heating element 22. Heating element 22 can be for example a coil for circulating heated water through the plenum chamber 13, or an electrical heating element.

An air flow pressure measuring device 25 is located close to the inlet of the housing 12 from duct 10, the position being indicated in Fig. 2. The device

25 itself can be either a hot wire anemometer type or differential pressure type, and the latter is shown in more detail in Fig. 3 and comprises two parallel tubes, 26, 27 extending lengthwise across the longest dimension (orthogonal to the air intake flow) of the housing 12. The upstream tube 26 is provided with a series of holes 28 spaced at e.g. 50mm centres directed towards the flow of air into the housing, and the downstream tube 27 is provided similarly with a series of holes 29, similarly spaced at 50mm centres, directed away from the flow of air.

The tubes 26, 27 are connected to pressure sensing transducers which detect and sense and convert into the measurement signals the air pressures appearing in the respective tubes 26, 27 and monitor the differential between them, which is in turn related to the velocity of air flow into the housing 12. The holes 28 in tube 26 being directed upstream, admit air to tube 26 at a higher pressure, and holes 29 in tube 27, being directed downstream, into the lee side of the tubes, admits air to tube 27 at a lower pressure. The greater the air flow speed, the greater will be the differential between these pressures.

Fig. 4 illustrates the fact that all the diffusers 11 serving a given space or room require to be individually controlled; if as shown in Fig. 4 an office room 30, has three diffusers 11a, 11b, 11c, each with respective plenum chambers 13a, 13b, 13c, and with air flow in duct 10 from left to right (arrow A) in the drawing, then there will normally be a pressure drop in the intake from the duct 10 of the respective diffusers from left to right. This may be compensated for in controlling the setting of the valves 14 to achieve equal flow rates into the respective plenum chambers and thus the diffusers.

Fig. 5 illustrates by way of a diagram, the operation of ventilating apparatus of the invention using a differential pressure air flow measuring device. A temperature detector 40 measures the external or internal temperature, e.g. the actual temperature from moment to moment of an office room such as 30. Pressure detectors 41 connected to the tubes 26, 27 in the respective housings 12 leading to each diffuser 11 also monitor, with reference to the respective difference in pressure between each pair of tubes 26, 27, the air flow rate from moment to moment into each housing 12. This data is applied to a control unit 42, which may be a microprocessor or functionally equivalent device, and compared with preprogrammed instructions to determine what variations in airflow to effect in order to achieve or maintain a desired air temperature.

The shaft 16 of each movable element 15 of each valve 14 is rotated by its respective motor according to instructions from the control unit 42, thereby varying the volume of air flow through each housing 12 into the respective plenum chamber 13.

Ordinarily, the air supplied via duct 10 will be air

which has been cooled by passing through a refrigeration plant, however in cold climates or in winter this may be replaced by a pre-heated airflow.

Provision can be made for counteracting short term variations imposed by changeable weather conditions for example, by allowing admixture in the or each plenum chamber of a supply of air of the opposite type (i.e. heated air when the ducted air is cooled or cooled air when the ducted air is heated) in controlled proportions, or by use of a water circulating coil, e.g. 22, in the plenum chamber. This may circulate heated water; or chilled water as required.

Such an arrangement can be used to compensate for unseasonably mild winter weather on one hand, or late/early frosts in summer, and the passage of warm and cold fronts.

Humidity may also be allowed for, e.g. by spraying water into the plenum chamber 13 when air is excessively dry, or use of a by pass through a desiccator such as silica gel, when the humidity is excessive.

More particularly a feature of the invention is the ability to connect the apparatus to separate prewarmed and chilled air supplies and for the supply volume of air passing through the diffuser to be mixed and controlled in the plenum chamber. Such an arrangement is shown in Fig. 6, wherein two parallel air supply ducts 100, 110 are provided, duct 100 supplying heated air, and duct 110 supplying chilled air. Each duct is connected via a respective housing 102, 112, to a single plenum chamber 103 wherein the flows from the ducts 100, 110 are mixed, to produce an outflow of air of a desired temperature from diffuser 101. The flow proportions of warmed and chilled air are controlled in the housing 102, 112 by respective flap valves each as shown in Fig. 2 and as described in relation thereto, and each independently operable under command of a control unit such as C.P.U. 40 in Fig. 5 to produce the desired temperature and total flow of mixed air.

Claims

1. Ventilation apparatus comprising at least one duct (10) for supplying air to at least one diffuser (11) wherein a plenum chamber (13) is provided between the diffuser (11) and the duct (10) and a variable constriction valve (14) is provided for controlling air flow to the diffuser (11), characterised in that the valve (14) is provided between the duct (10) and the plenum chamber (13).
2. Apparatus according to claim 1 characterised in that the plenum chamber (13) has a greater cross-sectional area than said duct (10) or said diffuser (11).
3. Apparatus according to claim 1 or 2 characterised in that the valve (14) has an inlet (12) containing a constriction member (15) having a first surface (17) which faces towards the duct (10) and a connecting second surface (18) which faces towards the diffuser (11) in the normal direction of air flow, the member (15) being pivotable to adjust the angle of the first surface (17) to the air flow and hence the constriction of the inlet (12).
4. Apparatus according to claim 3 wherein the first surface (17) of the constriction member (5) is provided by a substantially flat flap which is pivotally mounted at one end, and the second surface (18) is provided by an extension part at the opposite end of the flap which is curved convexly away therefrom.
5. Apparatus according to any one of claims 1 to 4 characterised by the provision of an automatic control system (42) operable to effect automatic operation of the valve (14) in response to a sensed parameter.
6. Apparatus according to claim 5 characterised by the provision of a pressure sensor to provide said sensed parameter, said sensor (26, 27, 41) being arranged to sense pressure between the duct (10) and the plenum chamber (13).
7. Apparatus according to claim 6 characterised in that the sensor (26, 27, 41) is operable to monitor the pressure averaged along a length.
8. Apparatus according to claim 7 characterised in that the sensor comprises a pair of parallel tubes (26, 27) an upstream one of said tubes (26) having a plurality of holes (28) facing towards the air flow, and the downstream one of said tubes (27) having a plurality of holes (29) facing away from the air flow, and a respective pressure measuring device (41) being applied to each said tube (26, 27).
9. Apparatus according to claim 7 characterised in that the sensor is a hot wire air velocity sensor.
10. Apparatus according to any one of claims 5 to 9 characterised by the provision of a temperature sensor (40) to provide said sensed parameter, said sensor (40) being arranged to sense ambient temperature.
11. Apparatus according to any one of claims 1 to 10 characterised by the provision of a temperature adjusting device (22) within the plenum chamber (13), for supplying heat to or for removing heat from air in the plenum chamber (13).

12. Apparatus according to any one of claims 1 to 11 characterised by the provision of a humidity adjusting device within the plenum chamber (13).

13. Apparatus according to claims 10 and 11 wherein the temperature adjusting device (22) is connected to the automatic control system (42) to be controlled thereby in dependence on sensed ambient temperature.

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14. Apparatus according to any one of claims 1 to 13 characterised in that one said diffuser (101) is arranged to be supplied with air from two said ducts (100, 110) via a common said plenum chamber (103) and via respective said variable constriction valves (14), said ducts (100, 110) being arranged to supply air at different respective temperatures.

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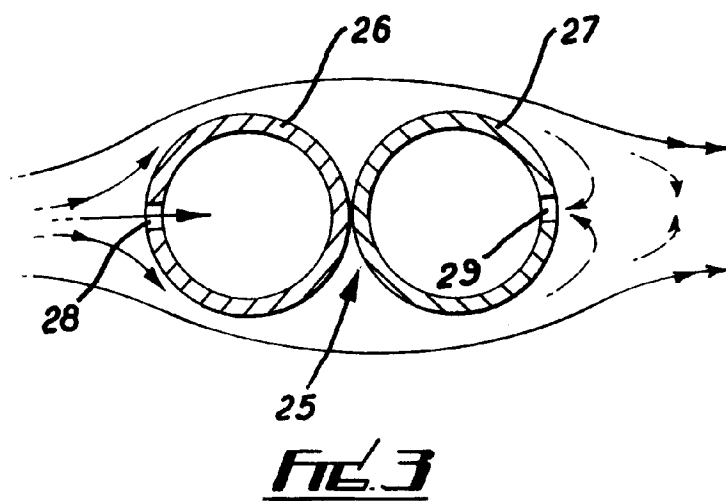
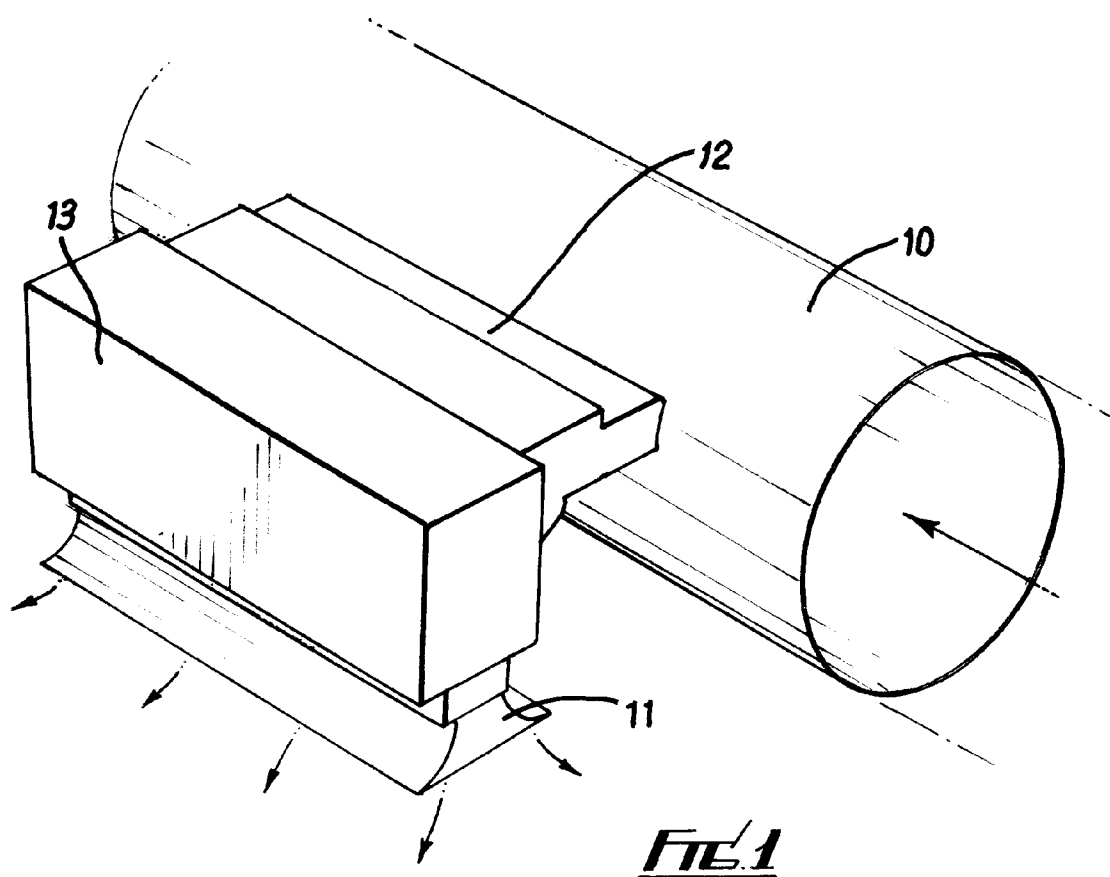
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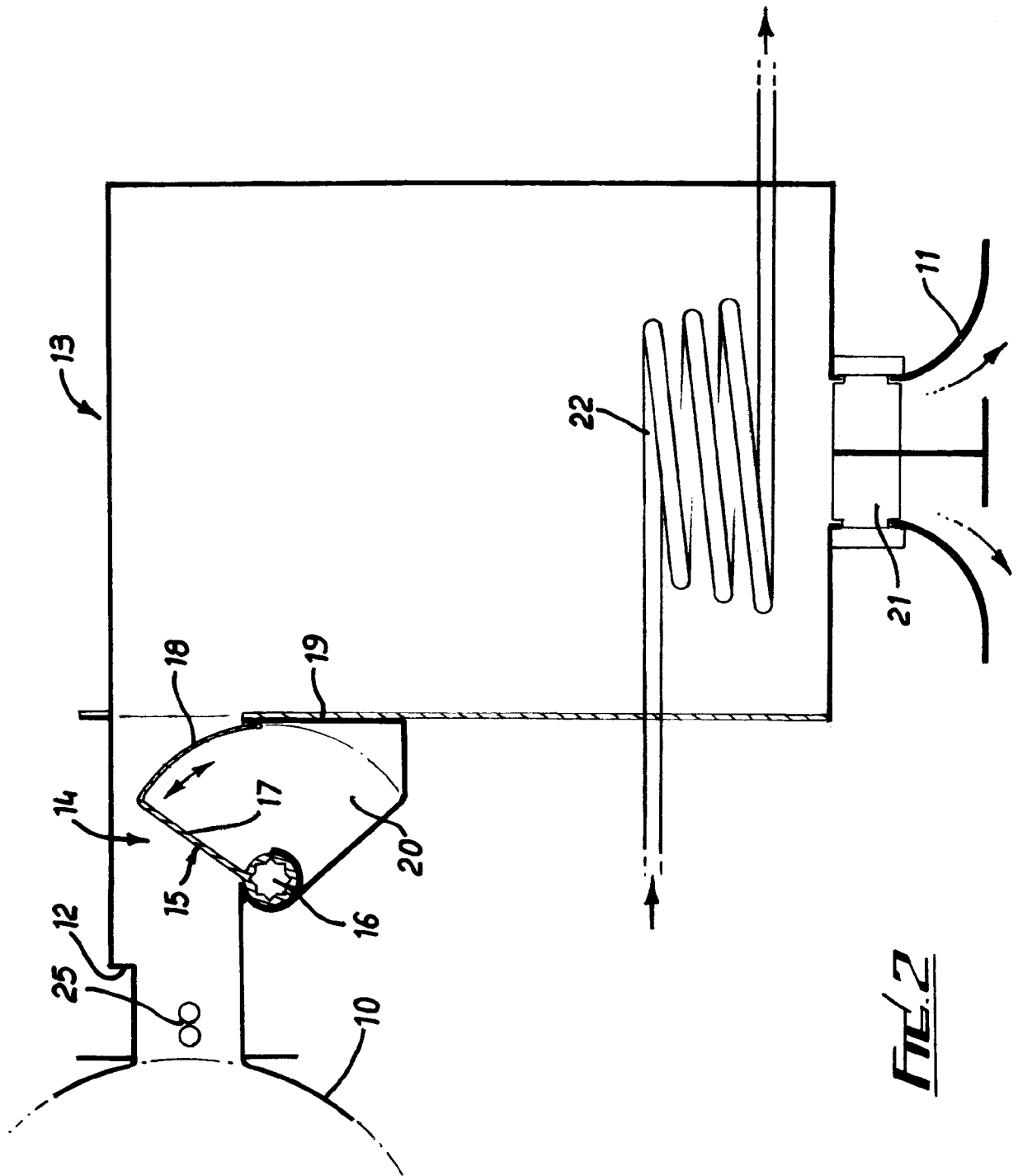


FIG. 2

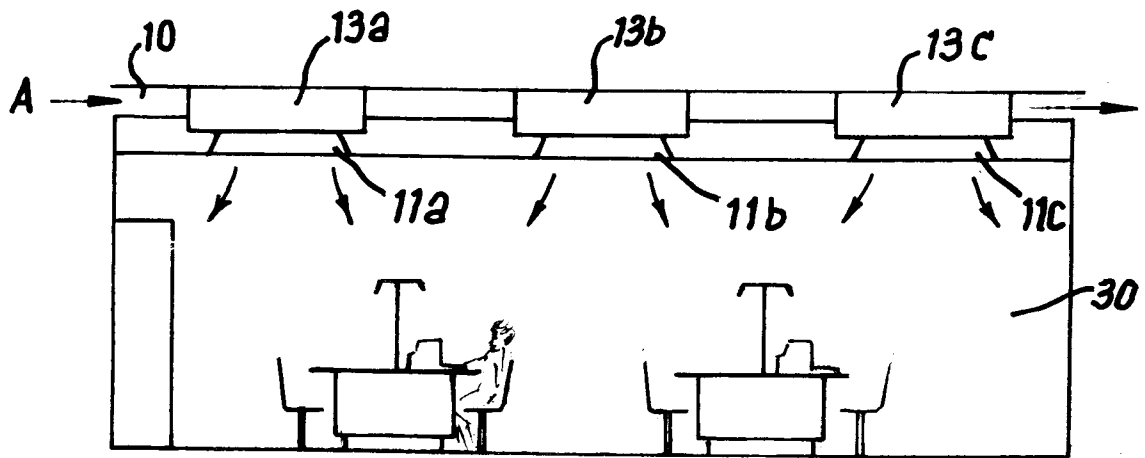


Fig. 4

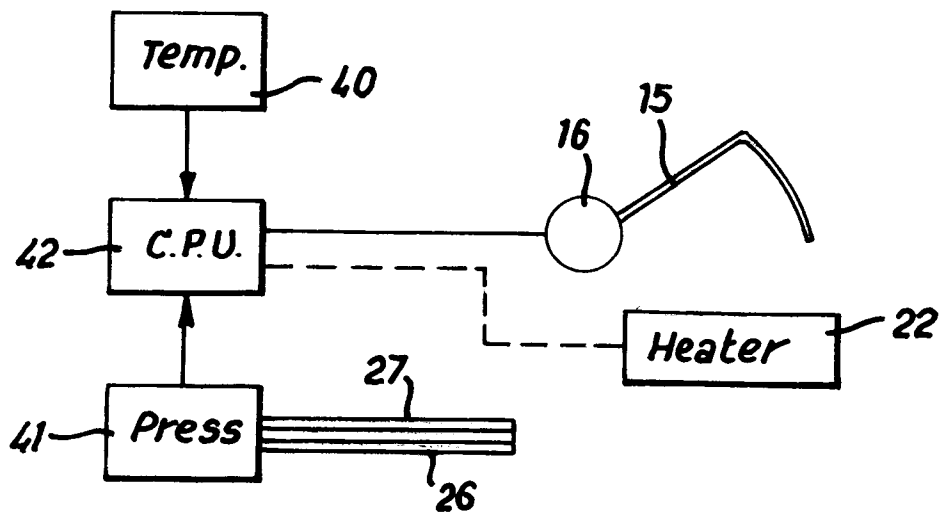


Fig. 5

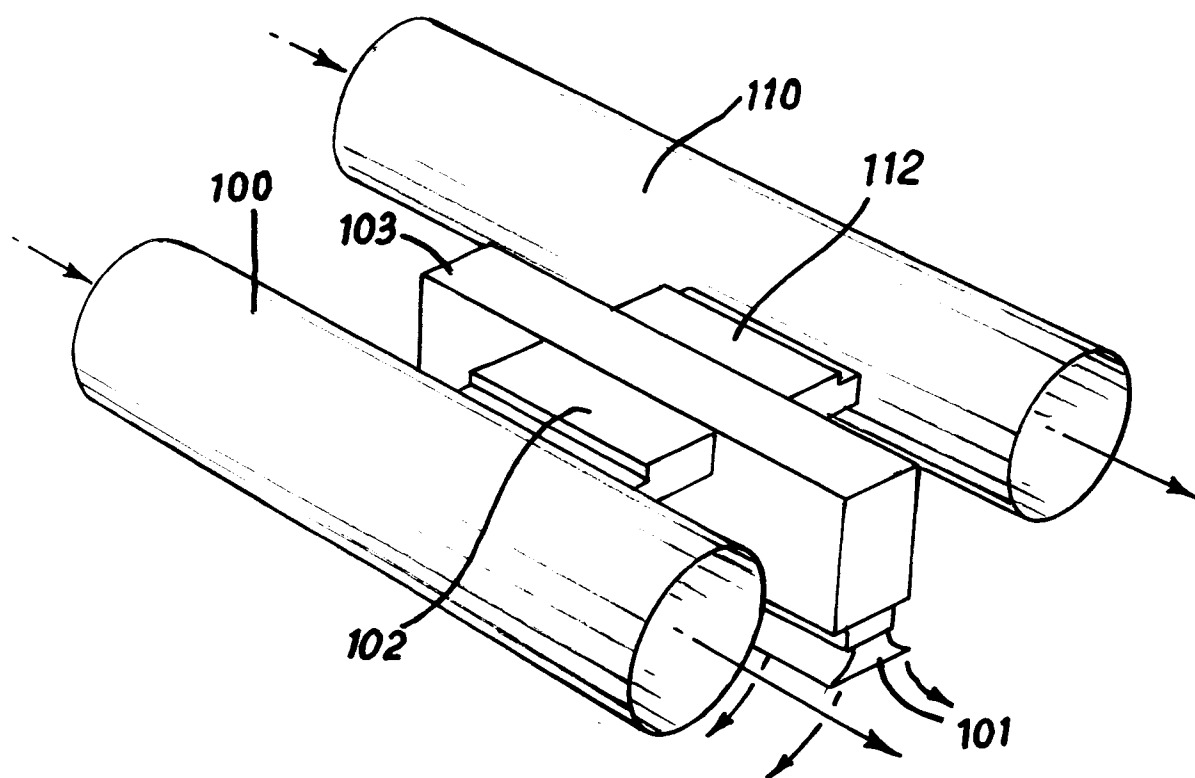


FIG. 6