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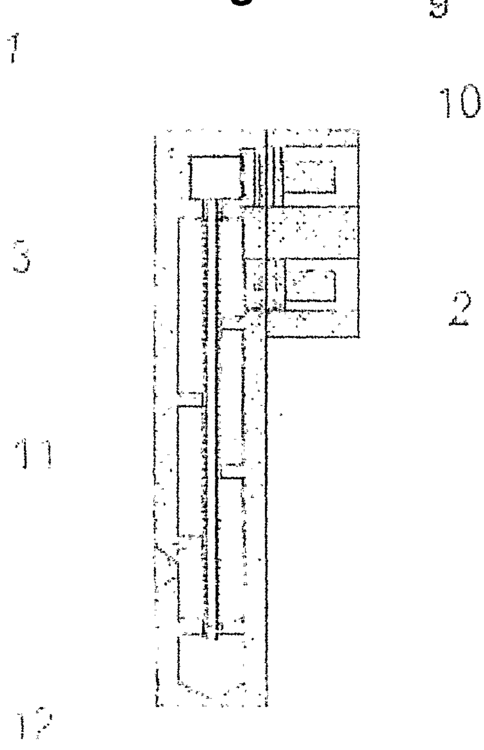
(54) Title: HEAT EXCHANGER

Fig. 1



(57) Abstract: The invention relates to a combination of a heat exchanger and heating of a gaseous medium, hereinafter "air", comprising a highly efficient heat exchanger composed of an exchanger body (1), with an inner space with an inlet (7) and an outlet (5) for the incoming air, in which there is a tubular radiator (2) with an inlet opening (4) and an outlet opening (6) for the exhausted air, and a powerful turbine (9) to compress the exhausted air and/or a turbine (10) for removing the incoming air to/from the heat exchanger, where a sufficient overpressure or underpressure is determined by nozzles (11) of the chamber and/or (12) the radiator (2), placed in the inlet opening (6) for the exhausted air and the inlet (7) for the incoming air. The invoked adiabatic processes in the heat exchanger and downstream of it, including the heat from the turbines and the electric motors, are used to heat the incoming air, which then heats and ventilates the closed area, and the connection of the nozzles and the turbines with the exchanger body (1) and the tubular radiator (2) is air-tight and all parts are placed in air-tight cases. The principle of the invention can be also used for a reverse effect, i.e. to cool the air blown to the ventilated area. However, the heat exchanger has to be adjusted so that the turbines (9, 10) with motors are placed in an arrangement where the first turbine (9) exhausts the exhausted air from the pipes of the radiator (2) and the other turbine (10) forces the incoming air to the last chamber of the heat exchanger. The radiator nozzle (12) is placed in the inlet opening (4) for the exhausted air to the pipes of the radiator (2) and the chamber nozzle (11) is placed in the last chamber of the heat exchanger.

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Heat exchanger

Technical field

The invention relates to a heat exchanger comprising an exchanger body with an inner space with an inlet and an outlet for an incoming gaseous medium - air, in which a tubular radiator is located with an inlet opening and an outlet opening for exhausted air.

State of the art

The prices of energy are constantly growing, and humanity is therefore facing a problem with the ventilation and heating of closed areas, such as flats etc., without unnecessary heat losses, which significantly increase the costs of their operation.

Presently, mostly separate heating and ventilation systems are used, with the use of air-conditioning on hot days, and in some cases also air recovery techniques, or the recovered air is additionally heated. The equipment is complicated, with high demands on manufacture and maintenance, without the needed valuation of the energy needed for its operation. It does not eliminate heat losses due to ventilation in closed areas.

Summary of the invention

The deficiencies above are, to a large extent, eliminated by a heat exchanger comprising an exchanger body with an inner space with an inlet and an outlet for an incoming gaseous medium, in which a tubular radiator is located with an inlet opening and an outlet opening for the exhausted air, as stipulated in this invention. Its essence is that there is an inlet turbine and/or an outlet turbine with a motor, hereinafter an electric motor, in the inlet opening and/or the outlet opening. In the outlet opening and/or the inlet there is an inner space nozzle, hereinafter the chamber nozzle and/or the radiator nozzle, and the vacuum in the inner space is equal to 0.8 to 0.2 times the external pressure and the overpressure in the tubular radiator is equal to 1.2 times to twice the external pressure. The connection of the nozzles and the turbines with the exchanger body and the tubular radiator is air-tight.

The heat exchanger therefore comprises a combination of a high-efficiency heat exchanger with a powerful turbine, driven by an electric motor, for the compression of the exhausted air, located in the area of the inlet opening for the exhausted air and/or for exhausting the incoming air from the heat exchanger, located in the area of the outlet for the incoming air, when a sufficient overpressure and underpressure are determined by the nozzle and radiator nozzles, located in the outlet opening for the exhausted air and in the inlet for the incoming air of the heat exchanger. The invoked adiabatic processes in the heat exchanger and downstream of it, including the heat from the turbines and the electric motors, are used to heat the incoming air, which then heats and ventilates the closed area, as stipulated in this invention. The connection of the nozzles and the turbines with the exchanger body and the tubular radiator is air-tight. All parts, including turbines with electric motors and connections to the air distribution pipes, are installed in sufficiently strong cases made from heat-insulating materials to avoid heat losses.

The invention presents a very advantageous and breakthrough solution. Ventilation combined with highly efficient heat interchange and the necessary heating of the incoming fresh air using the invoked adiabatic processes is secured by a gainful heat exchanger. The needed increase of the original temperature is achieved by adiabatic compression and expansion of air in the heat exchanger and downstream of it, including the use of all electricity supplied to the motors of the ventilators for air heating. This system achieves a significantly higher increase in air temperature than the quantity of the supplied electricity would provide. It is caused by the original combination of a highly efficient heat exchanger and the adiabatic processes invoked in it during air compression and expansion.

The air exhausted from the closed area is heated when the electric motors of the turbine are cooled, and then compressed by the turbine to the radiator pipes. A radiator nozzle is located at the end of the radiator pipes or in the outlet opening for the exhausted air; this radiator nozzle is designed to restrict the free passage of the exhausted air, which creates a large overpressure in the radiator pipes. The original temperature of the exhausted air is therefore first increased by temperature adequate to the heat supplied during the cooling of the turbine with the electric motor, the kinetic energy of gas supplied by the turbine and the energy generated by friction in the turbine and the gas. This pre-heated air increases the temperature thanks to adiabatic compression in radiator pipes. There, it is cooled to a temperature corresponding with the temperature of the incoming air and the efficiency of the heat exchanger. Passing through the radiator nozzle is followed by rapid adiabatic expansion and further cooling of the air to a temperature significantly lower than the temperature of the incoming air, which creates an energy balance in the whole system.

The air blown to the closed area first passes through the chamber nozzle, located at the air inlet to the first chamber upstream of the radiator end. It is designed to restrict the free passage of the incoming air, reducing its pressure significantly. The invoked adiabatic expansion in the chambers of the heat exchanger cools down the incoming air in the chambers by several degrees Celsius. Adiabatic compression of air in the radiator nozzles and adiabatic expansion of air in the chambers of the heat exchanger increase the temperature difference between the exhausted air and the incoming air inside the heat exchanger. If the efficiency of the heat exchanger is for example 95%, the incoming air is heated by 95% of the mentioned difference.

Another turbine exhausts and heats the air in the last chamber. Downstream of the turbine there is another adiabatic compression to the pressure of ambient air, which provides another heating. This reverse adiabatic process heats the incoming air again by several degrees Celsius.

The turbines with electric motors are placed in isolation cases so that they are fully cooled by the passing air, i.e. the first one with the exhausted air and the other one with the incoming air. The electricity supplied to them is therefore fully converted to heat that heats the exhausted and incoming air. This is heat supplied directly by heating motors as well as kinetic energy which, in gas, changes by internal friction again into heat, as soon as the air flow stops after passage to the closed areas. Likewise, the friction in the turbines fully converts into heat that heats the air.

The original temperature of the incoming air blown to the ventilated room therefore increases by the temperature corresponding with the electricity supplied to the electric motors of the turbines, which can achieve 15 to 50°C and more, temperature increase by way of heat interchange in the heat exchanger and the above-described adiabatic processes, which can achieve an increase by 10 to 40°C and more. The resulting temperature of the incoming air is therefore increased by 25 to 80°C and more, compared to the temperature of the exhausted air, with the same quantity of exhausted and incoming air, and the ventilated area is also heated in this manner. The resulting increase is particularly caused by the power of the turbines and the achieved pressure in the radiator pipes and the underpressure in the chambers of the heat exchanger. It is only reduced by the loss in the heat exchanger, given by its efficiency, as described above.

To maintain the same quantity of exhausted and incoming air, it is advantageous to complement the gainful heat exchanger with a device for indicating the quantity of the passing air. This is associated with the need to control air passage in the air suction as well as exhaust parts. This can be ensured either by controlling the power of at least one of the electric motors or by changes in the cross-section of the radiator nozzle or the chamber nozzle, or by a combination of both, depending on the purpose of use of the gainful heat exchanger.

The heat exchanger system guarantees a necessary efficiency exceeding 95%, with the same volume of incoming and exhausted air. Four and more chambers are needed for the purposes of the gainful heat exchanger; it is therefore possible to add one or several partitions. However, it is also possible to use a different type of heat exchanger with the required high efficiency and air-tight separated sections for incoming and exhausted air, in which it is possible to pressurize the section intended for the exhausted air and create underpressure in the section for the incoming air, e.g. multistage heat exchanger.

The gainful heat exchanger is especially intended for ventilating and heating closed areas, i.e. flats, offices, plants etc. If the ventilated areas are provided with good thermal insulation and the quantity of exhausted and incoming air in the heat exchanger is the same, warm air is not pushed out of the ventilated area and cold air is not sucked in from outside, so the heat losses only depend on the heat passing through the case, i.e. walls of the ventilated area and leaks when the door is opened etc. There are no losses due to ventilation, which usually constitute the primary part of heat losses. Dust and pollen filters are advantageously used at the inlets for incoming as well as exhausted air to limit soiling of the device and penetration of dust and pollen to the ventilated and heated areas.

If the location of the nozzles and the turbines in the heat exchanger changes, the gainful heat exchanger can be used to cool the air, just like air-conditioning; it can be used in closed areas to cool down the incoming air. Once again, the simultaneous ventilation and cooling of air is its big advantage. Subject to keeping the same volume of exhausted and incoming air, no hot air from outside is pumped in additionally. If the area is sufficiently thermally insulated, the costs of ventilation and cooling of air are minimal.

The advantages of this solution especially include low price, low demands on production and installation, long lifetime and easy maintenance, which makes this device available for the general public. In addition, its operation does not create any environmental burden. If the system is complemented with filters, a timer and a thermostat, it provides for a high comfort of the environment by itself, with the required temperature, cleanliness and air humidity, and always ventilated. This all with significant savings on heating, which exceeds 50% in well-insulated flats.

Brief description of the drawings

The gainful heat exchanger based on this invention will be described in detail on specific embodiments using the attached drawings, where figure 1 shows a side view of the gainful heat exchanger. Figure 2 shows a right side view of the gainful heat exchanger. Figure 3 shows a bottom view of the heat exchanger. Figure 4 shows a front view of the heat exchanger system used in our embodiment. Figure 5 shows a top view of the heat exchanger system, with an indication of its inner arrangement.

Preferred embodiment of the invention

The embodiment of a gainful heat exchanger comprising a highly efficient heat exchanger, employing the heat exchanger system specified in invention application CZ PV 2003-1875, featuring an exchanger body **1** with an inner space with an inlet **7** and an outlet **5** for the incoming air and an inlet opening **4** and an outlet opening **6** for the exhausted air. A turbine **9** with an electric motor providing compression of the exhausted air and a turbine **10** with an electric motor providing suction of the incoming air are located in the inlet opening **4** at the outlet **5**, and a radiator nozzle **12** and a chamber nozzle **11** are located in the outlet opening **6** and the inlet **7**, and the radiator nozzle **12** is advantageously situated at the bottom of the exchanger body. The connection of the nozzles **11**, **12** and the turbines **9**, **10** with the exchanger body **1** and the tubular radiator **2** is air-tight. All parts, including cases for the installation of the turbines **9**, **10** with electric motors and connections to the air distribution pipes, are made from thermal insulating materials with a sufficient strength to avoid heat losses and deformation of the device.

In the embodiment of a gainful heat exchanger in its basic design, the air exhausted from the ventilated area is forced by the turbine **10** to the pipes of the radiator **2**. A radiator **2** nozzle **12** is located at the end of the radiator **2** pipes or in the outlet opening **6** for the exhausted air; this radiator **2** nozzle **12** restricts the free passage of the exhausted air, which creates a large overpressure in the radiator **2** pipes. The air forced to the ventilated area first passes through the chamber nozzle **11**, located at the air inlet **7** to the first chamber, located in the section of the heat exchanger closer to the radiator **2** nozzle **12**, i.e. in the area of the last part of the radiator **2**. It restricts the free passage of the incoming air and reduces its pressure in the chambers of the heat exchanger significantly. The other turbine **9** removes air from the last chamber.

The turbines **9**, **10** with electric motors are placed in openings and cases so that they are fully cooled by the passing air, i.e. the first one with the exhausted air and the other one with the incoming air. It is advantageous to place them directly in the heat exchanger body. At the same time it is necessary to keep the connection of the turbine to the pipes of the radiator **2** in the former case and the connection to the last chamber of the heat exchanger in the latter case air-tight. Likewise, the outlet from the pipes of the radiator **2** to the radiator **2** nozzle **12** and the outlet from the last chamber of the heat exchanger to the chamber nozzle **11** shall have air-tight connections. An air-tight separation of the chambers from the pipes of the radiator **2** is a matter of fact. The whole system, i.e. the heat exchanger including electric motors and turbines and the connection to the ventilated area as well as the external environment, shall be made with a thermal-insulated case and pipes with sufficient thermal insulation to avoid heat losses through the walls of the heat exchanger or the cases around the motors and the turbines, or through air distribution pipes. The heat exchanger body, the pipes of the radiator and other parts connecting the turbines to the heat exchanger, if applicable, shall be made from materials of a sufficient strength to resist pressure and underpressure without deformation and, if applicable, vibrations caused by the electric motors and the turbines.

To maintain the same quantity of exhausted and incoming air, it is advantageous to complement the gainful heat exchanger with a device for indicating and controlling the quantity of the passing air. This can be ensured either by controlling the power of at least one of the electric motors or by changes in the cross-section of the radiator nozzle or the chamber nozzle, or by a combination of both, depending on the purpose of use of the gainful heat exchanger.

The gainful heat exchanger can be located inside ventilated areas as well as outdoors, in particular directly on building walls, similarly to air-conditioning units. In case of flats, it is especially expected to be placed outdoors to prevent the noise from the electric motors and the turbines from entering the inside. The distribution pipes remove the air for example from the kitchen and force it to the rooms so as to make sure that the incoming air passes from the most distant parts of the rooms to the corridors, and then on to the air exhaust point. It is advantageously placed in the kitchen of the flat etc. This ensures a very efficient air exchange, when clean and heated air gradually forces out original air, ensuring excellent ventilation and heating of the rooms. The distribution system can be made from round pipes, flat pipes or built-in channels. However, it is necessary to comply with the specified cross-sectional areas to avoid excessive resistance for air passage. Dust and pollen filters are advantageously used at the inlets for incoming as well as exhausted air to limit soiling of the device and penetration of dust and pollen to the ventilated and heated areas.

In practice, it is enough for flats with a floor area of 60 to 90 sqm, for ventilation and on cold days also for heating, to switch the gainful heat exchanger on for about 1.5 hours a day, in individual intervals divided for 15 - 30 - 15 - 30 minutes. With the total input power of the turbines for example at 1.5kW, only 2.25kW are consumed every day, i.e. not more than CZK 20 a day. These costs are further reduced by suitable tariffs for electricity, based on the concluded contracts. The dimensions of an aluminium radiator, which limit the total dimensions of the gainful heat exchanger, can be similar to that of a car radiator, i.e. 100 x 25 x 4cm. The turbines **9** and **10** with electric motors are similar to those in vacuum cleaners. However, it is necessary to reduce their noise, e.g. by making them from light alloy casts, instead of sheet metal. In its basic design, the gainful heat exchanger can be produced with the dimensions 140 x 35 x 30cm. The weight is about 8kg. The advantages of this system are evident. If the system is complemented with a timer, filters and a thermostat, it provides for a high comfort of the environment by itself, with the required temperature, air humidity, and always ventilated. This all with significant savings on heating, which exceeds 50% in well-insulated flats.

To better understand the advantages of this device, a simplified practical example of calculation is specified for specific conditions of the environment and parameters of the device.

The values and their use for the calculation are approximate, but real, e.g. the values involving turbines and electric motors are similar to those achieved by current vacuum cleaners.

Air:

specific weight $\varsigma = 1.28$ (kg/m^3)

specific gas constant $r = 800$ (J/kg^{0}K)

ambient air pressure: $p_1 = 100,000$ (Pa)

outdoor temperature: $t_0 = 0^0C$ i.e. $T_0 = 273^0K$

indoor temperature: $t_V = 20^0C$ i.e. $T_V = 293^0K$

Poisson constant for air: $\kappa = 1.3$

Turbines and heat exchanger:

turbine power input: $P_1 = P_2 = P = 1,000W$

heat exchanger efficiency: 95 %

overpressure: 125,000Pa

underpressure: 75,000Pa

quantity of exhausted air: V = 0.05 cu m per s

Used relationships:

$$\Delta t = \frac{(p_2V_2 - p_1V_1).T}{p_1V_1}; \quad P = V.\varsigma.r.\Delta t \ ; \quad p_1V_1^{\kappa} = p_2V_2^{\kappa}$$

The calculation itself determined the final temperature of the incoming air:

$$t = 73.7 \quad (^{0}C)$$

Under the given conditions, the incoming air would be heated from 0°C to 73.7°C.

To give a notion on the advantages of the invention, a comparison with conventional ventilation complemented with heating to the air temperature supplied by the gainful heat exchanger is added, with the outdoor temperature 0°C and indoor temperature 20°C, for a flat with a floor area of 72 sqm and a volume of 180 cu m:

a) energy needed for conventional air exchange with pre-heating from 0°C to 73.7°C:

Q = V.ç.r.Δt ; Q = 180.1,28.800.73,7 = 13,584,384 (J) = 13.6 (MJ) = 3.8 (kWh)

b) energy used on the same air exchange by the gainful heat exchanger: t=180:0,05=3600 (s)

Q = P.t ; Q = 2000.3600 = 7,200,000 (Ws) = 7.2 (MJ) = 2 (kWh)

In this case the invention has approximately twice as low energy consumption, i.e. costs of operation.

The principle of the gainful heat exchanger can be also used for a reverse effect, i.e. to cool the air blown to the ventilated area. However, the heat exchanger has to be adjusted so that the turbines **9**, **10** with electric motors are placed in an arrangement where the first turbine **9** exhausts the exhausted air from the pipes of the radiator **2** and the other turbine **10** forces the incoming air to the last chamber of the heat exchanger. The radiator **2** nozzle **12** is placed in the inlet opening **4** for the exhausted air to the pipes of the radiator **2** so that the pressure inside the pipes of the radiator **2**, i.e. its temperature, is reduced during operation. The chamber nozzle **11** is located in the last chamber and increases the pressure and temperature of the air inside the chambers of the heat exchanger. After passing through the chamber nozzle, the air exhausted to the ventilated areas goes through adiabatic expansion. Therefore, it is significantly cooled down to a temperature significantly lower than the temperature of the exhausted air. In this arrangement, the electricity supplied to the electric motors and the thermal energy generated by friction in the turbine heat directly the exhausted air downstream of the heat exchanger, i.e. without any influence on the temperature of the incoming air forced to the ventilated areas. Both types of energy from the turbine and the motor forcing the air to the ventilated areas are reflected in an increase of the temperature of the incoming air before it enters the first chamber of the heat exchanger, which is eliminated inside the heat exchanger depending on the efficiency of the heat exchanger, where the incoming air is cooled almost to the temperature of the exhausted air in the final section of the pipes of the radiator **2**. The electric motor of the second turbine **10** and the turbine **10** itself can be cooled separately by outside air, so the temperature of the air in the heat exchanger is not increased.

Industrial applications

A heat exchanger as stipulated in this technical solution can be especially used for ventilating and heating closed areas, i.e. flats, offices, plants etc. The gainful heat exchanger can be also used for cooling air or for air-conditioning.

PATENT CLAIMS

1. A heat exchanger comprising an exchanger body (1) with an inner space with an inlet (7) and an outlet (5) for incoming air, in which there is a tubular radiator (2) with an inlet opening (4) and an outlet opening (6) for exhausted air, ***characterized*** by the fact that an inlet turbine (9) and/or an outlet turbine (10) with electric motors are placed in the inlet opening (4) and/or the outlet (5) and a nozzle (11) of the inner space and/or a nozzle of the radiator (2) are placed in the outlet opening (6) and/or the inlet (7), while the underpressure in the inner space is equal to 0.8 to 0.2 times the external pressure and the overpressure in the tubular radiator (2) is equal to 1.2 to 2 times external pressure, and the connection of the nozzles (11), (12) and the turbines (9), (10) with the exchanger body (1) and the tubular radiator (2) is air-tight.

2. A heat exchanger as in Claim 1, ***wherein*** the tubular radiator (2) is straight and fitted with sheet-metal fins.

3. A heat exchanger as in Claim 1 or 2, ***wherein*** the exchanger body (1) is fitted with at least for inner partitions (3) seated on the tubular radiator (2).

4. A heat exchanger as in any of the above Claims, **wherein** the exchanger body (1) is fitted with a closable opening (8).

5. A heat exchanger as in any of the above Claims, **wherein** all parts, including connections to the air distribution pipes, are made from thermal insulating materials with a sufficient strength to avoid heat losses and deformation of the device.

6. A heat exchanger as in any of the above Claims, **wherein** at least one electric motor and/or at least one nozzle is fitted with a controller.

7. A heat exchanger as in any of the above Claims, **wherein** filters are placed in the inlet opening (4) and/or the inlet (7).

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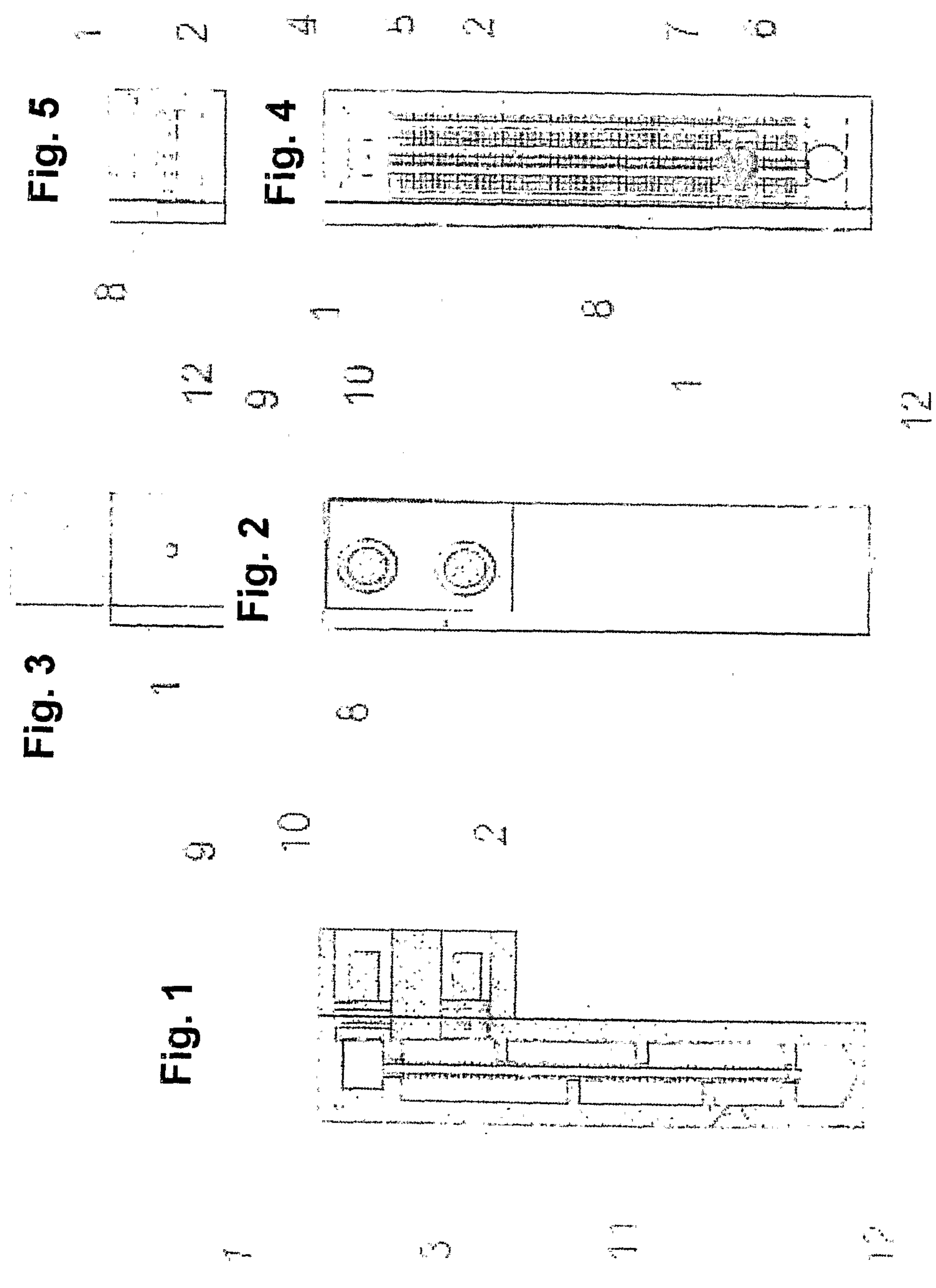

Fig. 5
Fig. 4
Fig. 3
Fig. 2
Fig. 1