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[54] DEMOUNTABLE HEAT PUMP WITH HERMETICALLY SEALED CIRCUIT

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[51] **Int. Cl.** **F25d 17/00**

[58] **Field of Search** 62/333, 499, 468; 165/29, 86, 165/88

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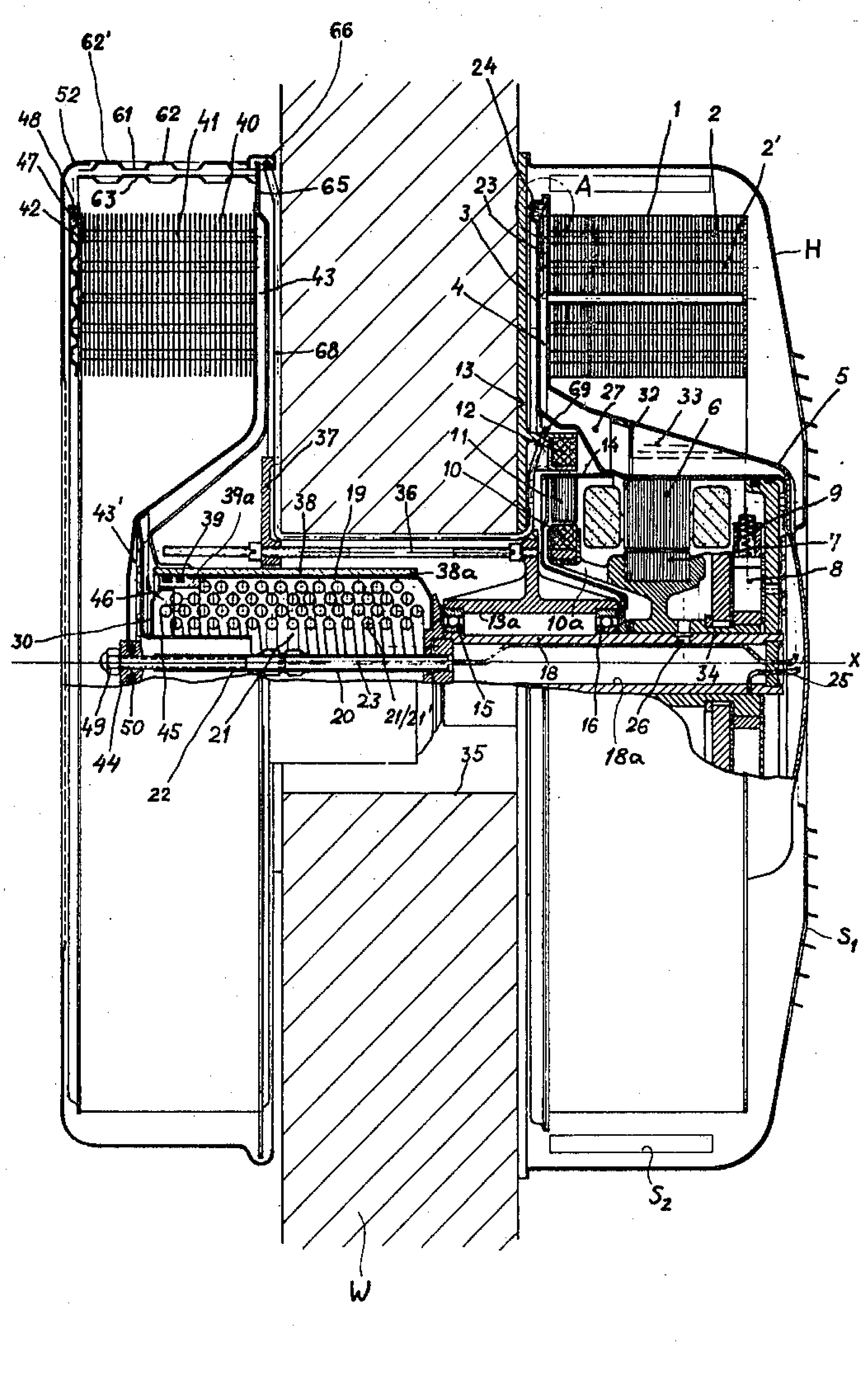
[57] **ABSTRACT**

A heat pump having a rotary air-flow-inducting heat exchanger, e.g., mounted on an exterior wall of a space whose temperature is to be controlled, forming a heat-pump circulation path with a further heat exchanger and a compressor. The latter is motor driven and is coupled with at least one of the heat exchangers via a magnetic drive operating through a magnetically permeable wall.

9 Claims, 5 Drawing Figures



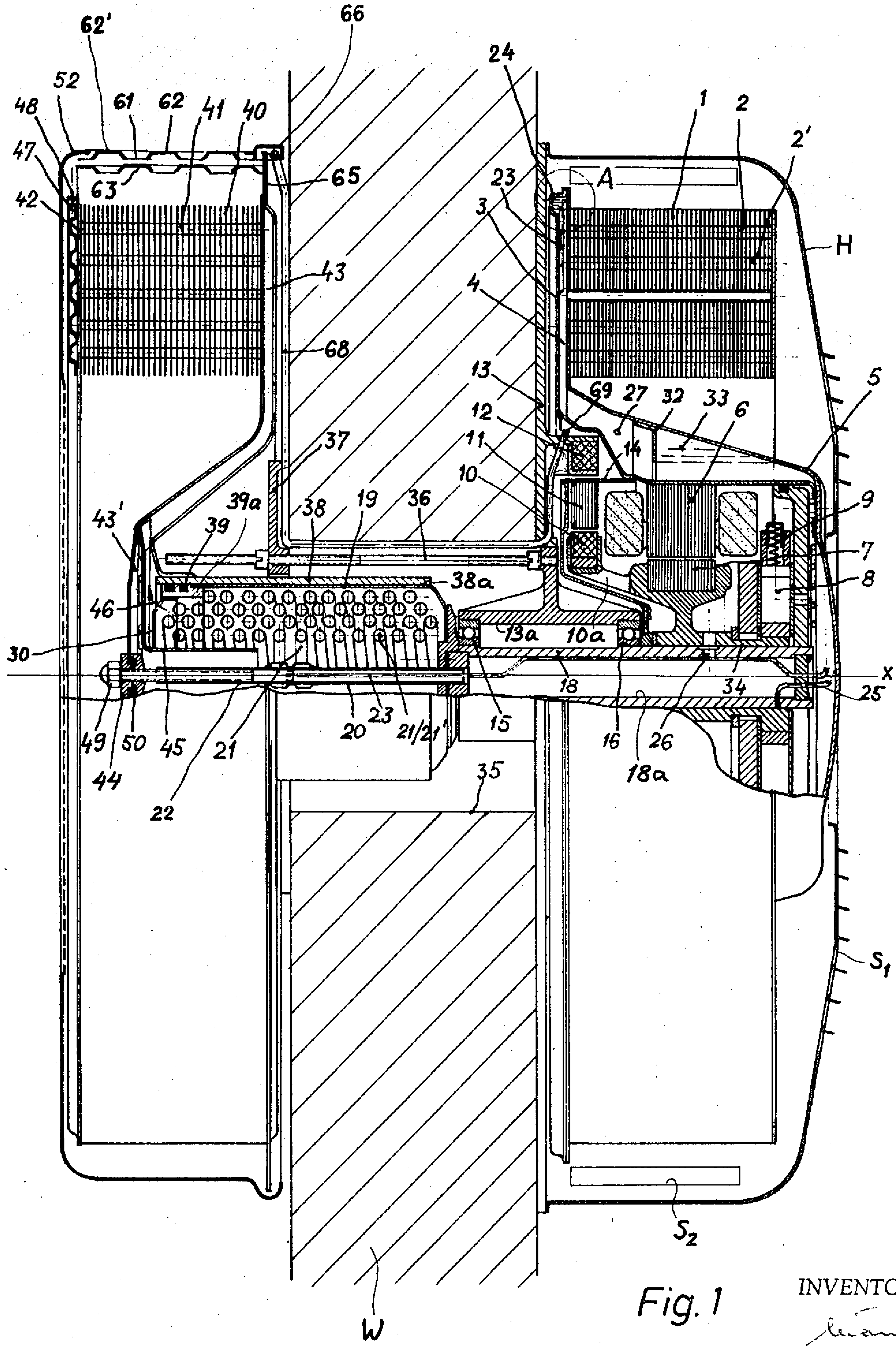


Fig. 1

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Fig. 3

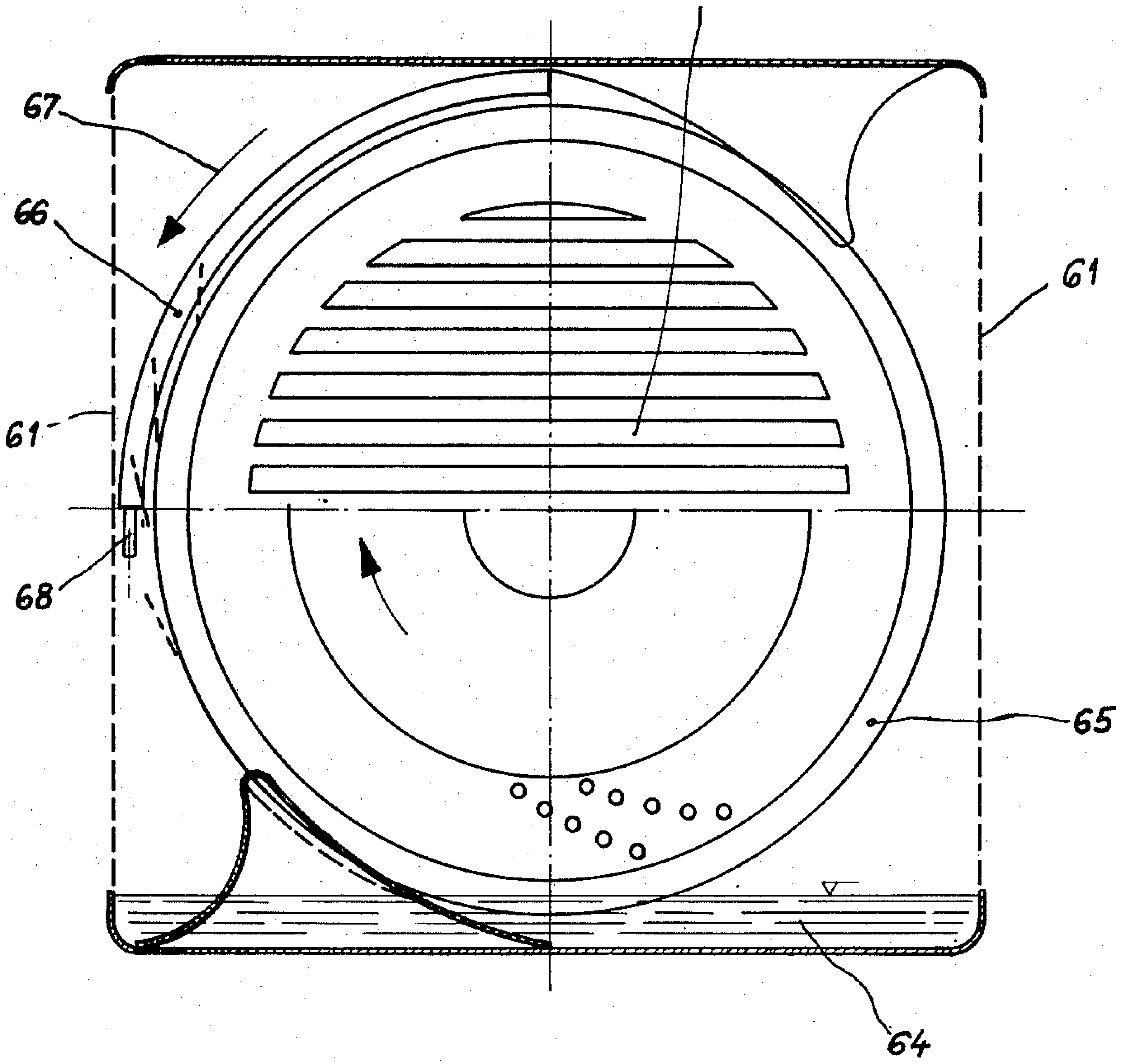

Fig. 2

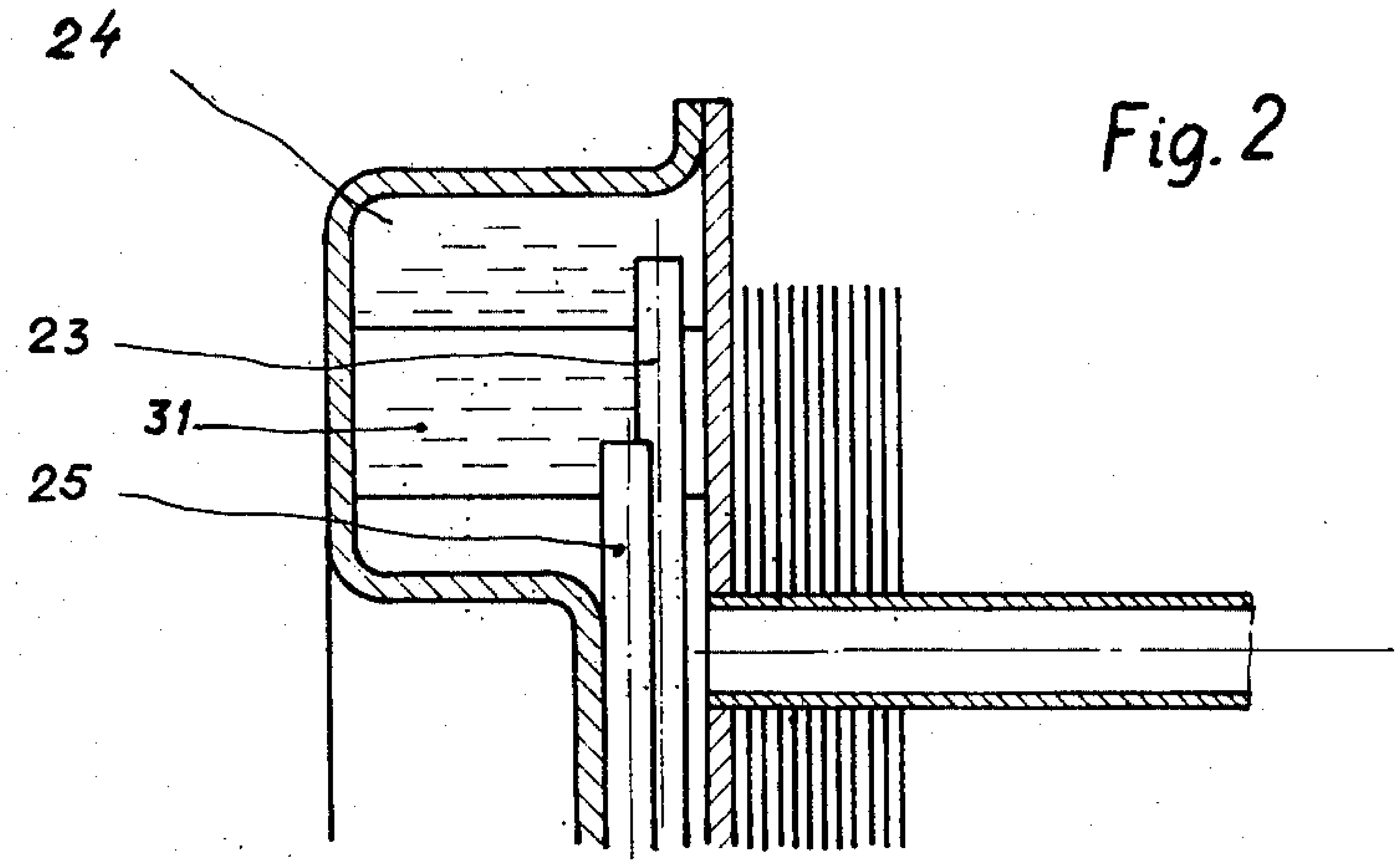

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Fig. 4

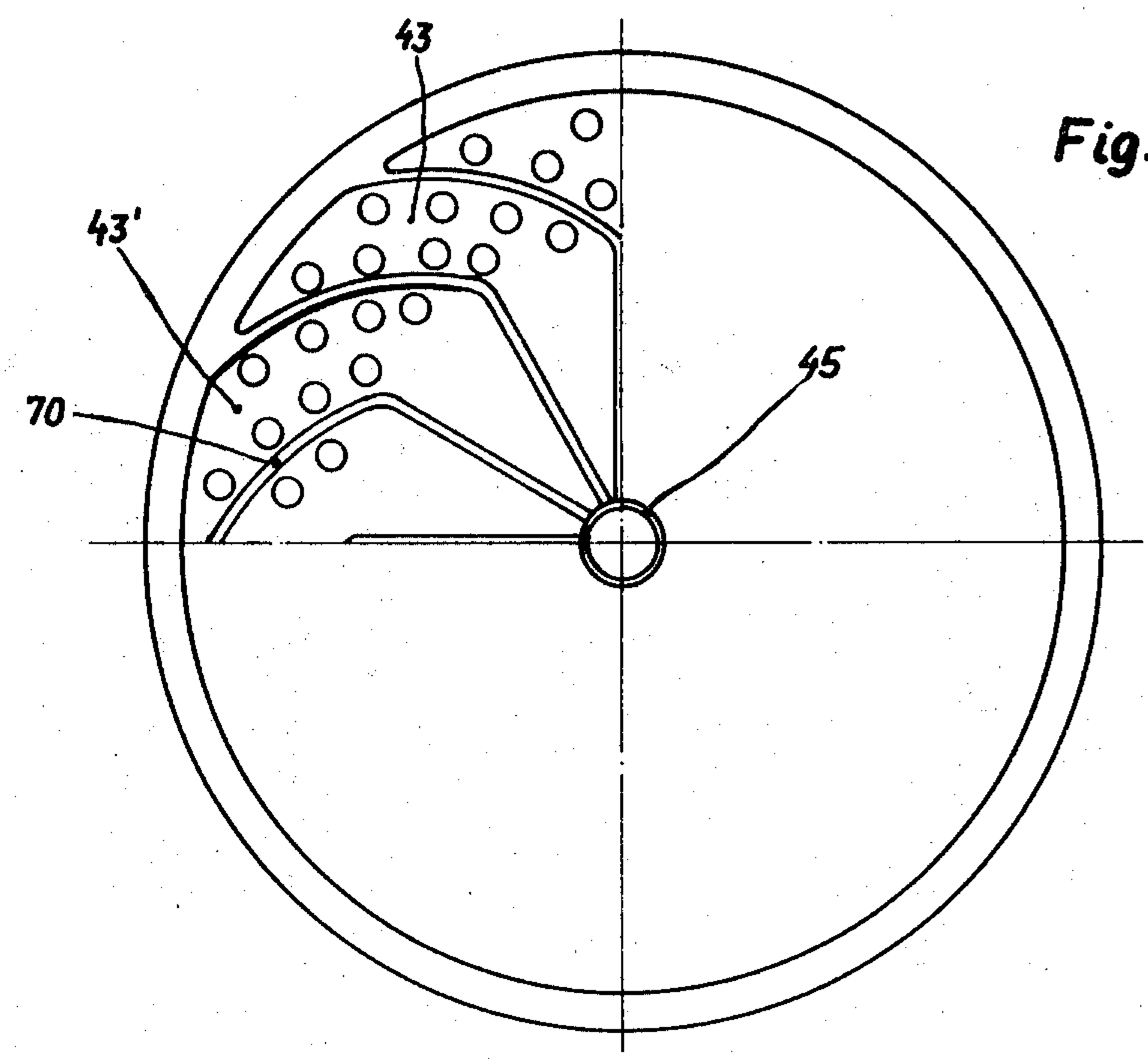
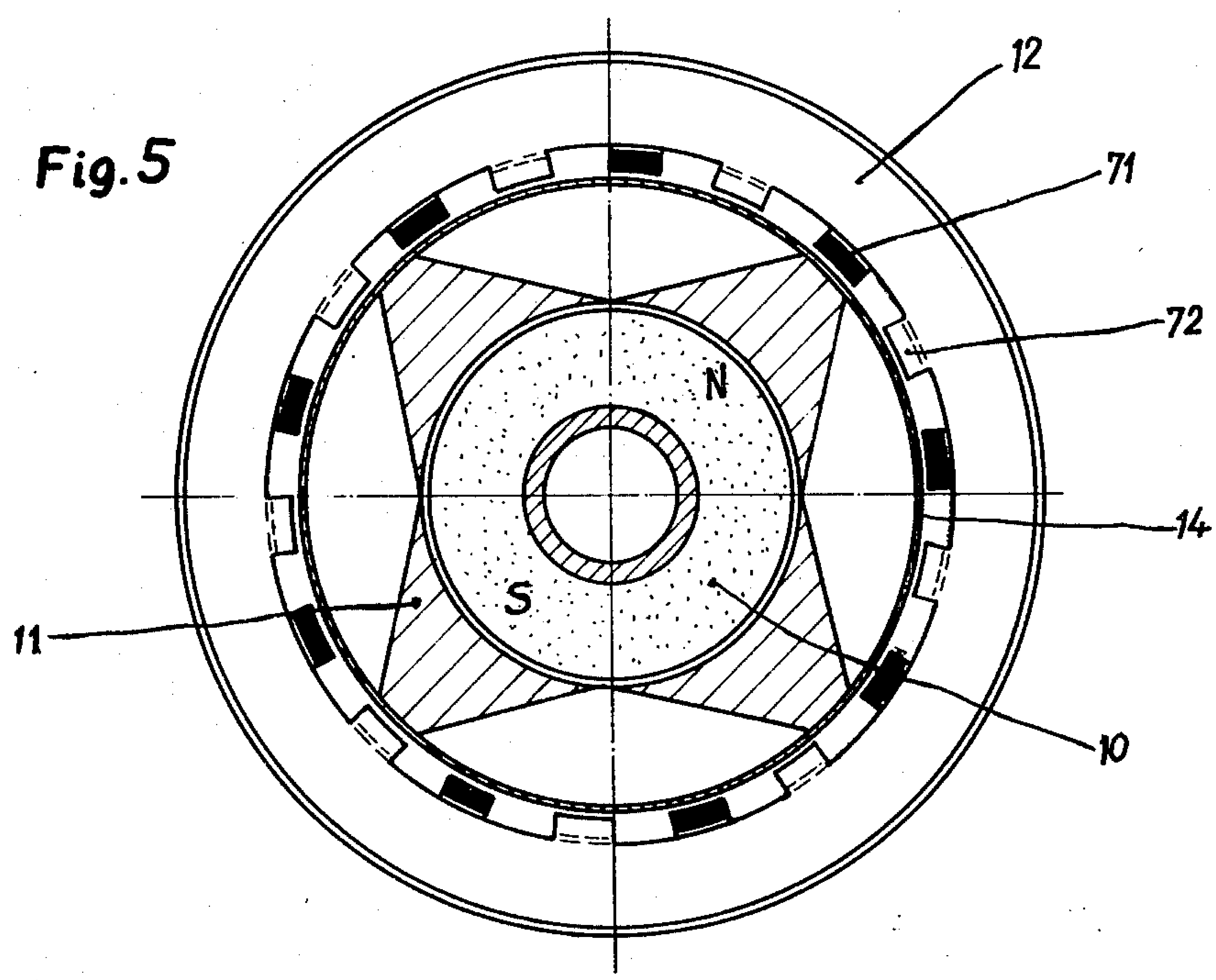


Fig. 5



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DEMOUNTABLE HEAT PUMP WITH HERMETICALLY SEALED CIRCUIT

FIELD OF THE INVENTION

The present invention relates to a heat pump for the heating and/or cooling of an interior space provided with a wall separating it from an exterior space and, more particularly, to an improved heat pump for the cooling of an enclosed space.

BACKGROUND OF THE INVENTION

For the heating and/or cooling of interior or enclosed spaces, e.g., building rooms separated by a wall from the exterior, either to maintain a specified temperature within the space or simply to cool the latter during periods of high exterior temperatures, it is known to provide so-called "air-conditioning" units in the wall separating this space from the exterior. In general such units include a heat-exchanger and fan or blower combination designed to expel heat abstracted from the space to be cooled to the exterior, a compressor, pump or like device inducing a change of state of a heat-pump fluid (e.g., a refrigerant), and a further heat-exchanger and blower combination in the fluid circuit for effecting heat transfer between the air within the enclosed space and the fluid. When the entire assembly constitutes a single body mounted on a common support, the disposition of the unit in the wall requires a large aperture which must be opened or provided during construction. It has, therefore, been common with such units to provide a window mounting which, however, obstructs the window.

To obviate some of the disadvantages of such systems, it has been proposed to provide air conditioners and space coolers in which the compressor, to limit the size of the wall opening required and reduce the noise in the space to be cooled, is located outside the space to be cooled while a heat-abstracting device (e.g., a heat exchanger) is disposed within the cooled space. A pair of connecting conduits, leading fluid to and removing it from this device, is passed through the wall. These systems, denominated "split units," necessitate only a small aperture in the wall, but have the disadvantage that separate drives are required for the interior heat exchanger and the compressor and exterior heat exchanger.

Mention may also be made of the existence of so-called rotary heat exchangers in which a compressor, heat-dissipating heat exchanger and heat-abstracting heat exchanger are coupled on a common shaft, the heat exchangers providing fluid channels for the heat-pump medium and, in addition, forming blowers or the like inducing the flow of air into heat-exchanging relationship with the channels. The last-mentioned heat pumps of prior-art construction require large apertures in the separating wall and are accompanied by the disadvantages of single-unit air conditioners mentioned earlier.

OBJECTS OF THE INVENTION

It is the principal object of the present invention to provide an improved heat pump of the rotary-heat-exchanger type which is of simple construction, requires a relatively small aperture in a wall in which the unit may be mounted, and provides efficient heat transfer between air on opposite sides of this wall.

Another object of this invention is to provide an improved heat pump utilizing rotary heat exchangers.

Still another object of the invention is to provide an air-conditioning or air-cooling unit for enclosed spaces which is mountable directly in a wall separating the enclosed space from the exterior and wherein the disadvantages of earlier systems for this purpose are avoided.

It is also an object of this invention to provide a cooling unit for an enclosed space which is of low cost, compact construction and high efficiency.

Yet a further object of this invention is to provide a room air conditioner mountable in a wall of the room but requiring only a small aperture in the mounting wall.

BRIEF DESCRIPTION OF THE INVENTION

The foregoing and other objects, which will become apparent hereinafter, are attained in accordance with the present invention with a heat pump having a hermetically sealed fluid circuit which comprises a first rotary heat exchanger, a compressor or other rotary device for modifying the thermodynamic state of a heat- pump fluid displaceable in a closed circuit including the heat exchanger, and a driving unit for the rotary heat exchanger, combined in a unitary structure supported by a mounting plate affixed to the wall separating the enclosed space from the exterior, and having a hub unit traversing an aperture of limited size in this wall. A second rotor, forming part of another heat-exchange arrangement, is removably or detachably mounted on the hub from the interior space, the hub structure having a diameter which may be a small fraction of the diameter of the rotors.

More specifically, the apparatus of the present invention comprises a first rotary heat exchanger of the type having channels traversed by the heat-exchange medium and means for inducing the flow of air in heat-exchanging relation with the medium in the channels, the rotary heat exchanger being mounted rotatably along the exterior side of the wall separating the enclosed space from the exterior; the device for modifying the thermodynamic state of the medium is mounted in the hub structure also along the exterior side of the wall and preferably is a compressor (although other functionally similar means, e.g., operating in accordance with the PELTIER effect, may also be used), having a rotary member driven by the drive means which is also common to the rotary heat exchanger. When the heat pump of the present invention is used to cool the interior space (e.g., is an "air conditioner" in accordance with common parlance), the rotary heat exchanger serves to transfer heat from the medium to the exterior air which is drawn through the rotor, while a second heat exchanger within the hub structure forms the heat-abstracting means and is disposed along an end of the hub structure proximal to the interior space. The heat exchangers and the compressor are connected by ducts in a hermetically sealed unit, the ducts extending through the hub structure.

According to a more specific feature of the invention in accommodation of the fact that the cooling-medium circuit should not be interrupted in a hermetically sealed system, thermal conduction to the heat-abstracting or second heat-exchange arrangement is effected via a liquid heat carrier having a high GRASHOF coefficient, e.g., a mixture of methyl alcohol and water. This liquid heat carrier is circulated within the second heat exchanger at least in part by gravity between conduits leading from the ribs to the center and return conduits. The rotary heat exchanger is driven through a magnetic transmission transmitting torque by magnetic means through a nonmagnetic partition.

As noted earlier, the thermodynamic state-changing device may comprise electronic PELTIER-effect elements or reciprocating fluid-displacement means instead of a rotary compressor.

DESCRIPTION OF THE DRAWING

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is an axial cross-sectional view through a heat pump in accordance with the present invention, some parts being broken away while others are represented in side elevation;

FIG. 2 is a detail view, in an enlarged cross-section, of the region represented at A in FIG. 1;

FIG. 3 is an end view of the unit from the interior side of the support wall, partly broken away, illustrating the rotor for abstracting heat from the room air and its housing;

FIG. 4 is an end view of this rotor in diagrammatic form; and

FIG. 5 is a transverse section through the magnetic transmission in accordance with the invention.

SPECIFIC DESCRIPTION

Structure

In general the unit of the present invention comprises, at the right-hand or exterior side of the mounting wall, an annular first rotary heat exchanger adapted, in the case in which the unit is used as a cooler for the interior space on the left-hand side of the wall, to transfer heat from a refrigerant to the exterior air; a hub unit traversing the wall; a compressor or similarly functioning device for modifying the thermodynamic state of the cooling medium mounted in the right-hand side or exterior portion of the hub unit and surrounded by the annular first rotary heat exchanger; a motor axially inwardly of the compressor, but nevertheless located along the exterior side of the wall and surrounded by the first rotary heat exchanger; a heat-transfer device located within the hub structure and extending beyond the left-hand or interior side of the wall and of helical-tube configuration, the heat-transfer device serving as the heat-abstracting member of the hermetically sealed unit consisting also of the compressor and first rotary heat exchanger; and a second rotary heat exchanger of annular configuration in part surrounding the heat-exchange device and serving to transfer room heat to the latter, the second rotary heat exchanger being provided with a heat-transfer liquid of high GRASHOF coefficient as noted earlier and being located along the left-hand or interior side of the wall.

The first rotary heat exchanger comprises an annular array of generally radial ribs **1** traversed by angularly equispaced tubes **2** running parallel to the axis X of rotation of the assembly. These tubes **2** are open toward the hollow wheel disk **3**, which extends generally transversely of this axis, and communicate with the annular space **4** provided within the disk **3**. In the region **5**, the wheel disk is dished into a generally frustoconical inwardly divergent configuration and accommodates the compressor **9**.

Axially inwardly of the compressor **9**, but adjacent the latter and within the frustoconical enclosure **5** of disk **3**, there is provided an electric motor. The stator **6** of this electric motor is press-fitted into a cylindrical inner sleeve of the frustoconical portion **5** of the disk **3** and surrounds the armature **7** to drive the latter at high speed. The armature **7** is mounted upon a hollow shaft **18** to which is likewise connected the rotor **8** of the rotary compressor **9**.

To drive the disk **3**, carrying the ribs **1** and the fluid channels **2** of the first rotary heat exchanger, there is provided a magnetic transmission within a magnetically permeable but non-magnetic partition **14**, forming an extension of the inner cylindrical sleeve of the frustoconical portion **5** of the disk. The transmission, located axially inwardly of the motor (to the left thereof in FIG. **1**), is designed to drive the first rotary heat exchanger at an angular velocity somewhat less than that of the compressor rotor **8**, and is shown in greater detail in FIG. **5**.

The transmission includes a rotor **10**, connected with the motor armature **7** via arms **10*a***, of a permanently magnetic material as represented by stippling in FIG. **5**. This rotor induces a magnetic flux in the laminar assembly **11** (composed of axially stacked lamellae as illustrated in FIG. **5**) which, in conjunction with an annular external magnet **12** rigidly connected with the mounting plate **13**, produces a rotary movement of assembly **11**, the sleeve **14** to which it is affixed, the disk **3** and the heat-exchange members **1** and **2** connected therewith. Thus the entire system, consisting of the first heat exchanger **1 – 5** and the compressor rotor **8** together with the shaft **18**, is driven about the axis X.

The entire rotating system is supported in the mounting plate **13** by a bearing housing **13**a and a pair of axially spaced ball bearings **15** and **16**. A tube housing **19** is attached to the hollow shaft **18** and receives a central tube **20**, the latter extending axially inwardly beyond the hollow shaft **18**.

Central tube **20** is provided with a helical coil **21/21'** of thin-walled tubing which, in turn, communicates with a central duct **22** affixed to the central tube **20**. Tube **22** is sealed from tube **20**. A capillary tube **23** has one end communicating with the annular space **24** (FIG. **2**) of the first rotary heat exchanger **1 – 5** and leads into the tube **20**. A further tube **25** also extends into the annular space **24** and terminates in the rotary compressor **9** and its motor.

A aperture **26** is formed in the hollow shaft **18** to provide an intake for the compressor. The compressed gases are collected in the space **27** between the cylindrical and frustoconical walls of the dished portion **5** of this space and condense in the tubes **2, 2'** of the first heat exchanger. The condensate collects by centrifugal force in the annular space **24** at the periphery of the disc **3** and, to this end, the space **24** is formed as an annular pocket along the periphery of the disc.

Capillary **23** conducts the condensate, i.e., the refrigerating medium, to the central tube **22** and thence to the helical coil 21, 21′ in which the condensate expands, upon its escape from the capillary, in the manner of the expansion of a refrigerant through an expansion valve or like element of an air conditioner. In other words the liquid heat-pump medium is decompressed, expanded and evaporated in the heat-exchange unit constituted by the helical coil 21, 21′ and thereby abstracts heat from air traversing the interstices of this part. The refrigerating-medium circuit is completed by the central tube 20 surrounding tube 23 which, consequently, constitutes an annular duct through which the refrigerating-medium vapors pass to the interior 18*a* of the shaft 18 and again to the rotary compressor 8, 9. In summary, therefore, the refrigerating circuit includes the rotary compressor 8, 9 which induces a thermodynamic modification of a vapor, the first heat exchanger 1 – 5 which acts as a condenser and transfers the heat energy of the compressed refrigerant to the exterior air, and the heat-exchange unit 21, 21′ which functions as an evaporator to draw the latent heat of vaporization for the refrigerating means from the air of the room to be cooled. This entire circuit is hermetically sealed.

A ring 32 defines an annular space 33 within the chamber between the frustoconical and cylindrical walls of the dished portion 5 of the disk 3 and enables this annular space 33 to collect the oil which is discharged from the compressor. The oil has a density greater than that of the gaseous refrigerating means and thereby lies outwardly of the liquid within chamber 33. However, the quantity of oil is greater than the volume of the annular space 33 defined by the ring or apron 32 so that part of the oil flows through the annular space 4 outwardly of the frustoconical portion 5 of disk 3 and into the annular pocket 24 along the outer periphery of this disk mentioned earlier. In the annular space 24 (see FIG. 2) the lighter oil forms a second layer 31 on the now-liquid cooling medium and is returned to the gap 34 through the tube 25. The gap 34 is at a pressure which corresponds approximately to the intake pressure of the compressor.

From FIG. 1, it is also apparent that the tube 19, which forms the housing for the coil 21, 21′, is passed through the wall aperture 35, this wall aperture having a diameter which need exceed the diameter of tube 19 only to the slight extend necessary to accommodate drawbolts 36. Drawbolts or tierods 36 interconnect member 13*a* with the flange 37 designed to lock against the interior face of the wall.

The tube 38 forms a unitary structure with the second rotary heat exchanger (left-hand side of FIG. 1) which is mounted by pushing the tube 38 axially over the tube housing 19. Sealing rings 39 prevent escape of liquid.

The second rotary heat exchanger is formed with ribs 40 which are traversed in the axial direction by heat-exchanger tubes 41. The latter communicate with rotating annular channels 42 and with radial channels 43 and 43′. Alternate radial channels 43 and 43′ have opposite functions as will be apparent hereinafter. The even radial channels 43′ communicate with an inner tube 45 extending axially into the space surrounded by the coils 21, 21′, while the odd radial channels 43 communicate with the interior of the tube housing 19 outwardly of the tube 45 as shown by the arrow 46.

At the peripheries of the annular channels 42 there is at least one pipe fitting (socket) 47 which is closed by a threaded plug 48. A bolt 49 extends through the hub 44 of the second heat exchanger and is threaded into the tube 22 to compensate for thicknesses of the wall W which may vary from place to place. Seals 39 and 50 are liquid-tight and prevent the escape of a heat-transfer of liquid (consisting essentially of methyl alcohol) from the system. The tubular housing 19 carries a cylindrical bushing 39*a* which is formed with the seal 39, the latter engaging the inner surface of the telescoping sleeve 38 whose end 38*a* is internally beveled to facilitate slipping the sleeve 38 onto the housing 19. As a result, the housing 19 encloses a space within which the coil 21, 21′ is disposed and in which heat from the heat-transfer liquid can be transferred, in turn, to the refrigerating medium.

After the second rotary heat exchanger is mounted upon the hub structure by means of the bolt 49, the interior of the tube housing is sealed at 39 and 50, and the pipe fitting 47 at the highest point of the system is opened by withdrawal of its plug 48. The hollow system is charged with the heat-carrying liquid, e.g., methyl alcohol, until the interior is completely full. When the heat pump is placed in operation, the coils 21 and 21′ are cooled and absorb heat from the heat-carrying liquid circulated by gravity and centrifugal force through the rotary heat exchanger 40, 41 etc. The cooled liquid flows from the vicinity of the coils 21, 21′ through the odd channels 43 as represented by the arrow 46 and thence through the heat-exchanger tubes 41. From the channels 41, the warming liquid, in indirect heat exchange with air displaced by the second rotary heat exchanger, flows to the annular channels 42 and into the alternate channels 43′ to return through the heat-exchanger tubes 41 and absorb more thermal energy from the displaced air. From the latter channels, the liquid is led through the inner tube 45 to the chamber enclosed by the housing 19 to transfer its absorbed thermal energy, via the coils 21, 21′, to the refrigerating liquid. Since the tube housing 19 and the tube 38 slide one into the other and the inner tube 45 telescopes into the end plate 30 of the heat-exchanger unit, the spacing of the two heat exchangers can be adjusted to the wall thickness and the axial length of aperture 35. The drawing, does not illustrate the means for connecting the electric motor to the power source, such means being conventional and possibly including slip rings or inductive-transmission means.

FIG. 3 illustrates the housing disposed within the space to be cooled and along the interior surface of the wall. The housing, generally represented at 52 of FIG. 1, is formed with slits 60 in the end face of the housing, through which air is drawn axially inwardly. The air is blown outwardly through vertical slits 61 represented in section in FIG. 1. The slits 61 are formed between bridges 62 and 62′ and webs 63, which are staggered relative to the bridges 62, 62′, to prevent droplets of condensed water developing on the rotating heat exchanger 40, 41 etc., from entering the room. These droplets are instead caused to collect in a trough 64 of the housing 52. The wheel disk 65 that supports the elements 40 and 41 of the second heat exchanger extends into the pool of condensed water and sprays drops of water against the channel 66. The condensed water, which runs back in the direction of arrow **67**, is conducted by the tube **68** to an outlet **69** in the region of the ribs **1** of the first heat exchanger through apertures which have not been illustrated, but are formed in the disk **3**.

In FIG. **4**, the wheel disk **65** of the second heat exchanger is illustrated in somewhat greater detail, albeit diagrammatically. The inner partition of the double-walled body is divided into the radial channels **43** and **43'**, as already noted. The radial channels **43, 43'** are separated by walls **70** so that the radial channels **43** communicate with the interior of the tube housing **19** while the radial channels **43'** communicate with the inner tube **45**.

The transmission between the first heat exchanger and the rotary member **7** of the motor is illustrated in somewhat greater detail in FIG. **5**, from which it can be seen that the outer magnetic rotor **12** has clawlike poles **71** and **72** and is magnetized axially. The inner rotor **11** is constructed as a ring magnet and is magnetized so as to form two poles on its circumference as represented at N and S. Between the outer rotor **12** and the inner rotor **11**, the magnetically permeable but non-magnetized supporting wall **14** is provided. The laminar assembly **11** comprises four soft-iron connecting pieces shown hatched in FIG. **5**. The relative speed between the outer ring and the inner ring, of course, varies with the ratio of the number of poles on each.

OPERATION

To mount the assembly on the wall W which is assumed to have been previously provided with the opening **35**, the right-hand structure consisting of housing H, heat exchanger **1 – 5** and hub structure **13***a*, **18** and plate **13**, pre-assembled at the factory, is inserted so that the sleeve **19** projects through the opening into the interior chamber to be cooled. The left-hand assembly is mounted upon the sleeve **19** as previously described and, prior to attachment of the housing **52**, the bolt **49** is inserted and tightened. Prior to mounting of the second rotary heat exchanger, the plate **13** may be locked in place against the flange **37** by the tie bars **36**.

The heat exchanger **40, 41** is then filled with the heat-carrier liquid and the electric motor is energized. Gas within the interior of the hollow shaft **18** is compressed by the rotary member **8** and driven into the chamber **27** past the cooling oil which is collected by the ring **32**. The refrigerant vapor moves outwardly into the channels **2** and air is induced to flow past the ribs **1** through inlet slots S_1 and is expelled through outlet slots S_2 in the housing H. The hot refrigerant is thereby cooled and condensed, the condensate being led by the capillary **23** into the coils **21, 21'** for evaporation therein. Such evaporation cools the heat-carrying liquid within the second heat exchanger.

What is claimed is:

1. A heat pump comprising a first rotary heat exchanger adapted to induce airflow therethrough and provided with channels for a heat-pump fluid;

a device for thermodynamically modifying said fluid;

a heat-exchange unit connected in a hermetically sealed fluid-circulating path with said first rotary heat exchanger and said device;

an electric motor having a rotatable member and a magnetic transmission operatively coupling said rotary member to at least one of said first heat exchanger, said device and said heat-exchange unit; and

a second rotary heat exchanger connected with said heat-exchange unit and in heat-transfer relationship therewith while defining a circulation path for a heat-carrying liquid whereby said liquid is brought into heat-transferring relationship with air displaced by said second rotary heat exchanger and into heat-transferring relationship with said fluid in said heat-exchange unit.

2. The heat pump defined in claim **1** and mounted in a wall separating an enclosed space from the exterior for cooling the enclosed space, wherein said wall is provided with an aperture of a diameter less than that of either of said rotary heat exchanger, said heat pump further comprising a hub structure traversing said aperture and receiving said heat-exchange unit at an interior axial end of said hub structure and said motor at an exterior axial end of said hub structure.

3. The heat pump defined in claim **2** wherein said device is a rotary compressor received in said hub structure along an exterior side of said wall.

4. The heat pump defined in claim **3** wherein said transmission includes a rotary magnetically permeable body connected to said first rotary heat exchanger, and a permanently magnetic body connected to said member and a further magnetic body fixed to said wall and co-operating to enable rotation of said rotary body and said first heat exchanger at different velocities.

5. The heat pump defined in claim **3** wherein said hub structure comprises a hollow shaft carrying said rotary member and formed with an intake port communicating with said compressor for delivering said fluid to the latter, said heat-exchanger unit including a coil assembly communicating with the interior of said hollow shaft for delivering evaporated fluid to said hollow shaft, said first rotary heat exchanger being formed with a pocket along its periphery for collecting condensate of said fluid and being provided with a capillary connecting said pocket with said coil assembly.

6. The heat pump defined in claim **3** wherein said heat-exchanger unit is telescopically interfitted with said second heat exchanger.

7. The heat pump defined in claim **3**, further comprising means along the interior side of said wall for collecting water condensed at said second heat exchanger and for delivering the collected water to said first heat exchanger for evaporization thereby.

8. The heat pump defined in claim **3** wherein said hub structure further comprises a tubular housing surrounding said coil and said second heat exchanger includes an axially extending sleeve slidably receiving said housing and means releasably retaining said sleeve on said housing.

9. The heat pump as defined in claim **3**, further comprising a pair of support flanges flanking opposite sides of said wall and tierods traversing said aperture and clamping said wall between said flanges, at least one of said flanges being provided with bearing means rotatably supporting said hollow shaft.

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