Oct. 31, 1950 N. A. PENNINGTON 2,527,569

COMPACT AIR CONDITIONING UNIT

Filed Sept. 5, 1946 2 Sheets-Sheet 1

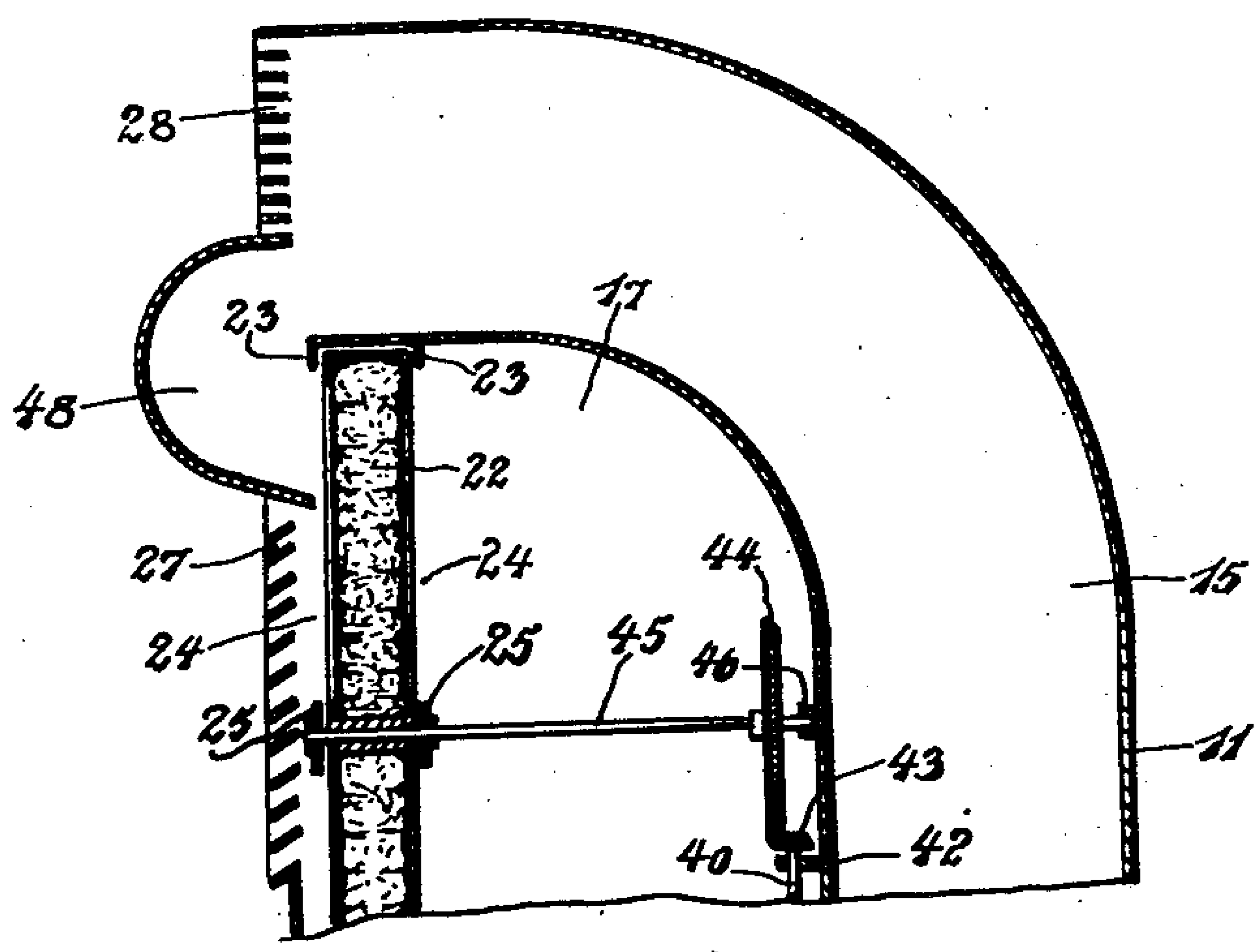

Fig. 2.

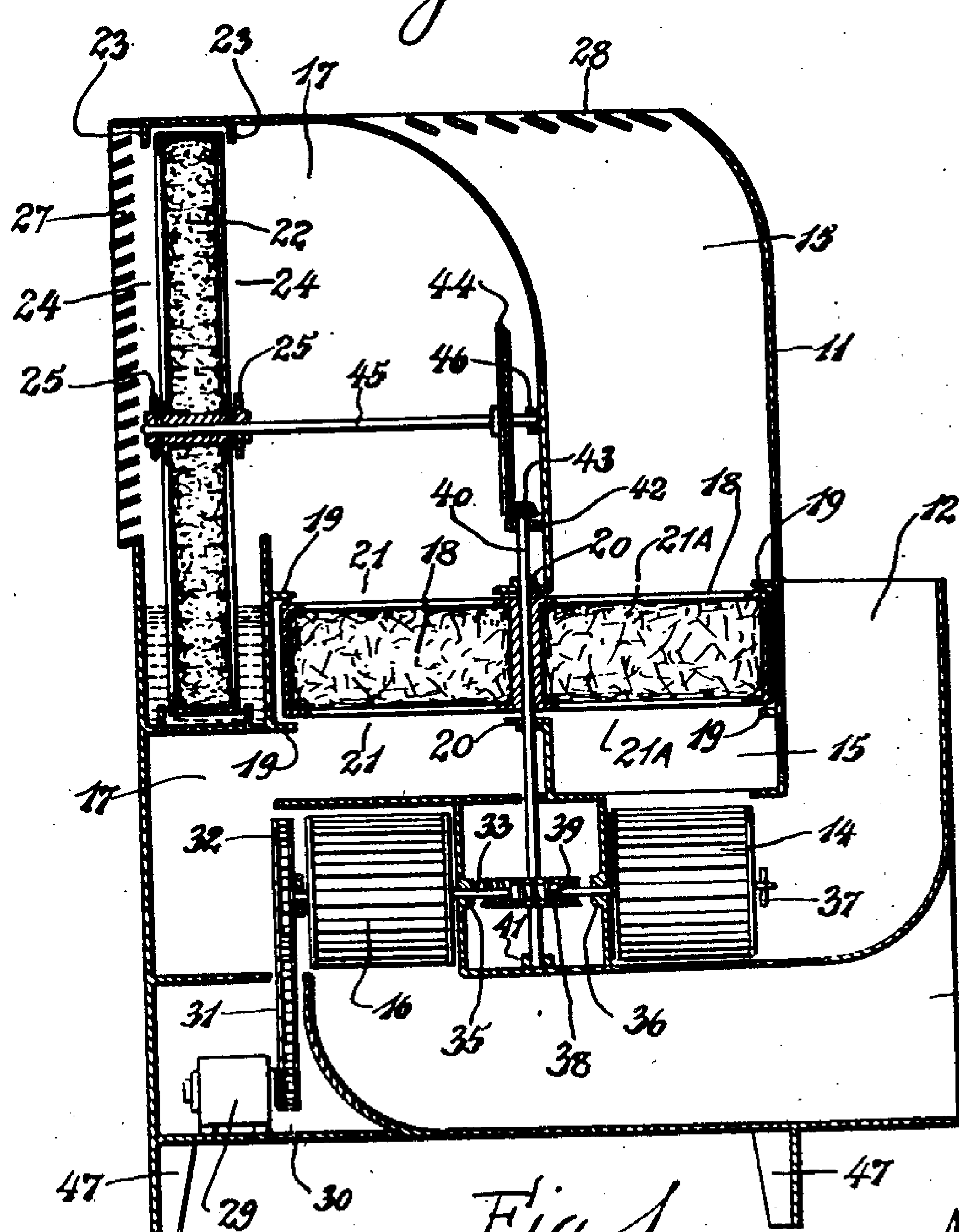

Fig. 1.

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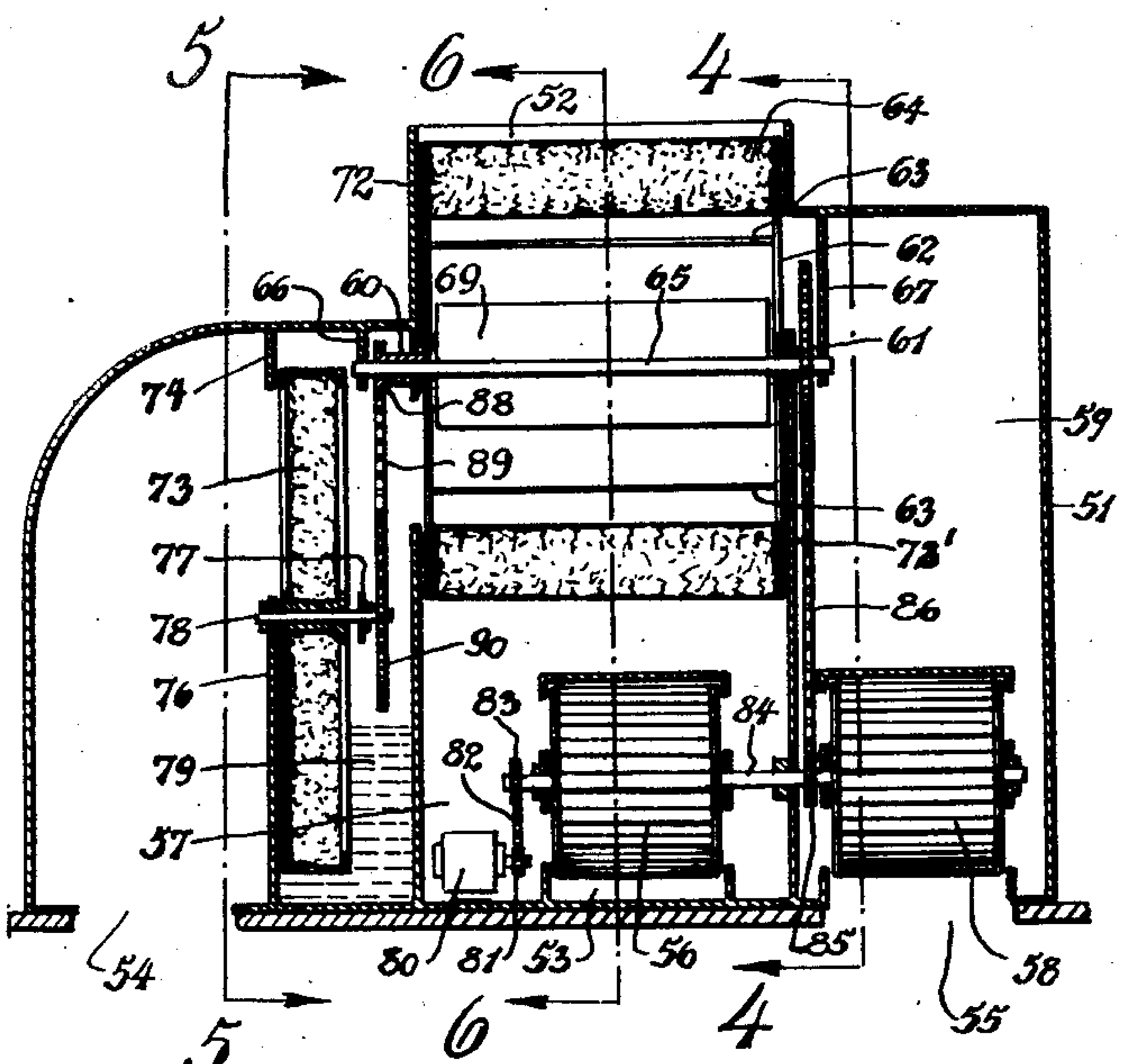

Fig. 3.

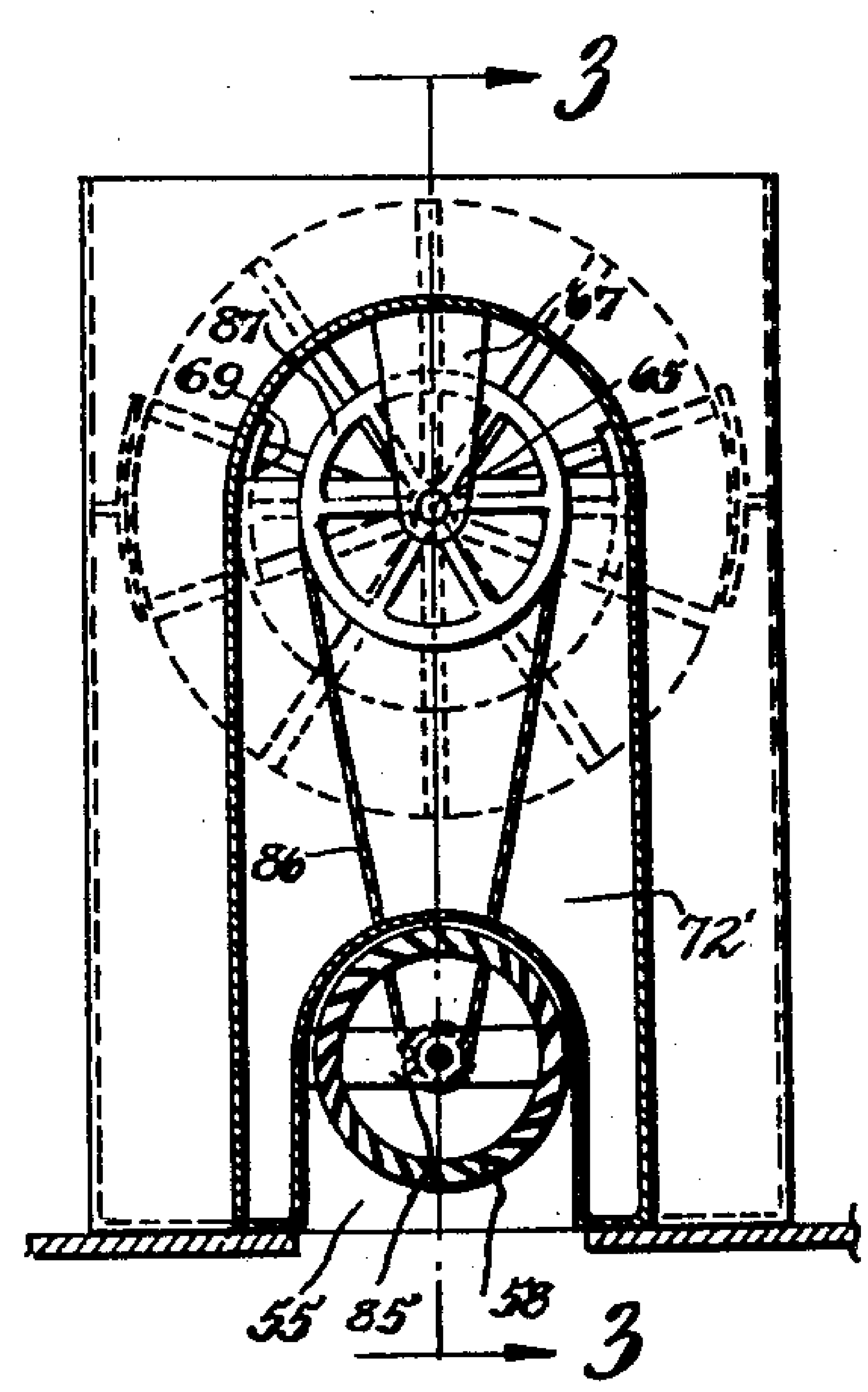

Fig 4.

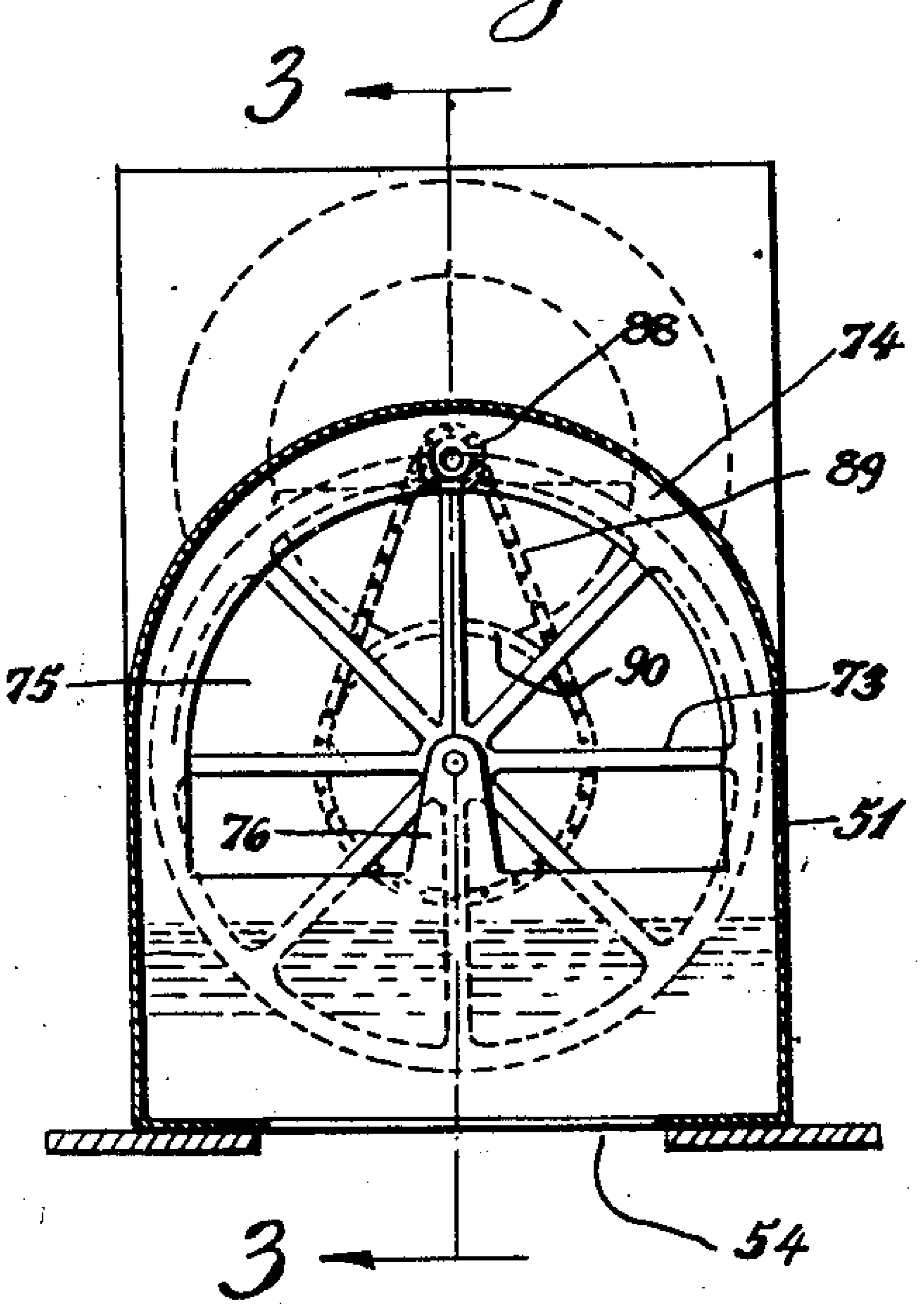

Fig. 5.

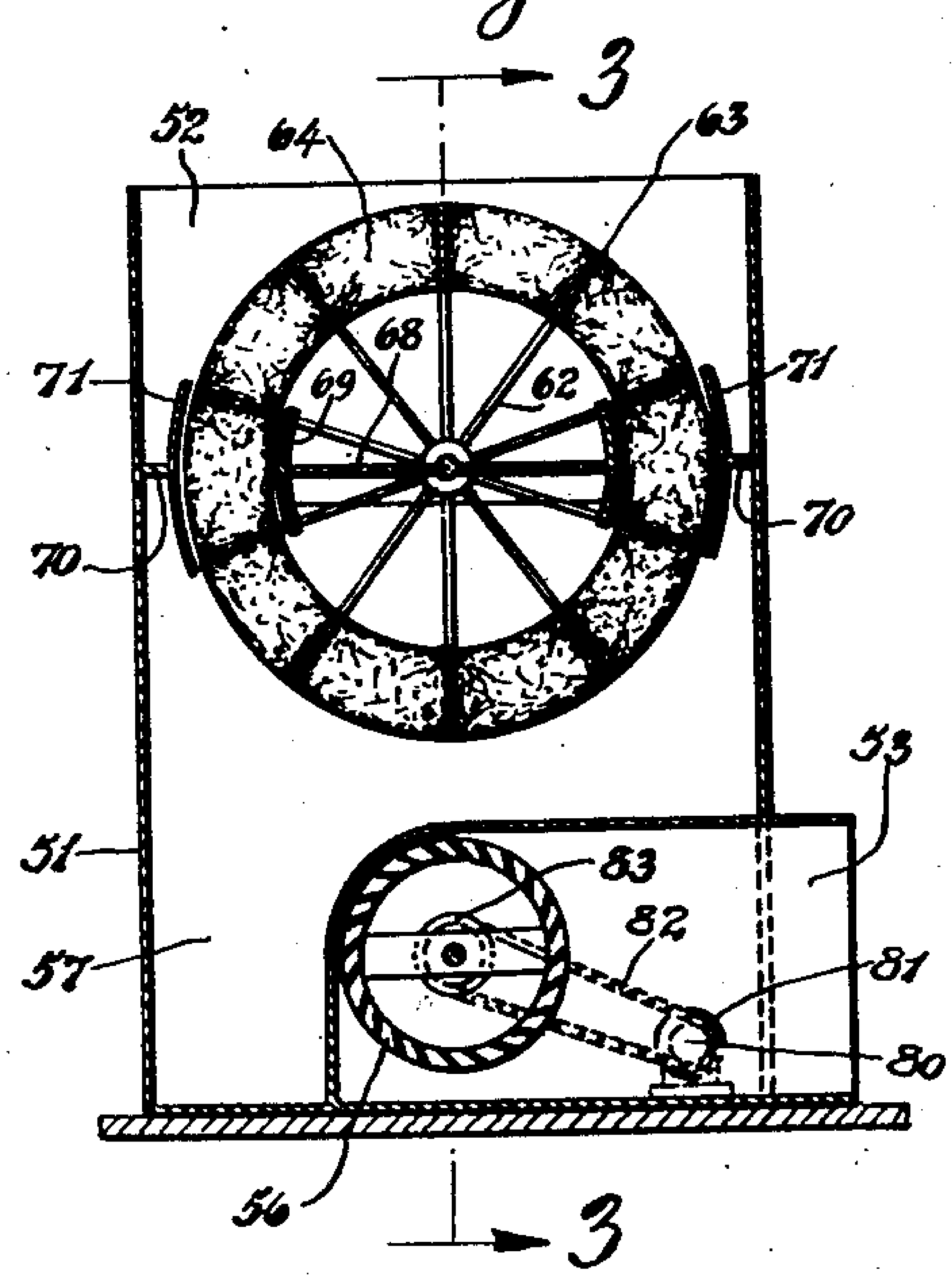

Fig. 6.

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UNITED STATES PATENT OFFICE

2,527,569

COMPACT AIR CONDITIONING UNIT

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Application September 5, 1946, Serial No. 694,972

16 Claims. (Cl. 62—139)

1

My invention relates to new and useful improvements in air-conditioning apparatus, and more particularly to the attaining of compactness in air-conditioning units.

In my copending applications, Serial No. 640,792, filed January 12, 1946, and Serial No. 676,962, filed June 15, 1946, which applications may be referred to for further details as to all common subject-matter, I show and describe several species of my basic invention, the object of which is to attain anhydrous evaporative cooling. The first of these two cited applications has matured into U. S. Patent No. 2,464,766, issued March 15, 1949. The objective is attained by evaporatively cooling (preferably by a circular absorbent pad, rotating partly in a trough of water and partly in the air-stream) one air-stream (preferably a stream of exhaust air from the room), and then transferring the heat from an incoming air-stream by means of an anhydrous heat-exchange circular pad rotating partly in one air-stream and partly in the other.

It is the principal object of my present invention to devise a more compact model or models of the simplest species of the above-mentioned genus, although many of the ideas employed by me to that end could well find a place in the other species.

A further object of my present invention is to devise a portable model for single-room use.

A further object is to devise a heat-exchange pad of the same air-capacity as the disc-shaped pad of my two copending applications, yet with much reduced diameter.

A further object is to devise an air-conditioning machine which will cool less air a greater number of degrees, for use where my regular device would cause an excessive rate of change of air.

In addition to my principal objects, above stated, I have worked out a number of novel and useful details, which will be readily evident as the description progresses.

My invention consists in the novel parts and in the combination and arrangement thereof, which are defined in the appended claims, and of which two embodiments are exemplified in the accompanying drawings, which are hereinafter particularly described and explained.

Throughout the description the same reference number is applied to the same member or to similar members.

Figure 1 is a vertical section of one variant of my present invention, namely the compact portable model.

2

Figure 2 is a portion of the same vertical section, modified so as to cool less air a greater number of degrees.

Figure 3 is a longitudinal vertical section of a third variant of my present invention, taken along the lines 3—3 of Figures 4, 5 and 6.

Figure 4 is a transverse vertical section, taken along the lines 4—4 of Figure 3.

Figure 5 is a transverse vertical section, taken along the lines 5—5 of Figure 3.

Figure 6 is a transverse vertical section, taken along the lines 6—6 of Figure 3.

Referring now to Figure 1, we see that **11** is the main container of the first variant to be described herein. **12** is an air inlet from outdoors. **13** is an air outlet to outdoors. It is contemplated that the right-hand side of the figure will be placed against the outside wall of the room, with these two orifices projecting out through a window or other opening in the wall.

In inlet **12** there is a fan **14**, preferably a centrifugal fan, so disposed as to suck air in from outdoors, and impel this air into passage **15**.

In outlet **13** there is a similar fan **16**, so disposed as to suck air from passage **17** and impel it out through outlet **13**.

18 is a rotatable anhydrous heat-exchange pad of the same general or specific sort as described and shown in my two copending applications. Copending application of Roger Sherman Hoar, Serial No. 677,295, filed June 17, 1946, points out the desirability of building the framework (i. e., the hub, spokes, and rim) of this pad out of plastic or some other non-heat-conducting material. However, there are certain advantages (including rigidity and durability) to the use of metal; and aluminum and magnesium (in spite of their high thermal conductivity) possess the advantages of lightness, cheapness, and malleability. To reconcile all these considerations, I build the framework of my pad of aluminum or magnesium and then coat it with liquid plastic or other heat-insulating paint. This expedient falls within the genus of said Hoar invention, but is believed to be preferable to his species. This pad rotates in a casing **19**, each face of which has two sectorial orifices, separated from each other by bridge **20**. Left hand orifice **21** connects with passage **17**. Right hand orifice **21A** connects with passage **15**. This casing, bridge, and orifices, are like elements **44**, **43**, **46** and **47**, of copending Patent No. 2,464,766 where they are thoroughly described.

22 is a rotatable water-holding pad of the same general or specific sort as described and shown in my two copending applications. This pad rotates in a casing 23, each face of which has an opening 24 in passage 17. Each of these openings is spanned by a bridge 25. The lower portion of pad 22 is submerged in water in trough 26. This casing, openings, bridge and trough are like elements 34, 36—37, unnumbered bridge, and 35, of copending Patent No. 2,464,766, where they are thoroughly described. The trough can be kept filled with water in any convenient manner, as shown and described in said application, or otherwise.

Louvres 27 lead from the room to passage 17. Louvres 28 lead from the room to passage 15.

Motor 29 drives the two fans 14 and 16 at a high rate of speed, through pulley 30, V-belt 31, pulley 32 and common shaft 33, which latter is journaled on the main frame 11 at 34, 35, 36, and 37. This shaft, through worm 38 and worm-gear 39, drives shaft 40, which is journaled in bridges 20, and on the main frame at 41 and 42, and is drivingly keyed to heat-exchange pad 18.

Shaft 40 in turn, through bevel gear 43, and bevel gear 44, drives shaft 45, which is journaled in bridges 25, and on the main frame at 46, and which is drivingly keyed to water-holding pad 22.

The various gear-ratios are such that water-holding pad 22 rotates preferably at about 3 R. P. M., and heat-exchange pad 18 rotates preferably at about 30 R. P. M.

Feet 47 can be provided, if desired.

It is to be noted that rotating pads 18 and 22 are at a substantial angle (preferably a right angle) to each other. This enables me to combine free air-flow with a compact arrangement, and furthermore enables me to drive the shaft of one pad directly from the shaft of the other, which further simplifies my construction.

The operation of this variant is as follows. Exhaust air from the room enters the machine through louvres 27, and passes through water-holding pad 22, where it has its dry-bulb temperature adiabatically reduced to nearly its wet-bulb temperature. The thus-cooled outgoing air then passes through heat-exchange pad 18, which it cools to nearly the dry-bulb temperature of this air. This air is then sucked through fan 16, and passes outdoors through outlet 13.

The incoming air is sucked in through inlet 12, by fan 14, and then passes through heat-exchange pad 18, which anhydrously reduces the dry-bulb temperature of this air to nearly that of the adiabatically cooled outgoing air. The incoming air then passes into the room through louvres 28.

It is to be noted that room inlet 28, through which cool air enters the room, is at a higher level than room outlet 27, through which warm air leaves the room. Inasmuch as relatively hot air tends to rise, and relatively cold air tends to fall, this arrangement minimizes cold floor-drafts, and assures a better mixing of the air in the room than would result from any other arrangement.

It is to be noted that outdoors outlet 13, through which indoor air leaves the machine, is at a lower level than outdoors inlet 12, through which the air to be cooled enters the machine. Inasmuch as relatively hot air tends to rise, and relatively cold air tends to fall, this arrangement assures that the highly humidified outgoing air (being slightly cooler than the outdoors air) will not be sucked back into the room. The elevation and upward direction of inlet 12 further guarantees against this.

Turning now to the variant of Figure 2, we see that this second variant is identical to my first, except as hereinafter described.

In addition to the features of my first variant, described and shown in Figure 1 and hereinabove, my second variant has a feed-back passage 48, which takes from passage 15 one-third (or other predetermined portion) of the incoming air cooled by my machine, and feeds it back into the outgoing air stream in passage 17, before that air passes through water-holding pad 22.

This expedient performs to some extent, and in much simpler fashion, the same precooling of the outgoing air as is effected by more complex means, but to a greater extent, by the precooling device of the two variants of my copending application Serial No. 676,962.

This expedient can be equally well employed in any of the other variants claimed in this application or in either of my two copending applications.

This expedient is useful whenever the room load is so heavy that an excessive rate of air-change is necessary in order to reduce the room temperature the desired number of degrees.

To get a clear mental picture of what this expedient accomplishes, let us compare it with the more obvious alternative of merely increasing the capacity of our machine. It is true that merely increasing the face-area of the heat-exchange pad and the capacity of the fans by 50% would decrease the load by one-third. But this would be accomplished at the expense of increasing the rate of air-change in the room by 50%. Whereas, increasing the face-area of the heat-exchange pad by 50%, and feeding back this increase into the outgoing stream, a one-third reduction in load can be effected by less than a 50% increase in fan-capacity (inasmuch as in this expedient, the added air does not have to be forced out into the room, and then be dragged back into the machine), and with no increase the rate of air-change in the room.

Turning now to Figures 3 to 6, let us consider my third variant.

51 is the main container. 52 is an air inlet from outdoors. 53 is an air outlet to outdoors, or the attic. 54 is the outlet from the room into the machine. 55 is the inlet to the room from the machine.

56 is a fan (preferably centrifugal) to suck outgoing air from space 57, and impel it outdoors through outlet 53.

58 is a similar fan to suck incoming air from space 59, and impel it into the room through inlet 55.

64 is an anhydrous heat-exchange pad, built on the same theory as those of variants 1 and 2 of this present application; and as those of my copending applications, but of radically different design, being in the form of a hollow cylinder. At each end is one of two hubs 60 and 61. Radiating from each of these hubs, are spokes 62. Corresponding spokes are connected by a radial partition 63 extending the length of the pad, but not extending inwardly more than about one-third of the distance from periphery to axis.

Between successive partitions 63 there is a peripheral packing 64 of metal-wool or other suitable heat-absorbing material. To help hold this packing in place and to add rigidity to the framework of the pad, diagonal bracing (not shown) or other appropriate means, may be employed.

The radial thickness of the packing of this variant is determined by the same considerations as determine the axial thickness of the packing in my copending applications. The mean area of that portion of the inner and outer cylindrical surfaces of the packing of this variant lying between bridges, is the bottle neck of each air-stream.

The bridging of the pad of this variant, so as to prevent the by-passing of air from one air-stream to the other, presents quite a problem, which I have solved in the following manner.

The two hubs **60** and **61** are rotatably mounted on a non-rotatable shaft **65**, firmly held to the main frame **51** by brackets **66** and **67**. This non-rotatable shaft supports an interior partition **68**, which extends almost the length of the cylinder, and carries two curved interior bridges **69**.

Exterior partitions **70** project inwardly from the main container **51**, and carry two curved exterior bridges **71**.

Each of the four bridges, just described, spans slightly more than one sector of the pad.

Exterior partition **72** blocks the upper half of one end of the cylinder, and exterior partition **72'** blocks the lower half of the other end.

Accordingly it will be seen that two independent streams of air can pass through the pad, one through the upper half, and one through the lower half.

73 is a rotatable water pad of the same general or specific sort as described and shown in my two copending applications, and in connection with the first variant described and shown in this present application. This pad rotates in a casing **74**, each face of which has an opening **75**, in passage **54**. A part of each face of this casing **74** constitutes a bracket **76** or **77**, for the support of shaft **78**, which is drivingly keyed to pad **73**. The lower portion of pad **73** is submerged in water in trough **79**. This casing, openings, and trough, are like elements **34**, **36—37**, and **35**, of copending Patent No. 2,464,-766, where they are thoroughly described. The trough can be kept filled with water in any convenient manner, as shown and described in said application, or otherwise.

Motor **80** drives the two fans **56** and **58** at a high rate of speed, through pulley **81**, V-belt **82**, pulley **83**, and common shaft **84**, which later is journaled in the main frame at various unnumbered but obvious points.

Shaft **84** in turn, through sprocket **85**, sprocket-chain **86**, and sprocket **87**, drives hub **61** of heat-exchange pad **64**, at about 25 to 30 R. P. M. The framework of pad **64** in turn drives hub **60**.

Hub **60** then, through sprocket **88**, sprocket-chain **89**, and sprocket **90**, drives shaft **78**, and thereby water-holding pad **73**, at about 2 or 3 R. P. M.

It is to be noted that my two air-streams pass through rotating pads **73** and **64**, as through the two pads of my first hereindescribed variant, at right-angles to each other. This enables me to combine free air-flow with a compact arrangement.

The operation of this present variant is as follows. Exhaust air from the room enters the machine through passage **54**, and passes through water-holding pad **73**, where it has its dry-bulb temperature adiabatically reduced to nearly its wet-bulb temperature. The thus cooled outgoing air then enters the lower half of the hollow interior of heat-exchange pad **64**, and passes radially outward through the lower half of the packing of this pad, into space **57**, thereby cooling this pad to nearly the dry-bulb temperature of this air. This air is then sucked through fan **56**, and passes outdoors through passage **53**.

The incoming air is sucked into the machine from outdoors, through air-inlet **52**. Thence it passes radially inwards through the packing of the upper half of heat-exchange pad **64**, into the upper half of the hollow interior of that pad, which anhydrously reduces the dry-bulb temperature of this air to nearly that of the adiabtically cooled outgoing air. Thence the incoming air, passes out through the right-hand end of pad **64**, thence through fan **58** and passage **55** into the room.

It is to be noted that outdoors outlet **53**, through which indoor air leaves the machine, is at a lower level than outdoors inlet **52**, through which the air to be cooled enters the machine. This arrangement is the same as in the first and second variants shown and described in this present application, and accomplishes the same advantages.

It is to be noted that in all three of the variants shown and described in this present application, as in all the variants of my copending applications, the two air-streams pass through the successive layers of packing of my anhydrous heat-exchange pads in the opposite direction from each other, thereby attaining the essential advantages of nearly ideal counterflow, which I have thoroughly explained in my copending applications.

Having now described and illustrated three forms of my invention, I wish it to be understood that my invention is not to be limited to the specific forms or arrangements of parts herein described and shown.

I claim:

1. An air-conditioning unit, having: two air-passages; a water-tank; an air-permeable water-holding pad, rotatable partly in the tank and partly in one air-passage; an air-permeable non-hygroscopic heat-transfer pad; rotatable partly in each air-passage; means for rotating the two pads; means for impelling air in the first passage, first through the water-holding pad and then through the non-hygroscopic pad, whereby this stream of air is first cooled by evaporation and then cools the non-hygroscopic pad; and means for impelling air in the second passage through the non-hygroscopic pad, whereby this stream of air is anhydrously cooled by the non-hygroscopic pad, and then passes into the space to be conditioned; characterized by the fact that the direction of passage of air through the water-holding pad is substantially at a right-angle to the direction of passage of air through the heat-transfer pad.

2. An air-conditioning unit according to claim 1, further characterized by the fact that the axes of the two pads are at approximately right angles to each other.

3. An air-conditioning unit according to claim 1, further characterized by the fact that the axis of the water-holding pad is substantially horizontal, and that the axis of the heat-exchange pad is substantially vertical.

4. An air-conditioning unit according to claim 1, further characterized by the fact that the heat-exchange pad is a hollow cylinder through the walls of which the air passes radially.

5. A rotatable heat-transfer pad for an air-conditioning unit, in the form of a hollow cylinder, comprising: a hub and spokes at each end only of the cylinder; a series of substantially

radial partitions impermeable to air, adjacent the periphery of the cylinder only and extending longitudinally thereof; and a packing of non-hygroscopic air-permeable highly heat-absorbent material between the partitions; each end of the cylinder being open from the hub to the peripheral packing.

6. In the heat-exchanger of an air-conditioning unit, the combination of: a rotatable hollow cylindrical heat-transfer pad, comprising a hub and spokes at each end of the cylinder, a series of substantially radial partitions impermeable to air, adjacent the periphery of the cylinder and extending longitudinally thereof, and a packing of non-hygroscopic air-permeable highly heat-absorbent material between the partitions; an air-passage leading to one side of the outer curved surface of the pad; a second and separate air-passage leading to the diametrically opposite side of the outer curved surface of the pad; a non-rotating partition separating these two passages, and extending the length of the pad, and also blanking the outer curved surface thereof for the length of the pad and for a width equal to slightly more than the distance between two partitions of the pad; a similar partition diametrically across the pad from the first; a third and fourth separate air-passage, each leading to slightly less than half of an open end of the pad, each such half corresponding to one of the two mentioned sides of the outer curved surface of the pad; partitions blanking the open ends of the pad except where the third and fourth passages lead; a non-rotating partition within the hollow cylindrical interior of the pad, extending the length of the pad and extending diametrically across the hollow cylindrical interior of the pad, and having means at each diametrically opposite extremity of the partition blanking the curved inner surface of the pad opposite to, and to substantially the same extent as, the two first-mentioned blanking means; all the partitions and blanking means being such as to prevent appreciable air-leakage through the pad from one side passage and one end passage to the other pair of such passages.

7. A heat-exchange according to claim 6, characterized by the fact that the heat-transfer pad is mounted for rotation with respect to a fixed longitudinal shaft which rigidly supports the non-rotating partition within the pad and the means blanking the inner surface of the pad.

8. An air-conditioning unit according to claim 1, further characterized by the fact that there is a by-pass passage for feeding back a portion of the air cooled by the heat-exchange pad direct from the second passage into the first passage to mingle with the air therein prior to said air passing through the water-holding pad.

9. In an air-conditioning unit, the combination of: two air-passages; a water-tank; an air-permeable water-holding pad, rotatable partly in the tank and partly in one air-passage; an air-permeable non-hygroscopic heat-transfer pad, rotatable partly in each air-passage; means for rotating the two pads; means for impelling air in the first passage, first through the water-holding pad and then through the non-hygroscopic pad, whereby this stream of air is first cooled by evaporation and then cools the non-hygroscopic pad; means for impelling air in the second passage through the non-hygroscopic pad, whereby this stream of air is anhydrously cooled by the non-hygroscopic pad, and then passes into the space to be conditioned; and a by-pass passage for feeding back a portion of the air cooled by the heat-exchange pad direct from the second passage into the first passage to mingle with the air therein prior to said air passing through the water-holding pad.

10. An air-conditioning unit according to claim 1, further characterized by the fact that the axles of the two pads are directly geared together.

11. An air-conditioning unit according to claim 1, further characterized by the fact that the entrance to the first passage is appreciably below the exit from the second passage.

12. An air-conditioning unit according to claim 1, further characterized by the fact that the entrance to the second passage is appreciably above the exit from the first passage.

13. An air-conditioning unit according to claim 1, further characterized by the fact that the entrance to the first passage is appreciably below the exit from the second passage; and that the entrance to the second passage is appreciably above the exit from the first passage.

14. In an air-conditioning unit, the combination of: two air-passages; a water-tank; an air-permeable water-holding pad, rotatable partly in the tank and partly in one air-passage; an air-permeable non-hygroscopic heat-transfer pad, rotatable partly in each air-passage; means for rotating the two pads; means for impelling air in the first passage, first through the water-holding pad and then through the non-hygroscopic pad, whereby this stream of air is first cooled by evaporation and then cools the non-hygroscopic pad; and means for impelling air in the second passage through the non-hygroscopic pad, whereby this stream of air is anhydrously cooled by the non-hygroscopic pad, and then passes into the space to be conditioned; characterized by the fact that the entrance to the first passage is appreciably below the exit from the second passage.

15. An air-conditioning unit according to claim 14, further characterized by the fact that the entrance to the second passage is appreciably above the exit from the first passage.

16. An air-conditioning unit according to claim 1, characterized by the fact that the heat-transfer pad includes substantially radial partitions, the space between the partitions being filled with non-hygroscopic air-permeable highly heat absorbent material, and the partitions being coated with poorly-heat-conducting material.

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The following references are of record in the file of this patent:

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