

July 3, 1923.

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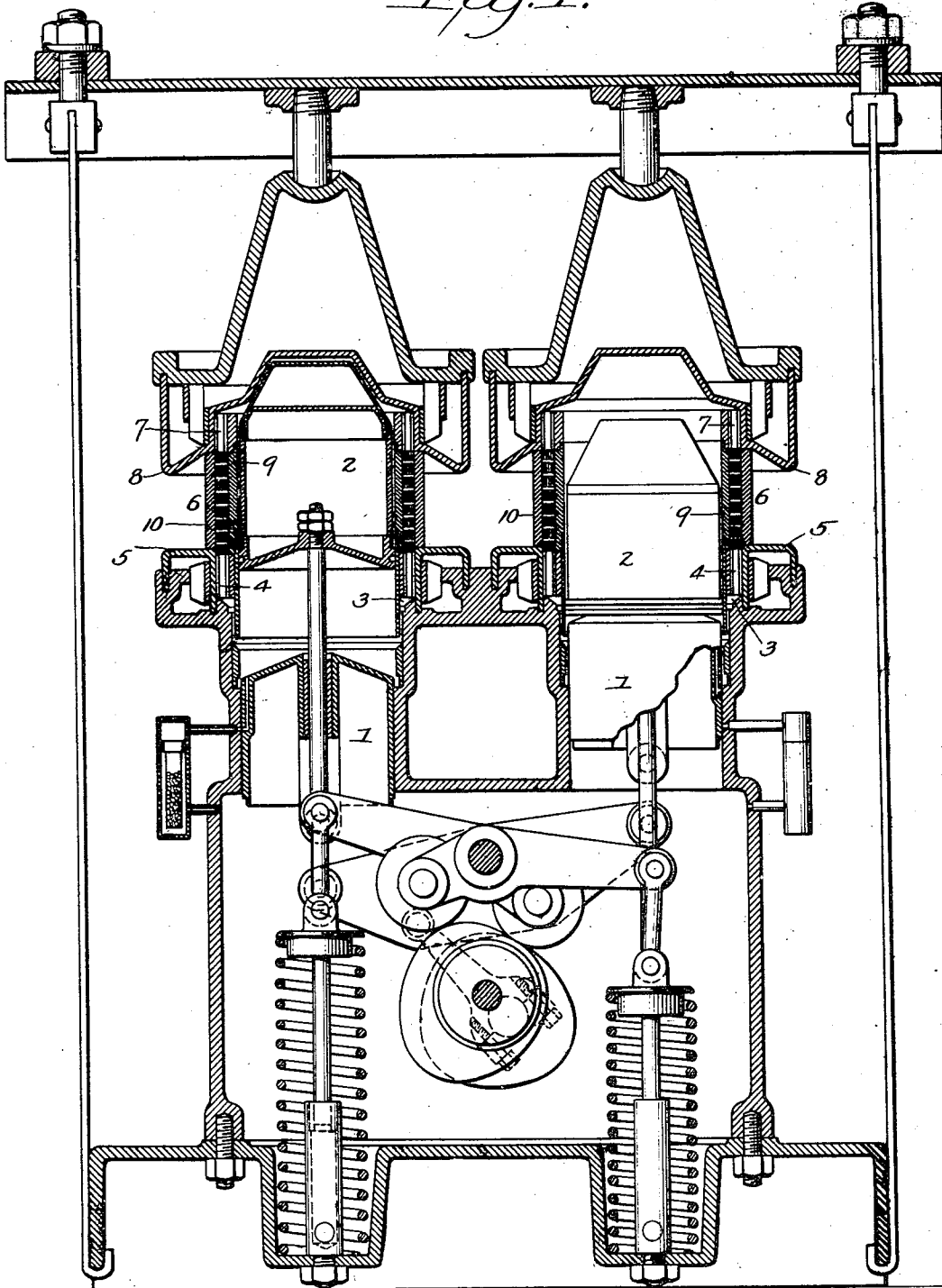
I. LUNDGAARD

AIR REFRIGERATING MACHINE

Filed May 22, 1922

3 Sheets-Sheet 1

Fig. 1.



WITNESSES

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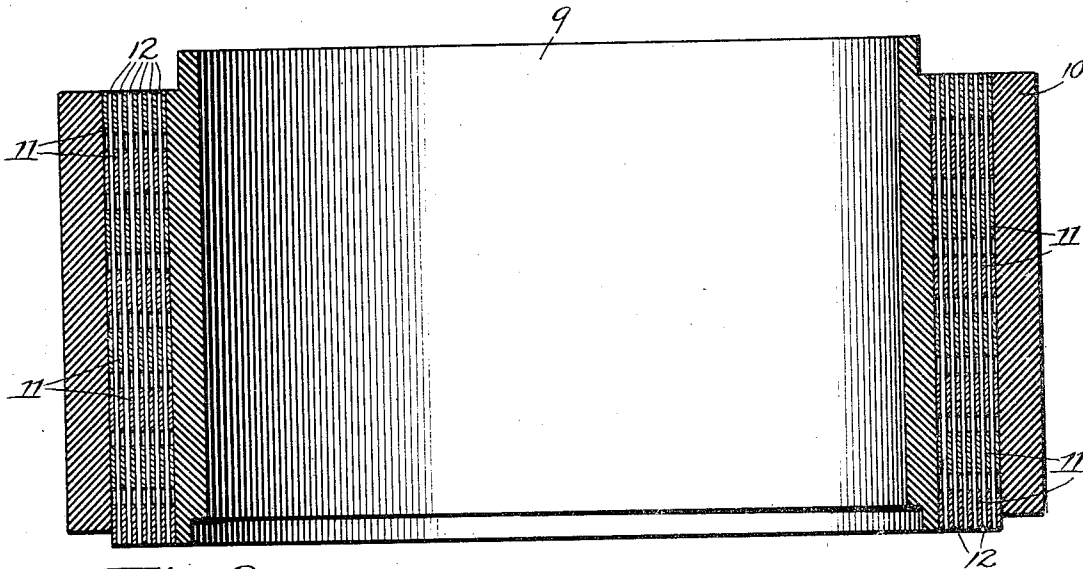


Fig. 2.

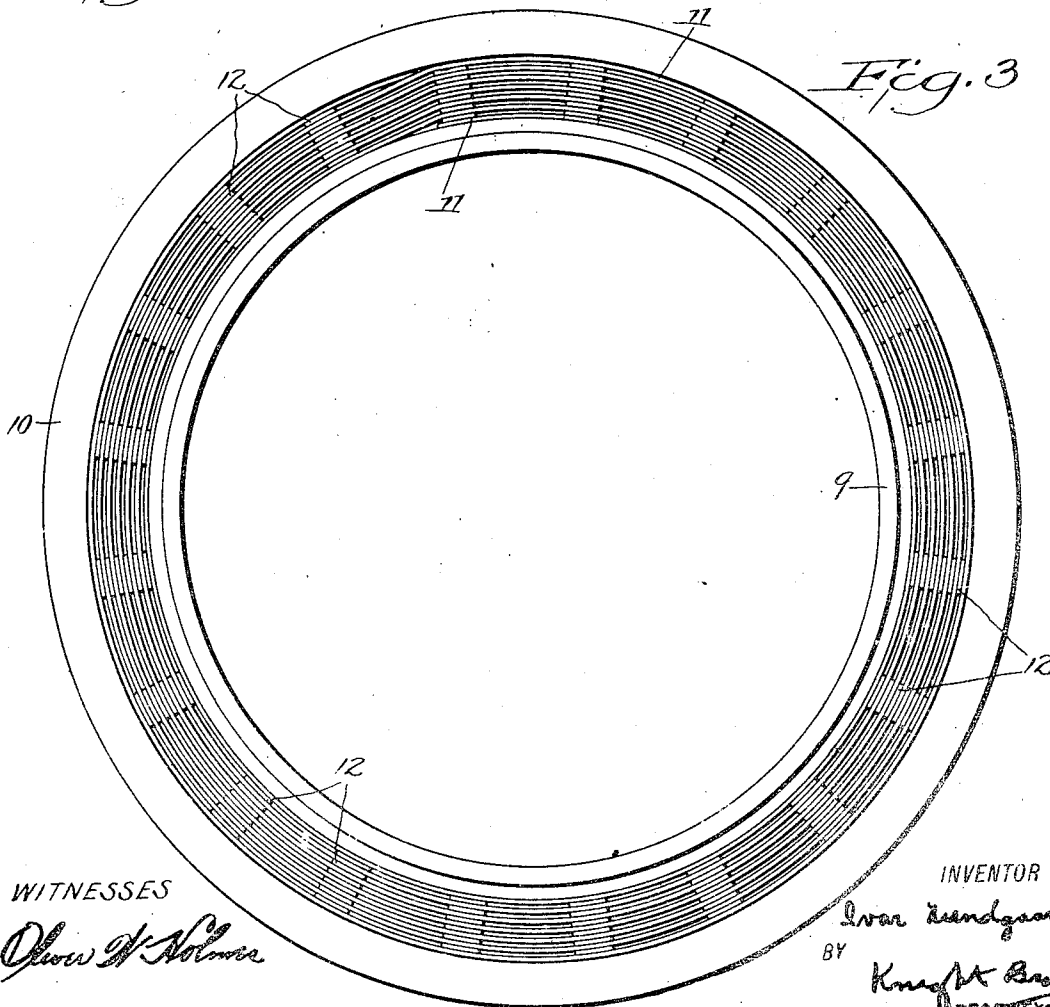


Fig. 3

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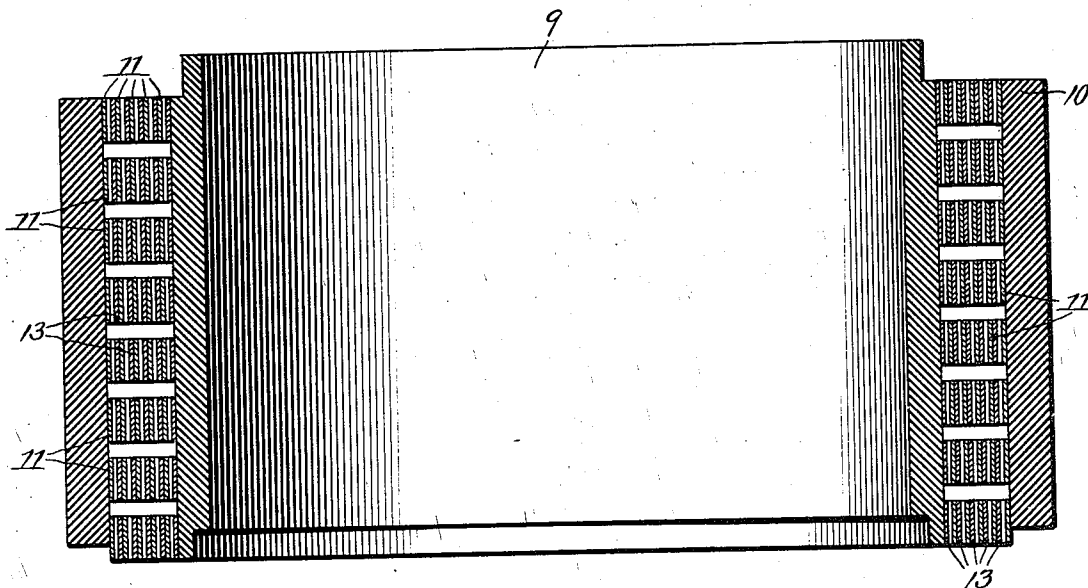


Fig. 4.

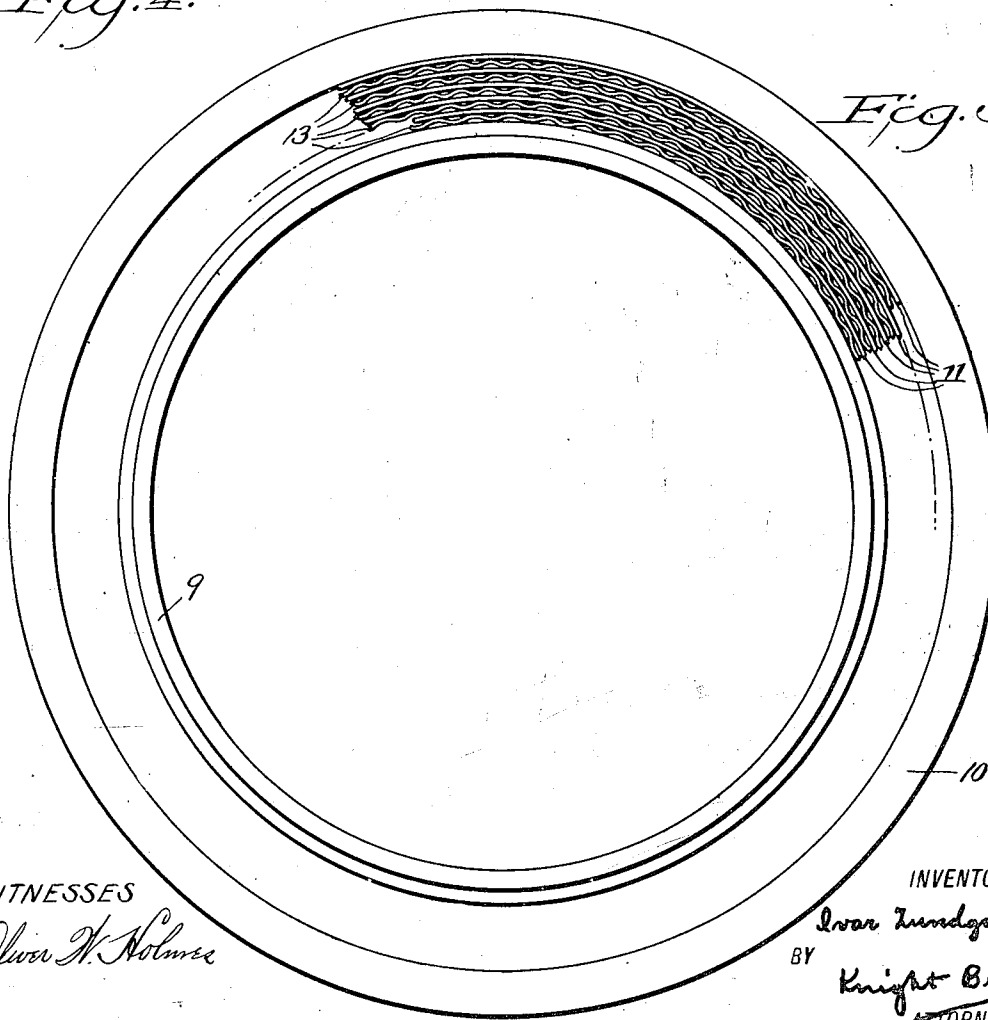


Fig. 5.

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UNITED STATES PATENT OFFICE.

IVAR LUNDGAARD, OF HARTFORD, CONNECTICUT, ASSIGNOR TO THE AUTOMATIC REFRIGERATING COMPANY, OF HARTFORD, CONNECTICUT, A CORPORATION OF NEW JERSEY.

AIR-REFRIGERATING MACHINE.

Application filed May 22, 1922. Serial No. 562,907.

To all whom it may concern:

Be it known that I, IVAR LUNDGAARD, a citizen of the United States, and a resident of Hartford, county of Hartford, State of Connecticut, have invented certain new and useful Improvements in Air-Refrigerating Machines, of which the following is a specification.

My invention relates to air refrigerating machines wherein a body of air acting as a mediating fluid is subjected to alternate compression and expansion in a closed cycle. Such a machine includes a chamber wherein the air is compressed and a chamber wherein the air is expanded. Between these two chambers the air is passed through a heat exchanger for transferring heat from the compressed air to a body of cooling fluid, a regenerator for maintaining a difference of temperature between the air entering it and the air leaving it and a heat exchanger for transferring heat from a fluid to be cooled to the expanded air. In my Patent No. 1,240,862 I have described a machine of this type.

As the volume of the air spaces in the heat exchangers and regenerator is constant and as this volume is interposed between the compression and expansion chambers, it comprises what might be considered a clearance volume and it is obvious that to obtain any great amount of refrigeration this volume must be small as compared to the piston displacement. Further a large area must be presented to the air to transfer the heat to or from it.

Since the function of the regenerator is to bring the mediating air to a temperature as nearly as possible equal to that in the chamber it is entering, whether it be the relatively hot compression chamber or relatively cold expansion chamber, it is necessary that it have capacity to absorb a given amount of heat during part of each cycle to be given up at another part of the cycle. In order that the output of refrigeration may be high, the regenerator must be constructed to prevent, as far as is possible, the conduction of heat from its hot end to its cold end.

The object of my present invention is to produce a regenerator that will contain a small volume of air, that will present a large surface to the air, that will be easy and cheap to manufacture, that will have suffi-

cient heat capacity to maintain its hot end and its cold end at the proper relative temperatures, that will conduct the minimum amount of heat from its hot end to its cold end, and that will offer low resistance to the passage of air.

I accomplish this object by constructing my regenerator in the form of a chamber, the walls of which are composed of heat insulating material, and providing in the chamber a plurality of sections of material having the required heat capacity, and extended surface, and a multiplicity of narrow spaces for the passage of air. These sections extend across the path of flow of the mediating fluid and are separated from each other so as not to be in heat-conductive relation. Each section may, for example, consist of a plurality of turns of thin metallic ribbons closely spaced with respect to each other and mounted so that their edges are presented in the direction of flow of the mediating fluid.

In order that my invention may be clearly understood, it will be described in connection with the accompanying drawings, and the novel features will be pointed out in the annexed claims. In said drawings:—

Figure 1 is a vertical, longitudinal section of my air-refrigerating machine, of which regenerators according to this invention form a part.

Figure 2 is a vertical, transverse section on an enlarged scale of one of the regenerators shown in Figure 1.

Figure 3 is a bottom plan view of the regenerator of Figure 2.

Figure 4 is a vertical, transverse section of another embodiment of my invention.

Figure 5 is a bottom plan view of the regenerator of Figure 4 showing in part the metallic strips forming the heat storage elements.

Referring to Figure 1, the operation of the machine may be as follows for one cycle of operations, which corresponds to one revolution of the crank-shaft. The movements of the pistons are controlled by the mechanism in the crank-case.

The air is compressed in the chamber between compression piston 1 and shifter piston 2 by upward movement of piston 1. It is then transferred at the higher pressure through annular port 3, the spaces between leaves 4 of heat exchanger 5, the regenerator

6 and the spaces between leaves 7 of heat exchanger 8 to the chamber above shifter piston 2. It is then expanded in the chamber above piston 2 by downward movement of both piston 1 and piston 2. Finally it is transferred back again at the lower pressure to the chamber between piston 1 and piston 2 through heat exchanger 8, regenerator 6 and heat exchanger 5. In this way, heat is discharged from the system by heat exchanger 5 and heat may be abstracted from any desired fluid by heat exchanger 8. A difference of temperature is established between the two heat exchangers and consequently between the upper and lower ends of regenerator 6.

The machine illustrated in Figure 1 has two cylinders and it will be understood that both cylinders are similarly constructed.

Regenerator 6 comprises an inner cylindrical wall 9 of heat-insulating material, such as bakelite and an outer cylindrical wall 10 also of heat-insulating material. An annular space is formed between the two walls. Walls 9 and 10 rest at their lower ends on the heat exchanger 5 and support at their upper ends heat exchanger 8. Wall 9 serves also as a portion of the cylinder wall inside of which piston 2 reciprocates. It is thus seen that the regenerator acts to insulate the hot end of the machine from the cold end while at the same time acting as a regenerator for the mediating fluid.

In Figures 2 and 3, one embodiment of my invention is shown as consisting of a plurality of thin metal ribbons 11, wound spirally on wall 9, each turn being immediately over another but separated therefrom by narrow spacers 12, of insulating material, such as paper. Spacers 12 are arranged about the circumference at intervals, sufficiently close to keep the strips in position, and extend the full length of the regenerator. Each of the metallic ribbons 11 comprises a coil of several wraps around cylinder 9 and each coil is separated, in the direction of flow of the mediating air, from the adjacent coils so to be heat-insulated therefrom. As any one coil is at approximately the same temperature at all points, it is important to subdivide the length of the regenerator into as many coils and insulating spaces as will produce a relatively smooth temperature gradient between the two ends. In regenerators I have constructed, which have given excellent results, there have been nineteen coils each having thirty turns of brass ribbon one-eighth of an inch wide by two-thousandths of an inch thick, the spacers between turns being paper one-sixteenth of an inch wide by six-thousandths of an inch thick, and the length-wise separation of the coils being eight-thousandths of an inch.

The outside diameter of the coils of strips 11 is such that outer cylinder 10 will

just slip over them. As the mediating air passes back and forth through the narrow spaces between turns it readily gives up or absorbs heat from the strips, while at the same time there is a small volume of air contained in the regenerator and a minimum of length-wise conduction of heat.

In Figures 4 and 5, I illustrate another embodiment of my invention. The thin metal strips 11 are wound spirally about the cylinder 9 and each turn is spaced from the previous turn by corrugated metallic strips 13, the corrugations of which extend in the direction of flow of the mediating air. Therefore, each coil consists of a number of alternate layers of flat metal and corrugated metal strips wound together on cylinder 9. Each coil is separated from the next by an air space so that they will be in heat-insulating relation to each other. The number of coils and their spacing is determined by the heat capacity required and the consideration of length-wise heat conduction between the two ends of the regenerator.

Broadly my invention comprises a regenerator having a number of sections, each consisting of a plurality of spaced metal leaves presenting an extended surface to the mediating air and disposed within a body of heat-insulating material in the path of the mediating air; each section being heat-insulated from the adjacent sections. It is apparent that numerous forms of construction may be employed without departing from the scope of the invention as disclosed in connection with the embodiments illustrated.

I claim:—

1. A closed cycle refrigerating system operating with gaseous mediating fluid, comprising in combination a plurality of heat absorbing and delivering units, arranged successively in the path of the mediating gas and in non-conductive relation to each other, means for insulating said units from the outside environment, and means for causing the mediating gas to move past said units in succession.

2. In a refrigerating machine, a regenerator comprising a body of heat-insulating material, a plurality of sections having capacity for absorbing and giving up heat, arranged one after another within said body of heat-insulating material and forming a portion of the path of the mediating gas, each of said sections being heat-insulated from the adjacent section.

3. In a refrigerating machine, a regenerator comprising inner and outer circular walls of heat-insulating material having an annular space between them to form a portion of the path of the mediating gas, a plurality of sections having capacity for absorbing and giving up heat, arranged within the annular space one after another but

heat-insulated from each other, said sections each presenting a large surface to the mediating gas and having a plurality of narrow spaces for the passage of the gas.

ton, inner and outer concentric circular walls of heat-insulating material, the inner wall forming a portion of the wall of the cylinder in which said pistons reciprocate, and the annular space between said two walls forming a portion of the path of the mediating air, and a plurality of heat absorbing and delivering units disposed in heat-insulated relation to each other within the said annular space.

7. An air refrigerating machine comprising a compression piston and a shifter piston, inner and outer concentric circular walls of heat-insulating material, the inner wall forming a portion of the wall of the cylinder in which said pistons reciprocate, and the annular space between said two walls forming a portion of the path of the mediating air, and a plurality of coils of metallic ribbons spirally wound on said inner wall in spaced relation to each other, the layers of each of said coils being spaced from each other by a plurality of circumferentially spaced strips of heat-insulating material extending along elements of the cylinder.

5 4. In an air refrigerating machine, a regenerator comprising inner and outer circular walls of heat-insulating material having an annular space between them to form a portion of the path of the mediating air, and a plurality of spirally wound metallic ribbons in said annular space having their layers spaced from each other to form air spaces between layers, said metallic ribbons being heat-insulated from each other.

15 5. In an air refrigerating machine, a regenerator comprising a chamber having walls of heat-insulating material and forming a portion of the path of the mediating air, and a plurality of sections each consisting of metallic ribbons in closely spaced relation to each other and arranged in the path of the mediating air to subdivide the air flow into a plurality of substantially equal small parts, said sections being separated so as to maintain them in heat-insulated relation to each other.

25 6. An air refrigerating machine comprising a compression piston and a shifter piston,

IVAR LUNDGAARD.