Feb. 5, 1963 H. CONRADI 3,076,320

AIR COOLING SYSTEM FOR COLD STORAGE ROOMS

Filed Jan. 4, 1960 2 Sheets-Sheet 1

FIG.1.

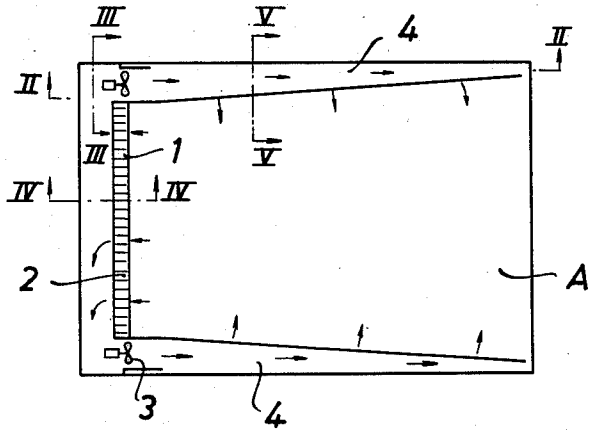


FIG.2.

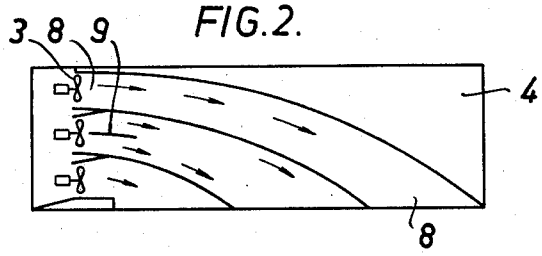


FIG.3.

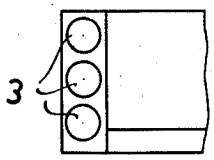


FIG.4.

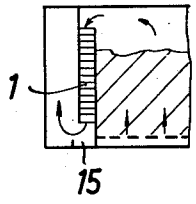
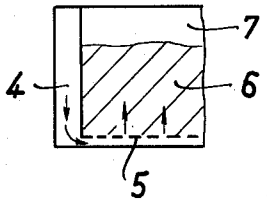


FIG.5.



Inventor
Henrik Conradi
by Sommers & Young
Attorneys

Feb. 5, 1963 H. CONRADI 3,076,320

AIR COOLING SYSTEM FOR COLD STORAGE ROOMS

Filed Jan. 4, 1960 2 Sheets-Sheet 2

FIG. 6.

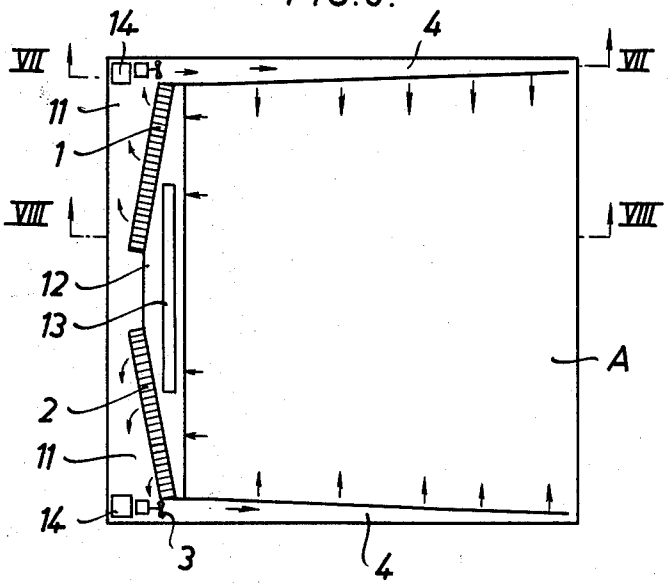


FIG. 7.

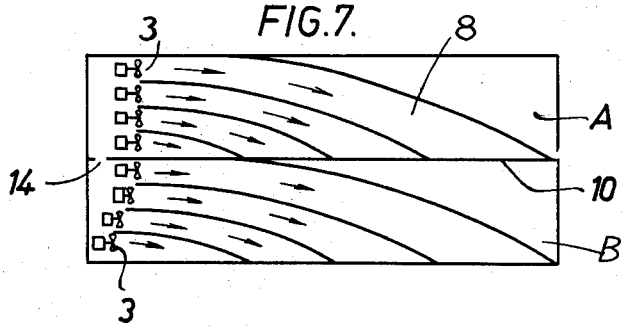
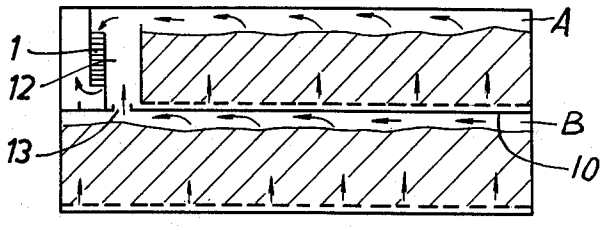


FIG. 8.



Inventor
Henrik Conradi
by Commers-Young
Attorneys

United States Patent Office

3,076,320
Patented Feb. 5, 1963

3,076,320

AIR COOLING SYSTEM FOR COLD STORAGE ROOMS

Henrik Conradi, Pampusvagen 69, Norrkoping, Sweden

Filed Jan. 4, 1960, Ser. No. 96
3 Claims. (Cl. 62—240)

The present invention relates to an air cooling system for cold storage rooms and more particularly for use in connection with ship's cargo holds.

The space of cold storage rooms, especially ship's holds, is very valuable. Where such rooms are to be used for rapidly cooling or freezing goods, as a ship's cargo, an efficient air circulation is required for carrying heat from the goods to the air cooler. The air circulation requires the provision of ducts for distributing the air in the storage room, and fans for overcoming the resistance to flow as exerted by the cooler, the ducts and the goods. The air cooler, fans, and ducts occupy a great portion of the useful space available.

The fans consume power which in the cold storage room is converted into heat which must then be carried away by cooling.

The present invention has for its object to provide an air cooling system including air coolers and fans which is so designed as to allow a substantial saving in space, a substantial reduction of power input required for driving the fans, and permits the use of particularly suitable and inexpensive air coolers.

The invention has reference more particularly to cold storage rooms, preferably cargo holds in ships, of the kind in which cool air taken from air coolers by ducts along one or both side walls of the room and delivered beneath a grating supporting the goods to be cooled to then pass upwards through the goods and flow back to the air coolers. According to a feature of the invention the air cooler or coolers are long and narrow and adapted to be traversed by the air in a direction from top to bottom and in counter-current to the refrigerant passing inside the coolers. According to a feature of the invention an air cooler unit is included in an end wall of a goods storage compartment provided inside the cargo hold, said end wall being positioned at a distance from the respective end wall of the holds so as to leave an air space between it and the last mentioned end wall. The air inlet of said unit is provided at the top of the end wall including the cooling unit, in communication with the interior of the compartment, and the air outlet of the unit is provided at the bottom of said end wall in communication with the air space outside of the wall including the cooling unit.

The invention is illustrated in the accompanying drawings, in which

FIG. 1 is a diagrammatic plan view of a ship's cargo hold;

FIG. 2 is a front view as seen in the direction indicated by the arrows II—II of FIG. 1;

FIGS. 3, 4 and 5 are diagrammatic front views as seen in the directions of the arrows III—III, IV—IV and V—V, respectively, of FIG. 1;

FIG. 6 is a plan view of a modified cargo hold, there being an underlying hold which is cooled by the cooler of the first-mentioned hold;

FIG. 7 is a diagrammatic front view as seen in the direction of the arrows VII—VII of FIG. 6, and

FIG. 8 is a diagrammatic front view as viewed in the direction of the arrows VIII—VIII of FIG. 6.

With reference to FIG. 1 the numerals 1 and 2 designate two air cooling units provided adjacent one end wall of a cargo hold generally designated by the reference character A. Air from said cargo hold is passed through the cooling units as indicated by arrows in FIG. 4, that is, from above downwards, and is delivered in cooled state into the space between the cooling units and the adjacent end wall of the hold. From said space the cold air is passed by the action of fans 3 into air ducts 4 extending along the side walls of the hold. Said air ducts communicate at the bottom with the space between the floor of the hold and a grating 5 provided somewhat above said floor, as shown in FIG. 5.

The air thus entering the space below the grating 5 passes upwardly through the grating and the goods resting thereon which is indicated by the reference numeral 6 in FIG. 5. During its passage through said goods the air has absorbed heat therefrom, so that it has an elevated temperature when it reaches the free space 7 above the goods. Within the space 7 the air flows substantially horizontally towards the upper or inlet end of the cooling units 1, 2.

The whole amount of power supplied to the fans is converted into heat which has to be carried away from the space to be kept cooled by the refrigerating plant. Thus, it is a matter of high importance to keep said amount of power.

It amounts to:

$$E=\frac{Q.(Ps+Pd)}{H}$$

where

E=power in kpm./s.
Q=rate of air flow in m.^{3}/s.
Ps=static head of fan in kp./m.^{2}
Pd=dynamic head of fan in kp./m.^{2}
H=efficiency or, if the losses due to the fan motor are supplied to the cold storage room as heat the total efficiency of the fan and its drive motor.

Since Q is determined by refrigeration-technical requirements, there remains the possibility of reducing $Ps+Pd$ and increasing H. Axial-flow fans being the most advantageous from considerations of procuring costs and space required have a high maximum efficiency.

Ps is determined on the basis of resistances to flow as exerted by air coolers, ducts, goods, etc. by balancing the installation and operation costs against the losses of useful space available for storing goods which are due to the mounting of air ducts, air coolers and fans.

Pd represents a substantial part of the total pressure and involves a loss unless utilized for air circulation purpose. It may be utilized completely, if the fan is mounted in the inlet end of an air duct in which the air will continue to flow at the same rate of speed throughout the length of the duct as it has when delivered from the fan and without changing its direction of flow; it may be utilized to a great proportion, if any subsequent changes as to rate of speed and direction of flow take place as a result of an adequate aerodynamic design of the duct. Such a design of air ducts extending between a circular axial-flow fan and flat ducts provided along floors, walls, or ceilings as of the refrigeration room, would tend to become bulky and expensive to accomplish. The state of things will be quite different if there are used several comparatively small axial-flow fans each delivering air into a separate one of a set of smaller sectional channels or ducts 8, as indicated in FIG. 2. These sectional channels, which may be of diffuser type, extend separately at least within the range where resistance-producing changes as to direction and speed may originate. Preferably, however, the sectional channels may extend separately until they reach their respective portions of the entrance to the

air space below the goods-supporting grating in order to secure a good air distribution therebelow. In the last-mentioned case, the use of small fans for the individual channels will yield an amount of air per sectional channel which is less dependent on deviations from the presupposed resistance to flow than if the sub-division into small channels were made behind a fan common to said channels.

As indicated in FIG. 2 each sectional channel may be divided in two in the neighborhood of the respective fan by means of a partition **9** (which may be slidably adjustable, if desired) extending from a point near to the outlet of the fan.

In the embodiment shown in FIGS. 6 and 8 the cooling room is divided into an upper storage compartment A and a lower storage compartment B by means of a horizontal partition **10** representing the floor of compartment A and the ceiling of compartment B. The cooling units **1** and **2** are common to both compartments though positioned in front of compartment A. They are positioned obliquely in lateral direction and at a distance from the front end of the compartment A in such a way as to form a laterally widening air chamber **11**, between themselves and the front wall of the room and a laterally contracting rear air chamber **12** between themselves and the front wall of compartment A. The rear air chamber **12** communicates through an opening **13** formed in the partition **10** with the lower storage compartment B. Both compartments are provided with goods supporting gratings located at a distance above the respective floor, as shown in FIG. 8.

Provided along the sides of the upper compartment A are air ducts **4** like those of the embodiment already described. Thus they are divided into a plurality of sectional channels **8** each provided with an axial flow fan **3** at its inlet, as shown in FIG. 7.

Similar air ducts with fans are provided along the sides of the lower compartment, as is also shown in FIG. 7.

The air ducts **4** of the upper compartment communicate at their inlet ends directly with the air spaces **11**, as shown in FIG. 6, and at their outlet ends with the space below the respective grating.

The air ducts of the lower compartment communicate with the air spaces **11** through openings **14**, formed in the partition **10**, as shown in FIGS. 6 and 7.

The operation is substantially as follows:

Air that has absorbed heat from the goods stored in the upper compartment passes along the ceiling of said compartment to the inlet of the cooling units **1** and **2**, while air that has absorbed heat from the goods stored in compartment B reaches the inlet of the cooling units via the opening **13** and the air space **12**, as is evident from FIG. 8.

In the cooling units the air to be cooled passes downwardly while the refrigerant as is usual in connection with the type of coolers under consideration passes in the opposite direction, that is, from below upwards.

The downwardly directed air flow secures positive separation of the drops of water which are precipitated within the cooler and carried off by the air flow. Said drops of water may be collected in a drip trough indicated at **15** in FIG. 4. In case of a deficient separation the drops would be carried into ducts and other outfitting where they may cause irreparable damage.

I claim:

1. In an air cooling system for a cold storage room having a floor, a front wall, a rear wall, side walls, and a ceiling, the combination of a means forming a goods storage compartment having a goods supporting grating at a distance from the floor of the room so that an air space is formed between said grating and said floor, an air cooling apparatus including heat transfer units of a long and narrow structure arranged in a vertical plane at the front end of said compartment spaced from the front wall of the room so as to form an air space between themselves and said front wall, said units having air inlets along their top surfaces in communication with the interior of the goods storage compartment and air outlets along their entire bottom surfaces in communication with the air space in front of the units, air ducts provided along the side walls of the room, which communicate at their front ends with the air space in front of the cooling units and at their bottom with the air space beneath the grating of the goods storage compartment, said air ducts each being divided into a plurality of section channels, arranged vertically with respect to each other, and being connected with the bottom space the more remote the higher their respective portions, and an axial flow fan provided in each such channel, whereby, in operation, the downward flow of the air through said cooling units, assists in eliminating condensed moisture from the air, and the fans act upon cooled densified air.

2. Apparatus according to claim 1, and a horizontal partition spaced between said floor and ceiling dividing said goods storage compartment into an upper and a lower storage space, said dividing floor also having a horizontal grating at a distance thereabove, said air cooling units being located in front of said upper storage space, some of said air ducts extending to the spaces between said floors and gratings of both said upper and lower storage compartments, said partition between said storage spaces having an opening for return passage of air, and means forming a conduit from said opening to said cooling units.

3. In an air cooling system as claimed in claim 2 the further feature that the air cooling units are located arranged at centrally converging angles with relation to the front wall of the room so that the fore air space increases towards the air ducts.

References Cited in the file of this patent

UNITED STATES PATENTS

1,749,134	Griswold	Mar. 4, 1930
1,913,857	Scherer	June 13, 1933
2,111,938	Robson	Mar. 22, 1938
2,240,377	Preble	Apr. 29, 1941
2,285,946	Kalischer	June 9, 1942
2,343,395	Bonsall	Mar. 7, 1944
2,468,932	James	May 3, 1949
2,529,651	Davis	Nov. 14, 1950
2,780,923	Jones	Feb. 12, 1957
2,871,677	Bradfield	Feb. 3, 1959
2,902,837	Willis	Sept. 8, 1959