June 13, 1933. J. L. KNIGHT 1,914,207

HEAT INSULATOR

Filed March 9, 1931

Fig. 1.

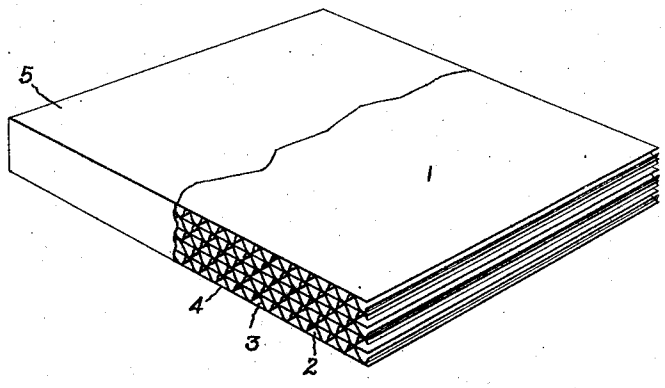



Fig. 2.

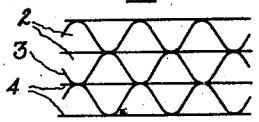
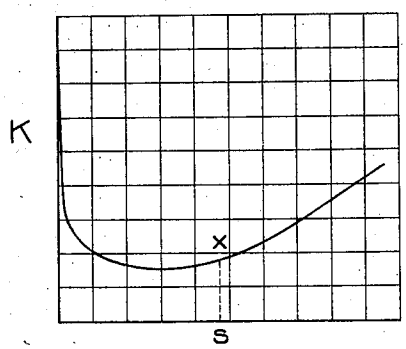



Fig. 3.




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# UNITED STATES PATENT OFFICE

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## HEAT INSULATOR

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My invention relates to heat insulators, more particularly to heat insulating structure of the cellular type.

In the insulation of cold surfaces, as in refrigeration, the best available heat insulating materials generally used for this purpose may be divided into two classes, i. e., loose fibrous materials, as mineral wool for example, and comparatively rigid materials, as pressed wood pulp or fibre board. In connection with the loose fibrous materials, it should be noted that although the insulating efficiency is good when initially installed, the fibre tends to settle and pack, thereby reducing the insulating efficiency and leaving an air space above the fibre causing further lowering of the insulating efficiency by reason of convection currents within the air space. This material is likewise comparatively expensive and retains its best insulating efficiency only when loosely packed.

In the class of comparatively rigid insulating materials formed as boards or blocks, an example of a well known material is a composition of mineral wool and asphalt. Since mineral wool, which is made by steam blasting blast furnace slag or fusible rocks, is brittle like spun glass and tends to settle to a great extent, it is mixed with a stiffening binder, as asphalt, so that the composite insulating material may be formed into a block. The asphalt, however, decreases the insulating efficiency of the material, the conductivity constant K being approximately .35 B. t. u. per square foot per inch per degree F. per hour as compared with aproximately .30 for mineral wool. Another well known insulator in this class consists of a pressed wood pulp or fibre board which is comparatively expensive as is the mineral wool and asphalt composition above referred to.

Insulating blocks of cellular structure generally in the form of built-up layers of air cells are known in the art and are comparatively inexpensive and easily constructed, but have, heretofore, involved the disadvantage that the insulating value was considerably less than in insulating materials having high enough insulating efficiency to be considered satisfactory for use in refrigerator cabinets.

In the manufacture of refrigerator cabinets, it has been found that the greatest economy in manufacture is attained by the use of the higher grades of insulating materials notwithstanding the fact that they are somewhat more costly than less effective insulating materials. This is due to the fact that more efficient insulators provide the necessary insulation for the cabinet while maintaining a minimum thickness of wall thereby reducing the cost of manufacture of the refrigerator cabinet.

A principal object of my invention is the provision of an improved and comparatively inexpensive heat insulator of the cellular type for cold surfaces which shall have an insulating efficiency comparable to that of the best available surface heat insulators.

My invention will be more fully set forth in the following description referring to the accompanying drawing, and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of the specification.

Referring to the drawing, Fig. 1 is a perspective view, partly in section, of an insulator unit embodying my invention; Fig. 2 is an enlarged fragmentary view of the cellular structure of the insulator unit in Fig. 1, and Fig. 3 is a graph representing conductivity.

In the specific embodiment of my invention illustrated in Fig. 1, the cellular heat insulating structure 1 comprises built-up layers of air cells 2 formed by stacking corrugated paper sheets 3 spaced by flat spacer or liner paper sheets 4. It will be apparent that the liner sheets may be dispensed with by arranging the corrugations transversely in alternate layers. This last named arrangement, however, involves increased cost of assembly of the insulating structure and does not constitute a preferred construction. It will likewise be noted in connection with the assembly that the corrugations of the stacked sheets are staggered for the purpose of preventing "nesting" or settling of the insulating structure into less space. In other words, referring to Fig. 2, the ridge of a

corrugation of one sheet is arranged substantially to abut the ridge of a corresponding corrugation in an opposing sheet so that there is no tendency of the corrugations to "nest."

The method of building up the heat insulating structure may comprise alternately stacking the liner and corrugated sheets within a suitable carton 5 to form a unitary insulating block, the sheets being either loosely stacked within the carton or glued together with an adhesive, as silicate of soda or the like, for the purpose of obtaining greater rigidity. Another method comprises affixing a single liner sheet to a corrugated sheet and loosely stacking the cell layer structure so formed within the carton. For the purpose of preventing condensation and accumulation of moisture within the insulating material causing a reduction of insulating efficiency due to the fact that a cold surface insulator is at a temperature lower than that of the surrounding atmosphere, the carton enclosing the cellular insulating structure is hermetically sealed and waterproofed in any suitable manner.

In a cellular structure of the type above described the transfer of heat therethrough at low temperatures takes place chiefly in two ways; first, by air convection currents in the air cells carrying the heat from one layer to the next, and second, by conduction through the solid material forming the cell walls of the structure. Since stagnant air is a heat insulator of high efficiency, the transfer of heat due to convection currents may be substantially eliminated by decreasing the cross section of the air cells so that the resulting high surface friction greatly restricts convection currents. The reduction of heat transfer, however, has not heretofore been accomplished to such a degree that this type of insulator favorably compares with other types of high grade cold surface insulators. In prior types of built-up cellular insulation, rigidity has been considered an essential requisite, the sheet material forming the cell walls being fairly rigid and of such thickness as to decrease its insulating value considerably below that of the class of good insulators which is required for economical construction of the refrigerator cabinet.

My invention comprises, among other features, cell walls, particularly those extending in the direction of heat transfer, having comparatively high resistance to heat flow thereby greatly reducing the amount of heat transferred by conduction. To this end the cross sectional area of the cell walls is limited to such a degree that the conductivity is comparatively small. This result is due to the fact that the cross sectional area of the cell walls bears an inverse relation to the resistance to heat flow longitudinally of the walls. Referring again to Fig. 2, it will be noted that heat transferred by conduction transversely of the insulator block must flow edgewise through the cell walls formed by the corrugations, in order to pass from one liner sheet or cell layer to the next. Accordingly, the resistance of the cell walls to heat flow determines to a great extent the amount of heat transferred by conduction through the insulator.

I have found that an order of thickness not exceeding 3.5 to 4 mils (.0035" to .004") of paper forming the air-cell walls results in a greatly increased insulating efficiency. The lower limit of thickness is determined generally by the stock available having the mechanical requisites for this type of insulation. The type of paper used may be selected according to cost, an example being that known in the trade as "kraft" or "sulphate", which is inexpensive but not too fragile in thin stock. A sulphate paper approximately 2.5 mils in thickness may be readily obtained and has the further advantage that it does not deteriorate with age to an appreciable extent.

The spacing of the liner sheets determining the cross sectional area of the air cells likewise is a factor in obtaining high insulating efficiency. In this connection, reference is had to the graph, Fig. 3 showing a relation between the conductivity constant K and the spacing S for a given thickness of cell wall within the limits above referred to. It will be noted that an appreciable variation in the spacing at the lower limits may be had without appreciably affecting the insulation conductivity constant. I have found that a spacing not exceeding .18 inches, generally indicated at X on the graph, limits the convection currents so that a low conductivity constant is obtained. It will also be noted in connection with the graph that the conductivity increases rapidly as the spacing becomes appreciably greater than the spacing at X and similarly that the conductivity also increases rapidly when the spacing decreases below a value giving approximately the same conductivity constant as that at X. A spacing not exceeding .18 inches furthermore does not involve difficulties in manufacture and assembly.

I have incorporated in a refrigerator cabinet a cellular insulating structure of the type above referred to having thin paper walls approximately 2.5 mils in thickness and a liner spacing of about .14 inches, and found the conductivity constant of the insulation to be approximately .28, an increase of approximately 20 to 25 per cent in efficiency which was heretofore believed impossible in this type of insulation. Furthermore, this insulating value is equal to or better than those of well known high grade insulators.

It should be understood that my invention is not limited to specific details of construction and arrangement thereof herein illus-

trated, and that changes and modifications may occur to one skilled in the art without departing from the spirit of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A heat insulator comprising a cellular structure forming multiple layers of air cells limited in cross section substantially to prevent convection currents therein, the walls of said air cells being composed of thin paper of the order of thickness not exceeding 4 mils.

2. A heat insulator comprising a built-up cellular structure forming layers of small air cells, the walls of said air cells extending substantially in the direction of heat transfer being composed of thin paper of the order of thickness not exceeding 4 mils.

3. A heat insulating cellular structure comprising a plurality of stacked corrugated sheets forming air spaces, said corrugated sheets being composed of thin paper of the order of thickness not exceeding 4 mils, the height of the corrugations in said corrugated sheets being not more than .18 inches and being not less than the height at which the conductivity of the insulation is approximately the same as that having corrugations .18 inches in height.

4. A heat insulating cellular structure comprising built-up layers of liner and corrugated sheets alternately arranged, said liner and corrugated sheets being composed of thin paper of the order of thickness not exceeding 4 mils, the spacing of said liner sheets being not more than .18 inches and being not less than the spacing at which the conductivity of said structure is approximately the same as that having said liner sheets spaced apart .18 inches.

5. A heat insulating cellular structure comprising built-up layers of liner and corrugated sheets of thin paper alternately arranged, said corrugated sheets being approximately 2.5 mils in thickness, the spacing of said liners being approximately .14 inches.

6. A heat insulator comprising a cellular structure forming multiple layers of air cells limited in cross section substantially to prevent convection currents therein, the walls of said air cells being composed of thin paper within the range of thickness between 2.5 and 4 mils.

7. A heat insulator comprising a cellular structure forming multiple layers of air cells limited in cross section substantially to prevent convection currents therein, the walls of said air cells being composed of thin paper of approximately 2.5 mils in thickness.

In witness whereof I have hereunto set my hand.

JAMES L. KNIGHT.