Nov. 2, 1937. C. G. MUNTERS 2,098,193

HEAT INSULATION

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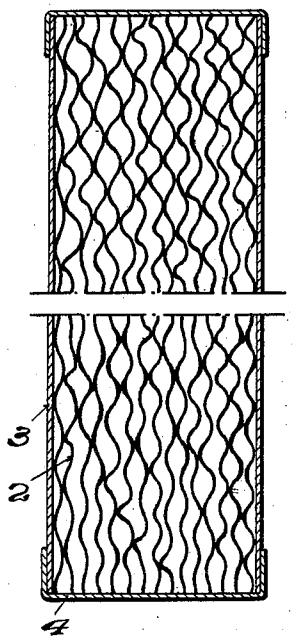


Fig. 1.

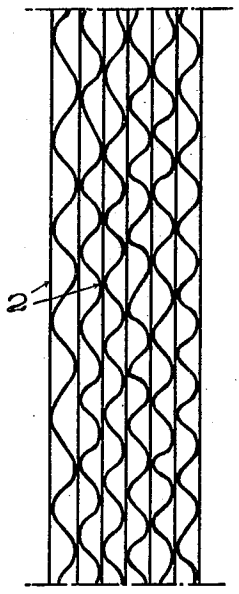


Fig. 2.

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HEAT INSULATION

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4 Claims. (Cl. 154—28)

This invention relates to heat insulation, and more particularly to heat insulation of the character comprising sheet material with intervening layers of gas.

I have discovered that a heat insulation can be produced having an efficiency in excess of the best known solid insulating materials and of substantially the same efficiency as insulation formed of sheets of metal foil as heretofore made, if the insulation is formed of thin folded or crinkled sheets of material of poor heat conductivity assembled with intervening layers of air or other gases having a thickness in the direction of heat transfer of from 0.1 to 1.2 mm. Notwithstanding the increase in solid material thus involved over that employed in insulation utilizing metal foil spaced by layers of gas as heretofore proposed, transfer of heat by conduction is so far reduced and transfer by convection and radiation so nearly eliminated that heat insulation of high efficiency and low cost is produced. So long as the number of sheets employed per unit of thickness in the direction of heat transfer is not increased to such an extent as to reduce the interposed gas layers to less than 0.1 mm. in average thickness and so long as the number of sheets employed per unit of thickness in the direction of heat transfer is not decreased to such an extent as to increase the interposed gas layers to more than 1.2 mm. in average thickness, the amount of solid material present and the number of paths for heat conduction are not such as to offset the advantage derived from the substantial elimination of heat transfer by convection and radiation, even though said sheets do not have bright surfaces. At the same time the use of folded or crinkled sheets eliminates the need for interposed spacing members, as the sheets are held in their proper relationship by the distributed points of engagement of the folds or crinkles.

It is therefore an object of this invention to provide heat insulation which is relatively inexpensive to construct, and which at the same time will have substantially the same efficiency as heat insulation formed of metal foils so spaced as to substantially eliminate convection in the intervening layers of gas.

Another object of this invention is to provide insulation of the type characterized which avoids the need for spacing members to maintain the layers of sheet material in proper relationship.

Another object of this invention is to provide insulation of the type characterized which can be readily formed into units, walls, receptacles, etc., of a wide variety of sizes and shapes without the use of highly skilled labor, inexpensive equipment or costly materials.

Other objects will appear as the description of the invention proceeds.

Stated broadly the insulation is characterized by a plurality of sheets of paper or similar non-metallic material which are spaced in the direction of heat transfer within the limits of 0.1 and 1.2 mm., preferably at an average of about 0.5 mm., said sheets being folded or crinkled, irregularly if desired, so as to contact only at a relatively few distributed points but sufficient in number to eliminate the need for separate spacing members. Such sheets are very durable, resisting deterioration under the action of moisture, changes of temperature and pressure, etc., and insulation so formed may be manufactured at a relatively low cost, both because of the character of the material employed and because of the manner in which it is fabricated.

The invention is capable of receiving a variety of mechanical expressions, two of which are illustrated on the accompanying drawing, but it is to be expressly understood that the drawing is for purposes of illustration only and is not to be construed as a definition of the limits of the invention, reference being had to the appended claims for that purpose.

Referring in detail to the drawing:

Fig. 1 is a diagrammatic illustration of heat insulation embodying the present invention; and

Fig. 2 is a diagrammatic illustration of another embodiment of the present invention.

Referring first to the embodiment of Fig. 1, a plurality of sheets of paper or similar non-metallic material, designated 2, are loosely disposed on each other so as to form a pack with intervening layers of air or other gas, and are disposed within a container of any suitable size, construction and material composed of exterior walls 3 and edge members 4. Walls 3 may be of cardboard, for example, and the edge members 4 may be of cardboard, paper or the like, folded over the faces of walls 3 and suitably secured thereto as by pasting. Sheets 2 are preliminarily folded or crinkled, so that when they lie face to face they will contact at distributed points where opposing folds or crinkles happen to engage. Thereby the sheets are maintained in their proper relationship without the use of interposed spacing members. In order to get the desired distance between the sheets, they are pressed together until the desired average spacing is obtained, as determined by dividing the thickness of the pack

as a whole, minus the total thickness of the sheets used, by the number of sheets employed.

The pack is so compressed until the average spacing between the sheets in the direction of heat transfer lies between 0.1 to 1.2 mm., although the distance between the sheets will vary from point to point because of the manner of the formation of the sheets. The preferred average spacing is substantially 0.5 mm.

The sheets may be of any suitable material having a relatively poor capacity for conducting heat, but by preference sheets of paper are used having a thickness of 0.035 mm. to 0.075 mm. in thickness. The paper itself may be of any suitable character, as for example a paper formed from a waste silk base. The gaseous medium employed may be air or, if preferred, gas of low heat conductivity may be used. The paper may be impregnated with linseed oil, paraffin or the like to render it waterproof, if desired.

Investigations carried out with insulation manufactured as above described have demonstrated that the efficiency thereof is on the order of 20% higher than that of cork of the same overall thickness and substantially equal to that of metal foils spaced by layers of gas as heretofore made and having the same overall thickness. In insulation so constructed the thickness of the gas layers is such as to assure the substantial absence of convection currents therein, and the high efficiency of the insulation notwithstanding the fact that the sheets are in contact at distributed points and therefore afford some paths for heat conduction establishes that, at the spacing employed, heat transfer by radiation has been substantially eliminated, notwithstanding the fact that inasmuch as paper has little reflecting capacity it has been heretofore considered as of little value for preventing heat transfer by radiation. Although a greater percentage of solid material is used and direct contact of the sheets is effected at distributed points, the efficiency is found to be substantially equal to that of insulation formed by brightly surfaced metal foil so spaced as to avoid substantial convection currents in the intervening layers of gas. Investigation has demonstrated that there is an optimum value of about 0.5 mm. for the average spacing of the sheets, and that the efficiency falls off rather rapidly until at an average spacing of less than 0.1 mm. or greater than 1.2 mm. the efficiency of the insulation approximates that of cork. As the sheets **2** do not extend in the direction of heat transfer, there is little or no transfer of heat by conduction in the direction of their extension. While said sheets are in contact at distributed points where their folds or crinkles are in engagement, the number of such points of contact is small, the area of each contact is infinitesimal, and the percentage of each sheet thus in contact with the contiguous sheets is but a very small percentage of the total area of the sheet. Therefore, heat transfer by conduction in the direction of heat transfer is very low.

In place of employing sheets all of which are folded or crinkled, as in the embodiment of Fig. 1, only alternate sheets may be folded or crinkled as shown in Fig. 2, every second sheet in this embodiment being plane, while the intermediate folded or crinkled sheets determine the spacing of the plane sheets.

While air is the preferred gas employed in the intervening spaces between the sheets, a gas having lower heat conductivity than air at corresponding temperature and pressure may be used, if desired. The sheets themselves may be formed of insulating material, if preferred, as asbestos paper, as when the insulation is to resist heat transfer with a relatively large heat differential. The confining walls **3, 4** may be made of any suitable material and, if preferred, they may be so constructed as to form a hermetically closed container for the insulation. The edge members **4** interposed between the walls **3** should be of low conductivity so as to minimize transfer of heat therethrough.

Various other changes in form, construction, and material will now readily suggest themselves to those skilled in the art, without departing from the present invention, and heat insulation constructed in accordance with the invention may be formed into a wide variety of units, walls, containers, cabinet structures, etc.

While the invention is of particular utility as applied to the walls of refrigerating cabinets, it may be used for other purposes in a wide variety of heat insulations, as will be apparent to those skilled in the art. Reference is therefore to be had to the appended claims for a definition of said invention.

What is claimed is:

1. The method of producing heat insulation which includes the steps of folding or crinkling a plurality of sheets of material of poor heat conductivity, laying a plurality of such sheets in face to face contact, and compressing the pack so formed until the intervening gas layers have an average thickness in the direction of heat transfer of from 0.1 mm. to 1.2 mm.

2. The method of producing heat insulation which includes the steps of folding or crinkling a plurality of sheets of material of poor heat conductivity, laying a plurality of such sheets in face to face contact, and compressing the pack so formed until the intervening gas layers have a thickness in the direction of heat transfer averaging about 0.5 mm.

3. The method of producing heat insulation which includes the steps of folding or crinkling a plurality of sheets of material of poor heat conductivity, laying a plurality of such sheets with interposed plane sheets in face to face contact and compressing the pack so formed until the intervening gas layers have an average thickness in the direction of heat transfer of from 0.1 mm. to 1.2 mm.

4. Heat insulation comprising a plurality of sheets of paper forming intervening gas layers the limits of the thickness of which in the direction of heat flow are between .1 and 1.2 millimeters, and whose average thickness is substantially .5 millimeter plus or minus a thickness insufficient to decrease the heat transfer efficiency as compared to cork below 80%.

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