

Nov. 15, 1955

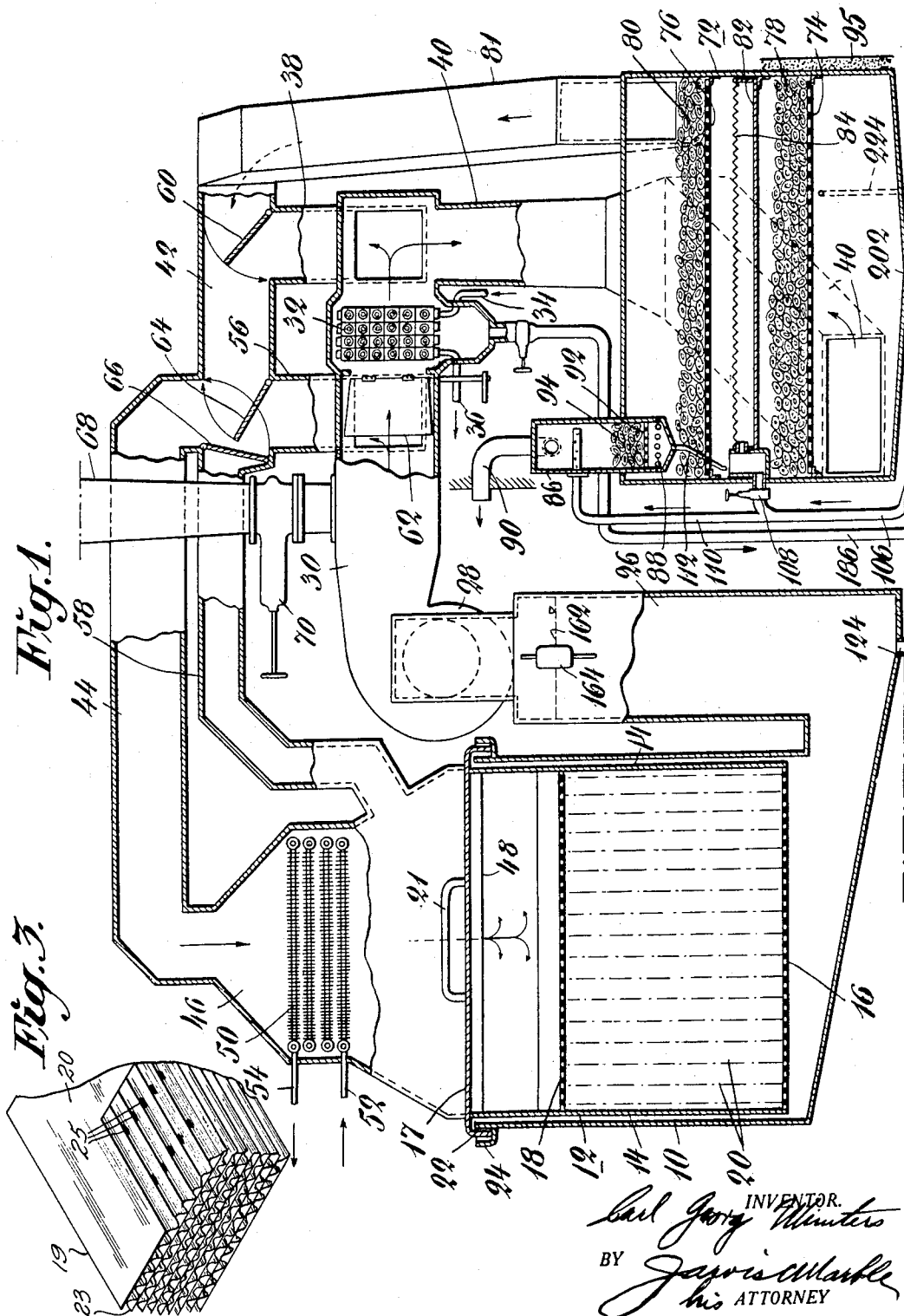
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2,723,923

METHOD OF IMPREGNATING MULTILAYER PAPER INSULATION

Filed Oct. 2, 1947

2 Sheets-Sheet 1



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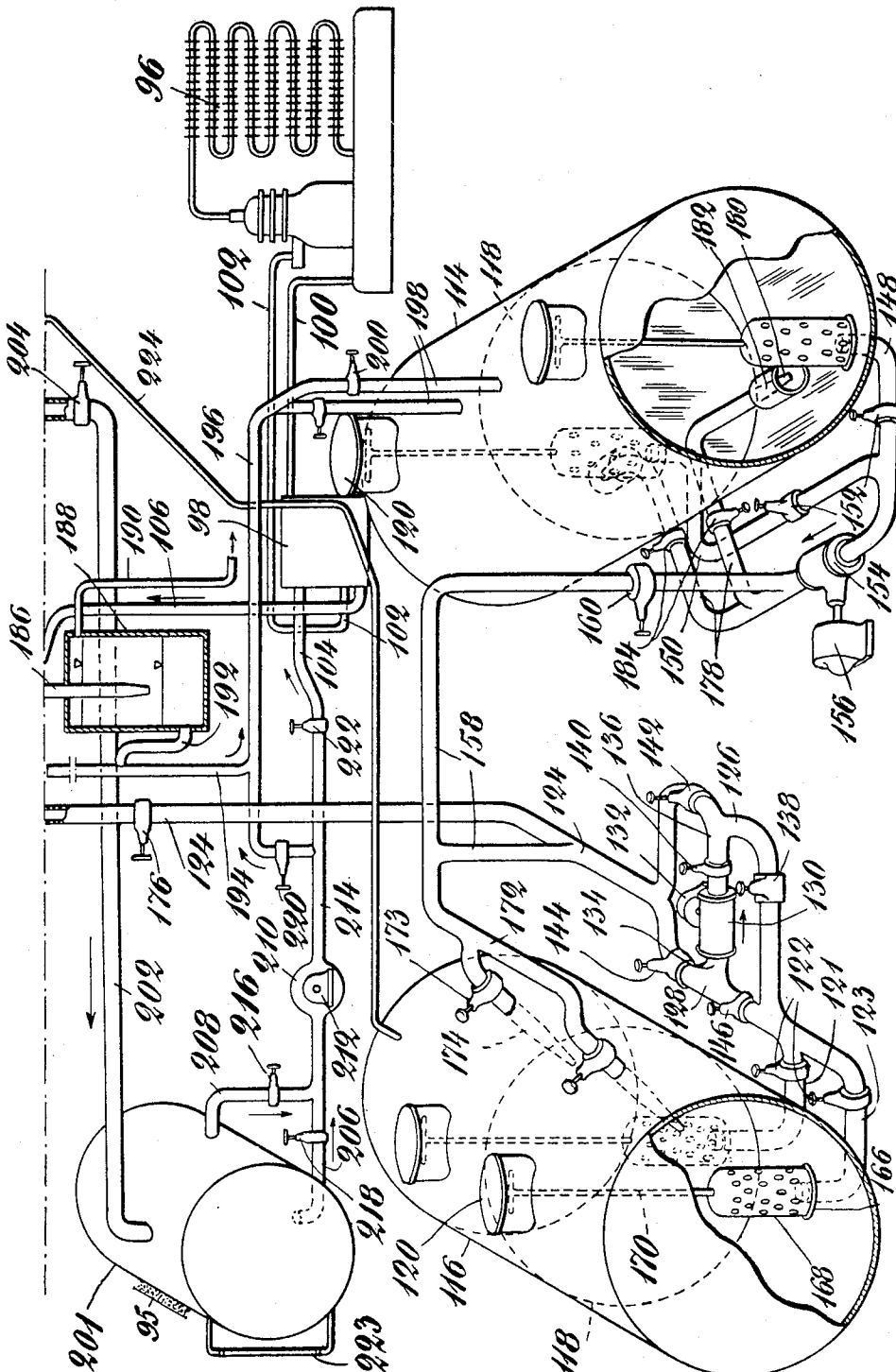
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2 Sheets-Sheet 2

Fig. 2.



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1

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METHOD OF IMPREGNATING MULTILAYER PAPER INSULATION

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Application October 2, 1947, Serial No. 777,534

1 Claim. (Cl. 117—102)

This application is a continuation in part of my application Ser. No. 396,014 filed May 31, 1941, now abandoned.

The present invention in one of its principal aspects relates to the treatment of material with a desired treating agent. More specifically the invention relates to the treatment of fibrous material with an impregnating agent and still more particularly the invention relates to the manufacture of impregnated insulating material of the multi-ply type form of paper sheets impregnated with a bituminous impregnating agent. In another of its aspects the invention relates to improved methods for the recovery of a vaporizable liquid solvent or other vehicle employed as a carrier for the treating or impregnating agent applied to the material.

Since the invention is particularly applicable and useful for the production of insulation of superior quality of the above described kind, it will hereinafter be described by way of example but without limitation, insofar as certain aspects of the invention are concerned, as employed for that use, it being understood that the scope of the invention in its several aspects is defined in the claim appended hereto.

Multi-ply insulating materials made of non-impregnated paper are less satisfactory when subjected to moisture, as is particularly the case in refrigerating plants, it being understood that the paper loses its strength when the moisture content thereof exceeds a certain value. If the various paper plies are connected with one another by gluing, for instance by means of water glass or other binding agents soluble in water, which is most frequently the case, the risk of the insulation being destroyed or collapsing after a certain time of use is increased still more. Furthermore, the non-impregnated paper insulation is subjected to decomposition and molding, and so forth.

It has been proposed, therefore, to impregnate paper with a bituminous agent, such as asphalt. This class of impregnating agents has exceedingly good properties for the purpose in view and, besides, it is comparatively cheap. It has been found, however, that the manufacture of paper insulation impregnated with such substances involves certain difficulties. Thus, where paper impregnated with bitumen is corrugated between toothed rollers, it may occur that the paper ply is caused to stick to the rollers, which incurs the risk of its becoming torn. Contributing to this is also the fact that the paper must be heated in conjunction with the corrugation to a comparatively high temperature, in order that its shape shall be maintained after it has left the toothed rollers. Upon such heating, the bitumen is caused to melt so as to become sticky. Certain difficulties are met with in uniting the various impregnated paper sheets with each other, particularly so if the binding is effected with the aid of bitumen. The paper sheets have also been sewn together by means of thread. An insulating unit produced in this manner does not, however, obtain any satisfactory rigidity and strength.

2

The factors, which are determining the efficiency of a heat insulation, are the following:

- (a) Heat transfer by radiation,
- (b) Heat transfer by convection,
- (c) Heat transfer by conduction in the solid and gaseous substance.

In the case of heat insulation of the particular type according to the present application, that is to say a multilayer insulation of non-metallic fibrous foils or sheets, it is possible to form the same in a manner such that it has a favourable figure of heat transfer. Here, it is necessary, however, in order to reduce or to eliminate the effect of the factors (a) and (b), to space the layers very close. The average spacing is thus preferably less than 2 mm. The radiation is eliminated to a great extent by the many layers, and convection of the gas or air in the interior of the insulation is prevented by the small height or cross section of the passages, whereby the air or gas is caused to remain stationary in the same. The conduction in the air (gas) which fills the passages is given by the figure of conduction thereof, whereas the conduction in the paper substance depends on the magnitude of the total cross sectional area, through which the heat flows. Now, if the paper of such a multilayer insulation is impregnated, the two first-mentioned factors are not influenced whereas the conduction in the solid substance depends on the quantity of impregnating agent.

To provide an insulation product withstanding a temperature as high as possible, without the impregnating agent melting, and which is not sticky at ordinary temperature but may be handled conveniently in storing, transport and mounting, it is important that the impregnating agent have a high melting point. If a unit of paper sheets is in known manner dipped into a bath of an agent of this kind, such as bitumen, being heated to the highest temperature which the paper can withstand without carbonizing, the agent will still not be sufficiently viscous. The result is that too much agent remains in the numerous passages of the insulation, whereby the factor (c) as per above is influenced insofar as the conduction through the solid substance impairs the efficiency of the insulation.

It is the general object of one aspect of this invention to provide a method which takes care of the conditions particularly applicable to insulations of a multi-ply type to provide a new and improved product having highly desirable properties, such for example as a very low figure of heat transfer, which may be as little as 0.034 cal./m. h. °C., low weight, high resistance to moisture and relatively great rigidity and strength. To this end impregnating agents such as asphalt or the like which are solid at normal temperatures are employed, and in another of its aspects the invention has as a general object the provision of improved methods for removing and recovering from the treated material the solvents required to apply such impregnating agents, so as to leave the material in substantially dry state without stickiness and also so as to recover a higher percentage of the solvent employed than has hitherto been possible with prior known recovery methods, thus enabling the treated material to be produced at low cost because of the high recovery of the relatively expensive solvent required.

Further objects and advantages of the invention will be apparent from the following description considered in connection with the accompanying drawings, which form a part of this specification, and of which:

Fig. 1 is a side view, partly in section, of the upper part of an apparatus for carrying my invention into effect.

Fig. 2 is a perspective in part sectional view of the lower part of said apparatus and

Fig. 3 is a perspective view of a heat insulation.

The apparatus shown in the drawings is preferably

built in two floors. The upper part illustrated in Fig. 1 comprises an impregnating and drying chamber 10 of rectangular form in a horizontal section. This chamber is adapted to receive a basket 12 including only two vertical walls 14, secured at the top to a cover 17. Secured to the bottom of the walls is a grate 16 while an upper grate 18 is movably mounted between the walls 14. The space between the grates 16, 18 and the walls 14 is adapted to be filled with units 20 of multi-layer paper insulation. Said units consist as shown in Fig. 3 of a plurality of alternating plane and corrugated plies 19, 23 which prior to being impregnated according to the invention are united with each other by means of a suitable binding agent, such as water glass. The corrugations are parallel through the whole unit. The binding agent may be applied onto the corrugations all over the length thereof; a comparatively strong binding of the various plies being attained thereby. In most cases it is sufficient, however, to attach the various plies at points only, as indicated at 25 in Fig. 3. The spacing of two adjacent plane sheets 19 is about 4 mm. The weight of the paper is preferably between 40 to 60 gr./m.². The units 20 are placed side by side over the whole cross sectional area of the basket with their open ended channels extending in the vertical direction, and are kept in position by the upper grate 18. The basket 12 with the units 20 is lifted by a handle 21 and placed in the chamber 10 by a vertical movement until the flanges 22 of the cover 17 bent 90° downwardly are supported on the bottom of a liquid seal 24 preventing gas from escaping from the chamber.

Connected to the chamber 10 is a circulating system comprising a channel 26 communicating with a lower part of the chamber and extending upwardly to a level above that of the grate 18 when the basket 12 is in the position shown in Fig. 1. The channel 26 is connected to the suction side of a fan 28. The pressure side of said fan communicates with a channel 30 in which a condenser 32 is disposed. Said condenser has an inlet conduit 34 and an outlet conduit 36 for cooling water having a temperature which may be between 4 to 25° C. in accordance with the season and climate conditions. The end of the channel 30 is divided into two branches 38, 40. The branch channel 38 communicates through channels 42, 44, 46 with the chamber 10, the last mentioned channel opening laterally into the chamber 10 below the cover 17 and above the grate 18, as indicated at 48. The channel 46 has heating elements 50 having an inlet 52 and an outlet 54 for a heating medium, such as steam. A channel 56 connects the channel 30 at a point between the fan 28 and the condenser 32, with the return channel 44. The return flow to the chamber 10 may in part be directed through a channel 58 arranged in parallel with the channel 44 and by-passing the heating elements 50. Valve members or dampers 60, 62, 64 and 66 are arranged in the channels for providing the various flows through the same as will be explained in the following. A vent pipe 68 to the atmosphere, controlled by a valve 70, extends from the channel 30 at a point between the fan 28 and the condenser 32.

The branch channel 40 opens at the bottom of a low temperature condenser 72 working with a liquid cooling medium, preferably a brine, such as water and calcium-chloride. The condenser 72 has two vertically spaced grates 74, 76 carrying layers 78 and 80 of distributing members for the cooling medium, preferably rings of clay of known construction. Between the two grates 74, 76 one or more distributing troughs 82 for the cooling medium are provided, the longitudinal upper edges of which may be toothed or the like, as at 84, to facilitate even distribution of the medium over the lower ring layer 78. While the grates 74, 76 and the ring layers 78, 80 extend horizontally over the whole cross section of the condenser 72, the trough 82 has less extent at right angles to the plane of the drawing so that the medium flowing over the toothed edges 84 is spread as evenly as possible over the layer 78. While the circulating system above described

is closed to the atmosphere the condenser 72 communicates with a container 86 having a ring of holes 88 and a passage 90 opening to the atmosphere. On a grate 92 positioned above the holes 88 there is a layer of ring members 94 of the same kind as the ring member 78, 80. The upper part of the condenser 72 is connected to the channel 42 by a channel 81 controlled by the valve member 60. To reduce heat losses by radiation parts of the apparatus, such as the condenser 72, are heat insulated, as indicated at 95.

A refrigerator 96 which may be of any known construction is connected with a heat exchanger 98 of well-known kind through conduits 100, 102. The cooling medium enters the exchanger 98 through a conduit 104 and after being cooled down to a temperature below 0° C., preferably -15° C. or more is pumped through a conduit 106 and through a valve 108 to the box 82 whereby the distributing rings 78 are soaked by the medium. A branch 110 of the pipe 106 opens in the interior of the air vent container 86 above the layer 94 so that also it is soaked by cooling liquid. From the bottom of the container 86 said liquid is conveyed to the box 82 through a pipe 112.

On the lower floor there are preferably two tanks 114 and 116 containing an impregnating agent, such as bitumen or asphalt, and a solvent, such as tri-chloro-ethylene or other chlorinated hydrocarbon compound of the same kind. The bitumen is of a kind being hard and brittle at normal temperature. The tanks may have an intermediate wall 118, dividing them into two compartments, each having an upper opening, normally closed by a cover 120. Extending from the lower part of the compartments of the tank 116 are pipes 121, 123, controlled by valves 122 and connected to a pipe 124 through two branch pipes 126 and 128, communicating with the suction and pressure side of a pump 130, driven by a motor 132, through pipe connections 134 and 136, respectively. In said pipes valves 138, 140, 142, 144 and 146 are inserted, in a manner such that fluid can be pumped from the pipes 121, 123 to the pipe 124 or vice versa while the pump 130 is rotating in one and the same direction. Likewise, the two compartments of the tank 114 have discharge pipes 148 and 150 controlled by valves 152 and connected to the inlet of a pump 154 driven by a motor 156. The outlet of the pump 154 communicates with the pipe 124 through a pipe 158 controlled by a valve 160.

The pipe 124 opens at the bottom of the channel 26 laterally of the chamber 10. While the impregnating fluid may be fed to the chamber 10 through any of the tanks 116 and 114, I prefer to store the fluid in the tank 116. When the chamber 10 is filled to the level 162 which is above the grate 18, a level control 164 of known construction automatically stops the pump. After the units 20 are impregnated, the excess fluid may flow back to the tank 116 by gravity, although I prefer to use the pump 130 for that purpose.

Secured to the ends of the pipes 121, 123, 148 and 150 in the tanks are disks 166 which carry strainers 168 adapted to prevent any solid particles from entering the container 10. These strainers can be lifted up for inspection and cleansing by rods 170.

Impregnating liquid may be prepared in the tank 116, pieces of the agent and solvent being for that purpose filled in through the upper openings of said tank. The solvent is circulated by the pump 130 through the conduit 121 or 123, the conduits 128, 134, 140, 126 and 158, a conduit 172, a valve 173 and an ejector 174 opening in each compartment of the tank 116 and adapted to give the solvent a high speed to facilitate the dissolving of the solid agent pieces. During this operation a valve 176 in the pipe 124 is closed. However, I normally store, as stated above, the impregnating liquid in the proper concentration in the tank 116, while new liquid is mixed in the tank 114, the pipe 158 having for that purpose branches 178, the ends of which are formed as ejectors 180. The

latter are in this tank surrounded by tubes 182 open at both ends to impart turbulence to the liquid. Valves 184 are inserted in the branches 178. The liquid can be circulated through the tank by means of the pump 154, the valves being adjusted to open connections between the pipes 148, 150 and 178, respectively. The liquid is fed over to the tank 116 as it becomes consumed in the same.

The two compartments of the tanks 114 and 116, respectively, may advantageously contain impregnating liquids of various concentration as far as the impregnating agent is concerned.

Solvent and water evaporated from the units 20 and condensed on the water cooled condenser 32, flows through a pipe 186 to a container 188, where it opens below the level of an overflow pipe 190. The solvent is of such nature that it is insoluble in water and separated therefrom by gravity. Tri-chloro-ethylene is heavier than the water and is consequently collected at the bottom of the container 188. A pipe 192 extends upwardly from the lower part of the container 188 to a level below that of the pipe 190 adjacent the container, and is connected to a vertical pipe 194, the upper end of which is open and drawn up to a suitable level. When the condensate flows into the container 188 and is separated, the water will press solvent up in the pipe 192 and out into the pipe 194. While the water escapes through the pipe 190 to waste the solvent follows the pipe 194, a pipe 196 and either of two pipes 198, controlled by valves 200, to the tank 114.

The brine passing the low temperature condenser 72 where it takes up solvent and water, is conveyed to a tank 201 through a pipe 202 controlled by a valve 204. In said tank the brine is separated from the solvent by gravity. A pipe 206 opens at the bottom of the tank 201 where the solvent is collected, and another pipe 208 at a point on a higher level. Both said pipes may be connected to the suction side of a pump 210 driven by a motor 212. The other side of the pump 210 is through a pipe 214 connected to the pipe 104 as well as to the pipe 196. Normally brine is pumped from the tank 201 to the heat exchanger 98 up to the condenser 72 by the pump 210. At intervals the solvent collected in the tank is pumped back to the tank 114 by one and the same pump, valves 216, 218, 220 and 222 being provided for creating the various connections. The levels of the two fluids may be controlled by a level indicator 223.

224 is a pipe, connecting the tank 116 with the interior of the condenser 72 in order to avoid losses of solvent vapors contained in the air space of the tank, when liquid is pumped into the tank and consequently air is expelled therefrom.

The operation of the apparatus is as follows:

After the basket 12 with a charge of units 20 is placed in position in the chamber 10, the pump 130 is started, feeding the impregnating agent dissolved in the solvent from one of the compartments of the tank 116 to the level 162 in the chamber 10, so that the units 20 are entirely submerged in the impregnating liquid. Thereafter the excess of liquid is pumped back to the tank 116. The fan 28 is now started and heat is supplied to the elements 50. The valves of the circulating system are so adjusted that substantially the whole current of air passes the channels 56 and 44. During a first short period the valve 66 is opened so that part of the air passes the channel 58 and thus does not become heated by the elements 50. This is for the purpose of ensuring gradual expansion of the air. The air which is expelled from the circulating system due to the increase of temperature thereof and evaporation of solvent from the units 20 is forced to pass through the low temperature condenser 72 and the container 86 where vapors of solvent following the air are condensed and thus recovered. As the circulating air becomes more saturated with vapors of the solvent, the valve 62 controlling the flow to the condenser 32 is opened while the valve 64 is moved towards closed position. The channel 81 is closed

by the valve 60. A part of the air and solvent vapors traversing the fan 28 thus passes the condenser 32, where the vapors vaporized from the units 20 are condensed to a partial pressure corresponding to the temperature of the condenser. The units contain water which is also evaporated and is also condensed on the condenser 32. While in this way the main part of the solvent is recovered, the units 20 and the air in the circulation system still contain considerable quantities thereof. Therefore the valve 60 is after some time opened, so that part of the circulating air after being precooled in the condenser 32 is allowed to pass the low temperature condenser 72, where it meets the lower ring layer 78 soaked by the brine, whereby the solvent vapors are absorbed to bring down the partial pressure thereof in the circulating air to the low value corresponding to the temperature of the brine. Any drops of brine following the current of air upwards are retained by the upper ring layer 80. The air is conveyed back to the channel 44 through the channel 81.

A part of the air in the apparatus is thus at this stage of the drying operation continuously conveyed through the low temperature condenser 72 resulting in the residue of the solvent contained in the air as a whole and in the material 20 being gradually reduced to a great extent. Thus, it has proved that the content of tri-chloro-ethylene in the units 20 is reduced to less than 1 or 2 percent counted on the weight of the impregnated units. The temperature of the air when entering the chamber 10 during the drying period is raised to about 160° C. At this temperature the solvent not only diffuses from the units 20 and the interior of their sheets but is also boiled off, whereby the time for removing the solvent is reduced. This is of importance also from the point of view that a solvent as tri-chloro-ethylene has a low viscosity and consequently penetrates into the fibres of the paper, which therefore are thoroughly impregnated by the bitumen. Due to the fact that the main part of the solvent is recovered in the water condenser 32 and that momentarily only a portion of circulated air traverses the condenser 72, the capacity of the refrigerating machine 96 can be kept within reasonable values. In the condenser 72 water following the air is condensed, which is removed together with the brine, so that there is no deposit of ice in the condenser, a matter which otherwise would complicate the operation of the same and highly reduce its efficiency. The essential demand of cooling effect in the condenser 72 is concentrated to a relatively short period, during which it is very high. Due to the fact that a brine is used which is circulated between the heat exchanger 98 and the tank 201, which may contain an appreciable quantity of brine, an accumulation of refrigerant is provided during the intervals between such periods which is well suited to meet the concentrated cooling demand.

When the recovering period is finished, the basket 12 is lifted somewhat, so that direct communication between the chamber and the surrounding air is established. The fan 28 is kept running while the valve 70 is opened and the passages through the condenser 32 and the channel 56 are closed. Fresh air is now passed through the units 20 cooling down the same, said air escaping to the outer atmosphere through the vent 68.

By varying the concentration of the bitumen in the solvent the quantity of the bitumen in the insulation may be determined at will. For refrigerating houses or the like it is suitable to use an insulation, in which the bitumen amounts to 35-60 percent of the weight of the finished insulation. The percentage of the bitumen in the finished insulation will be about the same as in the impregnating fluid.

The apparatus may be built for manufacturing 5 m.³ impregnated insulation or more in one charge. The fan 28 will then have to circulate about 750 m.³/minute to carry through the drying or recovering process within 15 minutes. The condenser 72 is dimensioned for about 75,000 cal./h. while the momentary load may be of the

order of 500,000 cal./h. The air volume enclosed by the apparatus is about 40 m.³.

While one more or less specific embodiment of the invention has been shown, it is to be understood that this is for purpose of illustration only, and the invention is not to be limited thereby, but its scope is to be determined by the appended claim.

What I claim is:

The method of manufacturing impregnated units of heat insulating material of the multi-ply type, which includes the steps of providing a plurality of sheets of paper secured together at spaced places to form a unit providing a multiplicity of channels of relatively small transverse dimensions as compared with their length; applying to said unit a liquid comprising a bituminous impregnating agent and a chlorinated hydrocarbon solvent thereof, confining said unit in a suitable receptacle forming a part of a duct system having an atmospheric vent and providing a closed circuit for circulating air, circulating and re-circulating the body of air in said circuit through said channels while adding heat thereto to raise the temperature of the air and the material to a value sufficiently high to vaporize said solvent and any moisture in the system and the material being treated; and to enhance the impregnation of the material by the hot impregnating agent, passing the gaseous mixture expelled through said vent due to the increase in volume resulting from the heating and vaporization in heat exchange relation with a cooling medium having a temperature below the freezing point of water to condense and recover solvent from the expelled gas, continuing the re-circulation of the body of gaseous mixture through said circuit and channels, while concurrently continuing to add heat thereto at one place in the circuit to maintain desired vaporizing temperature and passing the mixture at another place in the circuit in heat exchange relation with a cooling medium to condense and recover solvent from the circulating gaseous mixture and thereby progressively reduce the solvent vapor content of the mixture and the material being treated, further continuing the re-circulation of the gaseous mixture while continuing to add heat thereto and passing at least a portion of the circulating body in direct

contact heat exchange relation with a cooling medium having a temperature below the freezing point of water to further condense and recover solvent until the solvent content of the circulating body and the material being treated is substantially removed, and thereafter admitting fresh air to the circuit and forcing it through said channels at a rate operative to relatively rapidly cool the hot treated material and thereby prevent the self ignition thereof.

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