The present invention relates to cold plates, the term "cold plate" being used to designate a refrigerated surface, whether flat, cylindrical or of other configuration and whether horizontal, inclined, vertical or in other position. The invention is applicable to refrigerated tables, shelves, counters and other supporting surfaces and to refrigerated walls, ceilings, containers, cabinets and other enclosures, but is not limited to these specific applications.

When a refrigerated surface is exposed to atmospheric air that is warmer than the surface, moisture from the air condenses on it and either freezes in the form of ice or frost or remains liquid in the form of water, depending on the temperature of the surface. At the boundary or edge of a refrigerated surface, the adjacent material, such as a molding, trim or frame, surrounding the refrigerated surface becomes cooled by contact with, or proximity to, the refrigerated surface so that moisture condenses on it also. In many instances, such condensation is highly objectionable. For example, if the trim around a refrigerated table is continually wet from condensation of water from the air, it is unpleasant to touch, soils the clothing of anyone coming into contact with it and drips on to the floor or anything else beneath it.

It has been proposed to avoid condensation on the trim or frame by insulating the trim from the refrigerated surface. However, for reasons of appearance and sanitation, it is not desirable to separate the trim from the refrigerated surface to the extent necessary for the required thickness of insulation between them. It has also been proposed to avoid condensation by heating the trim, either electrically or by passing a heating fluid through a tube adjacent to the trim. The use of electric heating has been found undesirable because of the expense and inefficiency and the danger of electric shock. As a heating fluid, it has been proposed to use either the gaseous refrigerant directly from the compressor of the refrigerating unit or the liquid refrigerant from the receiver or reservoir. Neither of these expedients has proved satisfactory. If gaseous refrigerant from the compressor is led along the trim, the first part is heated too hot and subsequent portions are heated to a progressively lesser extent as the gas cools off, since the only heat available is the specific heat of the gas. If liquid refrigerant in the form of waifer is used, the only heat available is the specific heat of the liquid and the heating effect decreases progressively as the liquid cools off. Hence, in both instances the heating is not uniform and the amount of heat available—being only the specific heat of the refrigerant—is not sufficient to heat a large frame. Part of the frame is heated objectionably hot and part of it is not heated sufficiently to avoid condensation.

It is an object of the present invention to overcome these objections and to utilize the refrigerant to control the temperature of the trim or frame in such a manner as to assure accurate control and uniform temperature of the trim throughout its length, such control being wholly automatic. A further object of the present invention is to use the refrigerant of a central refrigerating unit to control the temperature of the trim on a series of cold plates in such a way as to maintain all of them automatically at a uniform temperature. Other objects of the invention are to improve the construction and operation of cold plates and to increase their utility.

In accordance with the invention, the temperature of the trim or frame is controlled and automatically maintained at a uniform temperature throughout its extent by means of a conduit which is in thermal transmitting relation with the trim and is connected in the circuit of the refrigerating system between the primary condenser and the receiver. The temperature control conduit thus contains refrigerant in the transitional stage between a gas and a liquid and acts as a secondary condenser in that it condenses additional refrigerant after part of the refrigerant has been condensed in the primary condenser. It is thereby possible to use a smaller primary condenser than would otherwise be required. The temperature controlling conduit also provides additional storage space for condensed refrigerant and thus acts as an auxiliary receiver. In view of this dual function the conduit is herein sometimes referred to as a condenser-receiver.

Since the refrigerant passing through the temperature control conduit of the trim or frame is partly liquid and partly gas or vapor, the heat available for maintaining the temperature of the conduit and hence that of the trim is the latent heat of liquefaction and the temperature is automatically maintained constant at the boiling point of the refrigerant at the pressure maintained in the conduit. If, through transitory local conditions, a portion of the conduit should become slightly cooler, a correspondingly greater amount of condensation of the refrigerant will take place at that point, thereby restoring uni-
form temperature. As the latent heat of liquefaction is much greater than the specific heat of the refrigerant in either a gaseous, as before condensation, or in the liquid state, following the receiver of the refrigeration system, there is adequate heat available for controlling the temperature of the trim of even a very large cold plate or the trim of a series of cold plates served by a single refrigerating unit. Moreover, regardless of the length of the trim or the number of cold plates in a series, the temperature of the trim is maintained uniform and constant throughout.

The control is entirely automatic, requiring no attention.

In combination with the improved temperature control system described above, the invention embodies improved constructional and operational features which greatly enhance the value and usefulness of cold plates of this general category, as will appear more fully from the following description, in conjunction with the accompanying drawings which illustrate by way of example several embodiments of the invention.

In the drawings:

Fig. 1 is a schematic view showing a cold plate in accordance with the invention in top perspective and an associated refrigerating unit in side elevation.

Fig. 2 is a partial cross-section of the cold plate on a larger scale.

Figs. 3 and 4 are similar cross-sections showing the arrangement of a receiver and an expansion valve for the cold plate.

Fig. 5 is a cross-section similar to Fig. 2 but showing a modification.

Fig. 6 is a schematic view showing several cold plates connected with a single refrigerating unit.

Fig. 7 is a schematic perspective view showing a cold plate used on a wall surface for air-conditioning a room or chamber.

Fig. 8 is a schematic side elevation illustrating application of the invention to refrigerated containers such as ice-cream cabinets.

Fig. 9 is a vertical cross-section on a larger scale of a refrigerated container like those shown in Fig. 8.

In Figs. 1 and 2, there is shown a cold plate C connected with a refrigerating unit R. The cold plate is shown in the form of an oval shaped table but may be any shape or size desired. The refrigerating unit R comprises a compressor I driven by a motor 2. The discharge side of the compressor is connected with a condenser 3 which is shown in the form of an air-cooled condenser having a fan 4 driven by the motor 2. A water-cooled condenser may be used if desired.

The cold plate C comprises a refrigerated surface or top plate 5 surrounded by a peripheral trim or frame 6 the bottom of which is closed by a back 7. The frame 6 is formed of plastic, metal or other material and is provided at its upper edge with an inwardly projecting flange 8 which is shaped to provide a gasket recess 9 and a downwardly projecting lip 10. Adjacent, but preferably spaced slightly from the lower edge, the frame 6 is provided with an inwardly projecting flange 11 which is flat on its under side and curved on its upper side, as shown (Fig. 2).

The refrigerated top plate 5 is formed of conducting, and preferably non-corrosive, material, such as stainless steel or Monel metal. It is inserted from the bottom of the frame and is held in place by being clamped between a gasket 12 disposed in the gasket recess 9 and a clamping strip 14 having on its upper face a heat-insulating strip 15 and pressed upwardly by means of a plurality of screws 16 threaded through nuts 17 held between spaced and upwardly inclined projections 18 and 19 provided on the inner side of the frame 6 at a distance spaced from the upper edge of the frame. The gasket 12 is formed of rubber, or similar water-resistant material having relatively low heat-conductivity. The lip 10 of the flange 8 is spaced only a slight distance from the top plate 5, for example about a sixteenth of an inch. The upper surface of the flange 8 is rounded, or otherwise shaped, to form an attractive raised edge or rim around the top plate. This retains any water or slush that is formed when the cold plate is turned off, for example at night. As the inner edge of the flange extends down almost to the top plate and as the slight space between them is sealed by the gasket 12, the cold plate has a highly attractive appearance and is, moreover, easy to keep clean and sanitary.

The bottom plate or back 7 seats on the inwardly projecting flange 11 of the frame and is held in place by screws, bolts, or other securing means. The joint between the back 7 and the frame 6 is preferably sealed by a gasket, putty or other sealing compound, to provide a substantially airtight joint. As the joint between the top plate 5 and the frame 6 is also hermetically sealed, any condensation of atmospheric moisture inside the space between the top and bottom of the cold plate is prevented.

The top plate 5 is provided with passageways for the refrigerant by which the plate is cooled. Such passageways may be provided in any convenient manner, for example by using a double-walled top plate with passageways formed between the walls by soldering or otherwise securing one or more tubes 21 on the under side of the plate, as illustrated in Fig. 2. In Fig. 1, the tube 21 is shown as winding back and forth underneath the top plate 5 so as to cool the entire surface. The tube 21 constitutes the evaporator of the refrigerating system and is connected into the circuit, as described more fully below.

The space between the top plate 5 and bottom 7 is filled with glass wool, granulated cork, or other suitable insulating material.

It will be noted that the convolutions of the tube 21 extend close to the edges of the top plate 5 so that the plate is cooled over its entire area, including marginal portions. By reason of its proximity to the refrigerated top plate, the frame 6 tends to be cooled to a temperature at which atmospheric moisture would condense on it. In accordance with the present invention, the temperature of the frame 6 is accurately and automatically controlled so that such condensation is avoided.

On the inside of the frame 6, there is provided a temperature control conduit 22 which extends all the way around the frame. As illustrated in the drawings, it comprises a flattened tube which extends along the inner face of the frame 6 and fits snugly between the lower flange 11 and the projections 19. Two or more convolutions of the tubing may be used when the width of the frame requires it and the tubing may, of course, be circular or other cross-section, as desired.

The tubing or conduit 22 for controlling the temperature of the frame 6 is connected in the refrigerating circuit between the condenser 3 and a receiver 23, one end of the tubing being connected to the discharge of the condenser by a
pipe 24 and the other end being connected to the receiver. Liquid refrigerant from the receiver flows through a conduit 25 to an expansion valve 26 and from there into the evaporator coil compris-
ing the tubing 21. The other end of the tubing 21 is connected by a pipe 27 to the intake or suction side of the compressor 1.

With this arrangement, the refrigerant gas drawn off from the evaporator 21 is compressed by the compressor 1 and the evaporator gas is then cooled to its boiling point—thus removing its superheat—and is partially condensed by the condenser 3. A mixture of gas and liquid refrigerant flows from the condenser 3 through the connecting pipe 24 and around the temperature control conduit 22. The latter thus contains both liquid refrigerant and gas refrigerant, as illustrated in Fig. 2, and serves as a secondary con-
denser. By reason of the conditioning action of the temperature control conduit 22, the condenser need not be of as large capacity as would otherwise be required. The temperature control conduit 22 also provides considerable storage space for liquid refrigerant, thereby serving as an auxiliary receiver. The receiver 23 can hence be of smaller size than would otherwise be re-
quired and may, if desired, be merely a continuation of the tubing 22.

By reason of the fact that it contains both liquid refrigerant and gas or vapor, the tubing 22 is maintained at a constant temperature, namely at the boiling point or condensation point of the refrigerant at the pressure maintained in the tube. If, through outside influence, the tem-
perature of the tubing should be momentarily decreased, additional condensation of refrigerant will take place to restore the desired temper-
ature. If a portion of the frame 8 and associated tubing 22 is subjected to greater cooling, more con-
densation of refrigerant will take place at that point, since more rapid condensation naturally occurs at a point of lower temperature. This automatically assures that the temperature of all portions of the frame is maintained uniform and constant at all times. As the heat utilized for maintenance of this temper-
ature is the latent heat of liquefaction of the re-
frigerant, rather than merely its specific heat, there is ample heat available for controlling the temperature of even a very long or large frame or a series of frames. It will be further noted that heat is supplied to the frame, not by cool-
ing the refrigerant but rather by condensing additional refrigerant without change in temperature. There is hence no decrease in the tem-
perature of the refrigerant and of the tubing as the refrigerant flows around the frame and all portions of the frame are maintained at uniform temperature. It will be further observed that the control of temperature is wholly automatic, the loss of heat through the frame being constantly balanced by the condensation of refrigerant in the tube 22. Preferably the frame 8 is main-
tained at a temperature approximately equal to or slightly above room temperature so that con-
densation of moisture on the frame is avoided without the frame feeling hot.

In Figs. 3 and 4, there are shown preferred ar-
rangements in which the receiver 23 and the ex-
panston valve 26 are built into the cold plate itself, being accessible through a removable in-
sulated cover 28. In Fig. 3, the expansion valve 26 is shown as being of the thermostatic type with a temperature responsive bulb or element 29 secured in position adjacent one of the turns of the evaporator coil 21. Tubing 30 connects the temperature control bulb 29 with the ex-
panston valve. In Fig. 4, the expansion valve is illustrated as being of the automatic type. In either instance, the expansion valve is provided with an adjustment 31 for setting the desired temperature of the top plate 5.

When the compressor unit operates intermittently, as it ordinarily does with the thermo-
ostatically controlled expansion valve, it is de-
sirable to provide the top plate 5 with storage capacity for maintaining its temperature while the refrigerating unit is not running. For ex-
ample, the top wall is hollow and filled with brine or is provided with brine chambers or pas-
sageways, as illustrated in Fig. 5. In this em-
bodyment, a brine tube 32 parallels the evapor-
tor tube 21 and is in thermal conducting rela-
tionship with the evaporator tube and the top plate. This provides an effective construction which is easily fabricated with standard tubing, so that no special equipment or facilities are re-
quired for its manufacture.

Fig. 6 illustrates how a plurality of cold plates C1, C2 and C3 can be connected to a single re-
frigerating unit R. The cold plates may be of any desired shape and may be of the same size or different sizes, as desired. It will be seen that the temperature control conduits 22 for main-
taining the temperature of the frames 8 are con-
nected in series with one another between the condenser 3 and the receiver 23. The evapor-
tors 21 of the respective cold plates C1, C2 and C3 are connected in parallel between a pipe 33 leading from the receiver 23 and a pipe 34 connected with the suction side of the compressor 1. Although the temperature control conduits of the cold plate frames are connected in series of one another, the temperature of the last frame in the series is the same as the first frame since, as explained above, the control of temperature is by condensation of refrigerant rather than by utilizing its specific heat.

Fig. 7 illustrates how cold plates in accord-
ance with the invention may be utilized to ”air-
condition” or cool a room or other enclosure. In this embodiment, a cold plate 41 is attached on, or constitutes, a wall of the room, being mounted in a vertical position. A fan 35 mounted on a bracket 36 secured to the back of the cold plate is positionned so as to blow air against the refrigerated surface 5. The cold plate has a peripheral trim or frame 6, the temperature of which is controlled, as described above, to prevent condensation on it. To take care of condensation on the refrigerated surface 5, as well as of any water formed by the melting of frost or ice on the cold plate when the latter is turned off, a drip trough 37 extends along the lower edge and is connected with a drain 38. As shown in Fig. 7, the drip trough 37 is of semi-
circular form closed at the ends and is secured to the lower frame member so as to project out in front of the frame and the refrigerated sur-
face 5.

Figs. 8 and 9 illustrate the application of the invention to ice-cream cabinets, deep-freeze ches and other refrigerated containers. The embodiment shown in Fig. 9 comprises an inner container 40, an outer shell 41, a bottom 42 and a top trim or frame member 43. The unit is held in assembled position by means of a pa-
rity of rods or bolts 44 which are screwed in-
to or otherwise attached to the frame member 43 and have their lower portions threaded. The
upper edge of the inner container 40 fits into a groove 48 provided in the frame 43 and is pressed up by the means of a spider 45 which engages the bottom of the container 40 and is held by nuts 47 on the threaded rods 44. A U-shaped rubber gasket 46 provides a liquid-tight and airtight seal between the upper edge of the container 40 and the top frame member 43. The upper edge of the outer casing or shell 41 also seats in a peripheral groove 49 provided in the top frame member 43, an airtight joint being provided by a suitable gasket or sealing compound 50. The bottom 42 is provided with an annular seat 51 for a gasket 52 which is disposed between the seat 51 and the lower edge of the casing 41. Nuts 53 on the bolts 44 draw the bottom 42 up against the lower edge of the casing 41 and, at the same time, press the top edge of the casing into the groove 49 of the top frame member 43. The space between the inner container through the outer casing and the bottom is filled with heat insulation material 54.

The inner container 40 is cooled by a refrigerating coil 55 which corresponds to the coil 21 of Fig. 1 and constitutes the evaporator of a refrigerating system. It will be noted that portions of the refrigerating coil 55 extend up near the top of the container so that the latter is cooled to a substantially uniform temperature throughout its depth. To prevent condensation of moisture on the top frame or trim 43 by reason of its proximity to the cold inner container 40, the temperature of the frame 43 is controlled by means of conduits 56 which correspond to the temperature control conduits 22 of Figs. 1 and 2 and is connected in like manner between the condenser and the receiver of the refrigerating circuit. The temperature control conduits 56 maintain the top frame 43 at approximately room temperature or slightly above. The container may be provided with a lid, as illustrated in Fig. 3, or may be left open, as desired.

The connections between the refrigerated container and the refrigeration plant are illustrated more fully in Fig. 4. In this embodiment, there are shown three cabinets similar to that illustrated in Fig. 5 operating from a single refrigerating unit, the parts of which are designated by the same reference numerals as in preceding figures. The discharge side of the condenser 3 is connected by a pipe 51 with a manifold 58 with which each of the cabinets C5, C6 and C7 is connected. The cabinets are also connected with an exhaust manifold 59 which is connected by a pipe 60 with the intake or suction side of the compressor 1. The path of the refrigerant in each of the cabinets is from the condenser 3 through the pipe 57 and manifold 58 to the temperature control conduits 56 and thence to a receiver 61. From the receiver, the refrigerant flows through an expansion valve 62 to the cooling coil or evaporator 55 and from there to the exhaust manifold 59. The cabinets are thus connected in parallel between the manifold 58 and the exhaust manifold 59 and can be added or removed, as desired, to provide the desired storage capacity. The temperature control conduits 56 are in each instance connected in series between the condenser 3 and the cabinets 56 and function in the manner described above in connection with temperature control coils 22 of Figs. 1 and 2. The cabinets are shown being provided with lids 63.

In some instances, the exhaust line leading from the evaporator coil to the compressor tends to frost, even though a thermostatically controlled valve is employed to regulate the flow of refrigerant. To avoid such frosting, the initial portion of the discharge pipe is preferably led along the temperature control conduit 22 or 56, in order to raise the temperature of the refrigerant to approximately room temperature.

While there is some heat flow from the frame or trim to the adjacent portion of the refrigerated surface, the resulting energy loss is compensated for in the compression side of the refrigeration cycle where the lower condensing temperature resulting from the cooling effect on the temperature controlling conduits 22 and 56 gives higher economy in operation.

As the temperature control of the frame is entirely automatic and self-compensating, it requires no attention from the user of the cold plate. The choice of refrigerating pressures is made in accordance with refrigerating practice well known to those skilled in the art. However, the condenser is of smaller capacity than would normally be required, by reason of the fact that the temperature control conduits of the frame acts as a secondary condenser. It also supplements the usual receiver, so that the receiver can likewise be of smaller capacity.

While preferred embodiments of my invention have been shown by way of example, it will be understood that the invention is not limited to the specific forms illustrated in the drawings. The cold plates or refrigerating cabinets can be made of the size, shape and capacity desired. The number of cold plates or cabinets connected with a refrigerating unit may also be varied to suit particular conditions and requirements. It will be further understood that the various features of the several embodiments illustrated in the drawings are mutually interchangeable. For example, the trim or frame of the cold plate illustrated in Figs. 5 to 7 may have a plurality of parallel turns of the temperature control conduit, as illustrated in Fig. 9. While some of the receivers and expansion valves have, for convenience, been shown outside of the cold plate, they may, if desired, be located inside, as illustrated in Figs. 3 and 4, for greater compactness and better appearance. Other modifications will be readily apparent to those skilled in the art.

What I claim and desire to secure by Letters Patent are:

1. In combination with a refrigerating unit comprising a compressor, a primary condenser for cooling the compressed refrigerant to its boiling point and partially condensing said compressed refrigerant, a receiver for liquified refrigerant and an evaporator, a cold plate comprising a refrigerated surface cooled by the evaporator of said refrigerating unit, a frame extending along the edge of the refrigerated surface in juxtaposition to said surface, a gasket forming an air tight joint between the refrigerated surface and the frame and a temperature control conduit in heat transferring relation with the frame to maintain the frame at a uniform temperature approximately equal to room temperature, said conduit being connected in series between said condenser and constituting a secondary condenser, the refrigerant in said conduit being in a composite gaseous and liquid stage.

2. In combination with a refrigerating unit comprising a compressor, a condenser including a coil for the refrigerant and means for cooling
said coil, a receiver and an evaporator, a cold plate comprising a refrigerated surface cooled by the evaporator of said refrigerating unit, a frame extending along the edge of the refrigerated surface in juxtaposition to said surface, a gasket forming an air tight joint between the refrigerated surface and the frame and a temperature control conduit for maintaining the frame at a uniform temperature slightly above room temperature throughout its extent, said conduit being disposed in heat transferring relation to said frame and being connected in series between said condenser and receiver, said condenser being of such capacity as to partially condense the compressed gaseous refrigerant received from the compressor and to deliver to said conduit a mixture of gaseous and liquid refrigerant.

3. In combination with a refrigerating unit comprising a compressor, a condenser for cooling the compressed refrigerant to its boiling point and partially condensing said compressed gas refrigerant received from the compressor, a receiver and a plurality of evaporators, a plurality of cold plates each comprising a refrigerated surface cooled by one of said evaporators, a frame extending along the edge of the refrigerated surface in juxtaposition thereto and having a temperature control passage, a gasket between the refrigerated surface and the frame, clamping means for drawing the frame and refrigerated surface toward one another to form an air tight seal, the temperature control passage of the frame being connected in series between the condenser and the receiver and receiving from the condenser a mixture of liquid and gaseous refrigerant.

4. In combination with a refrigerating unit comprising a compressor, a condenser for partially condensing compressed gas refrigerant received from the compressor, a plurality of receivers, an evaporator connected with each receiver and return lines from the evaporators to the compressor, a plurality of cold plates each comprising a refrigerated surface cooled by one of said evaporators and a frame extending along the edge of said surface in juxtaposition thereto and having a temperature control passage connected in series between the condenser and one of said receivers and receiving from the condenser a mixture of liquid and gaseous refrigerant, said passage and frame constituting a secondary condenser in which refrigerant condenses in inverse proportion to the temperature of the frame and thereby counteracts any temperature fluctuations of the frame.

5. In combination with a refrigerating system comprising a compressor, a condenser for cooling gas refrigerant received from the compressor to remove the superheat of said gas and partially condense it, a cold plate comprising a refrigerated surface, a casing, a frame connecting the casing with the refrigerated surface to provide an air tight enclosure space between the refrigerated surface and the casing, a temperature control passage extending along the inside of the frame, a receiver for liquid refrigerant disposed in said space, an evaporator in heat transferring relation with the refrigerated surface and connected with said receiver, an expansion valve disposed in said space and connected between the receiver and evaporator, the temperature control passage of said frame being connected in series between said condenser and receiver and with the frame constituting a secondary condenser, whereby the frame is maintained at a uniform predetermined temperature throughout its extent by isothermal condensation of refrigerant therein.

6. In combination with a refrigerating system comprising a compressor, a condenser for removing the superheat of compressed gas refrigerant received from the compressor and partially condensing said refrigerant, a receiver and an evaporator, a cold plate comprising a refrigerated surface cooled by said evaporator, a casing, a frame connecting said refrigerated surface and casing to form an air tight enclosure, insulating material substantially filling the free space inside said enclosure, said frame having on its inner surface spaced, longitudinally extending flanges, a temperature control conduit disposed between said flanges and having a flattened side in contact with the inner side of the frame, said conduit being connected in series between the condenser and the receiver and constituting a secondary condenser, whereby a mixture of gas and liquid refrigerant flowing through said conduit maintains the conduit and frame at a predetermined constant temperature throughout their extent by isothermal condensation of refrigerant in said conduit.

7. In combination with a refrigerating system comprising a compressor, a condenser for removing the superheat of compressed gas refrigerant received from the compressor and partially condensing said refrigerant, a receiver and an evaporator, a cold plate comprising a refrigerated surface cooled by said evaporator and disposed in a vertical plane, a backing plate, a peripheral frame connecting said surface and backing plate to form an air tight enclosure, insulating material substantially filling the free space inside said enclosure, a fan mounted on said cold plate and positioned to direct a stream of air against the refrigerated surface thereof and a temperature control conduit extending along said frame, said conduit being connected in series between the condenser and the receiver and constituting a secondary condenser, whereby a mixture of gas and liquid refrigerant flowing through said conduit maintains the conduit and frame at a predetermined constant temperature throughout their extent by isothermal condensation of refrigerant in said conduit.

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