

March 29, 1960

C. D. MacCRACKEN
PERSONAL THERMAL DEVICES

2,930,594

Filed June 25, 1954

2 Sheets-Sheet 1

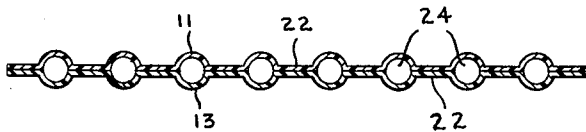
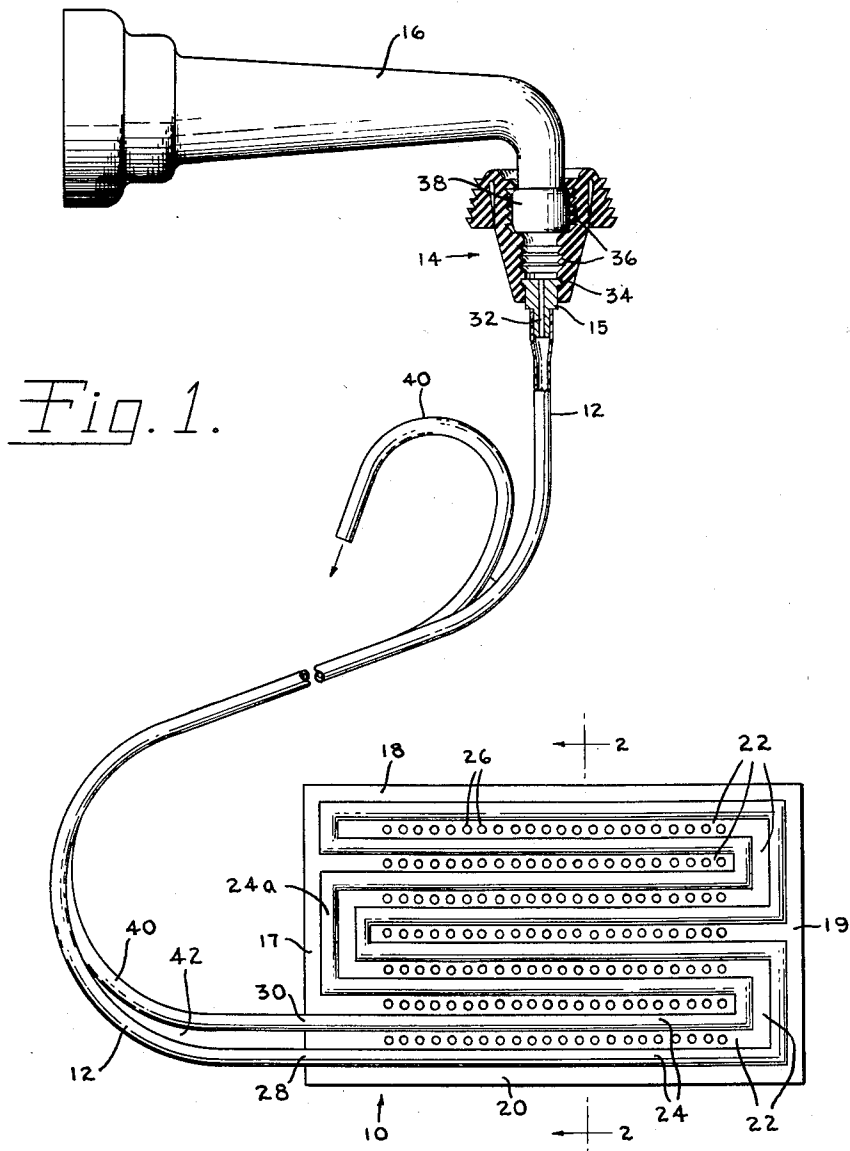


Fig. 2.

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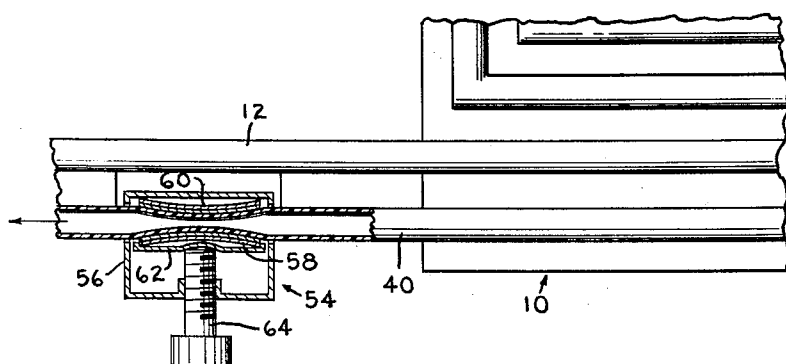
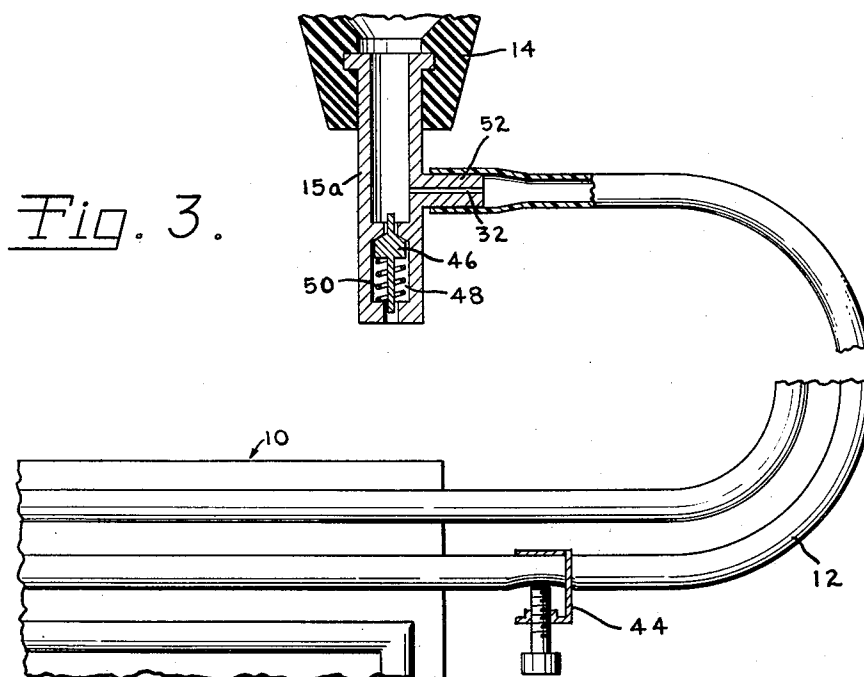


Fig. 4.

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PERSONAL THERMAL DEVICES

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5 Claims. (Cl. 257—306)

This invention relates to improvements in personal thermal devices, and particularly to an improved device for personal heating or cooling by liquid circulation.

It has previously been proposed to make a personal thermal device in which a heating and/or cooling liquid is circulated through a thin, liquid-conducting flexible panel by means of a pump or similar circulating mechanism. The panel may comprise a pillow insert, a mattress covering or otherwise be arranged to be contacted by the user's body so that it can supply heat to or receive heat from the body, as determined by the temperature of the circulated liquid.

It is among the objects of the present invention to provide a simplified personal thermal device of the foregoing general type, and particularly such a device wherein the circulating mechanism is eliminated. In accordance with a preferred embodiment of the invention, a flexible, liquid-conducting panel is arranged to be connected by suitable coupling means to a conventional water faucet and drain, such that warmed or cooled liquid from the domestic water supply system can be circulated from the tap directly through the panel and then discharged in the drain associated with the faucet. The improved simplified arrangement provided by the present invention has very material advantages from the standpoint of simplicity and economy of parts, and is of great utility in any situation where a water outlet is available within reasonable distance of the point of intended use. In accordance with a further feature of the invention, there is provided a panel of novel structural features especially suited for a personal thermal device of the foregoing type.

A more complete understanding of the invention can be had by reference to the following description of an illustrative embodiment thereof, when considered in connection with the accompanying drawing, wherein

Figure 1 shows a personal thermal device embodying the invention, as it would normally be connected to a water faucet, with certain of the parts shown in plan view, others in perspective and others in section,

Figure 2 is a section view of the heat exchange panel in the system of Figure 1, and

Figures 3 and 4 illustrate embodiments of the invention wherein temperature control means are provided.

Referring to Figure 1 of the drawing, a personal heating system embodying the invention is shown to include a flexible, liquid-conducting panel 10, coupled by a flexible tube 12 and a connector 14 to a conventional water faucet 16.

The panel 10 comprises two superposed sheets 11, 13 of flexible waterproof material; preferably one of the thermoplastics such as vinyl plastic, heat sealed together along the outside edges 17, 18, 19, 20 and along spaced lines 22 intermediate the edges, to define passages 24 between the seal lines through which liquid can be circulated. The term "heat sealing" will be understood to include both direct and indirect heating in conjunction with pressing of the layers together along the desired seal lines. In indirect heating, so-called dielectric heating may

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be included. In some instances, the areas between the passages 22 may be provided with many small perforations 26 to prevent accumulation of perspiration or other moisture on the panel surface, although such perforations may not be required where the panel is used under an absorptive layer, such as a mattress pad, for example. It may be noted that the panel can be made in a variety of shapes and sizes, depending on the particular purpose for which it is used. For example, one very beneficial use is as a pillow insert, the panel being of a suitable size to be placed on the pillow body under the pillowcase, to warm or cool the user's head as conditions require. In a large size, the panel may be used to warm or cool substantially the entire body of the user, being located for this purpose on the mattress of a bed, as previously mentioned, or spread over the seat of an automobile, a chair or the like. A panel of similar size has further utility as the floor pad or floor mat in a child's playpen. Whatever its location, the panel 10 will carry heat away from or supply heat to the user's body, depending on the relative temperature of the liquid circulated through the passages 24.

The particular circuit or passage configuration in the panel 10 shown in Figure 1 is described in detail and claimed in a copending application of R. E. Coleman et al., Serial No. 309,416 filed September 13, 1952 and assigned to the assignee of the present invention. Briefly, the passages 24 are connected together between the inlet and outlet points 28 and 30 in such fashion that the incoming and outgoing liquid flows in opposite directions in parallel paths throughout the panel. With this arrangement, the average temperature of the liquid in adjacent passages is the same throughout the panel. This keeps the panel surface temperature reasonably uniform, rather than having a continuous temperature change from point to point between the inlet and outlet.

Among many other more or less conflicting characteristics of the panel which warrant consideration, those of special importance include pressure drop (flow resistance) in the passages, kinking characteristics and user comfort. Each is related to one or more of the structural features of the panel, which include gauge (thickness) of the panel material, passage width and spacing between the passages.

If the passages are made too narrow, the resistance to flow and the pressure drop between the inlet and outlet becomes excessive. Not only does this require an abnormally high-pressure liquid source to obtain adequate flow for good heat exchange, but also it makes the pressure in those portions of the panel near the inlet point so high that the panel surface in that vicinity will be uncomfortably rigid. Furthermore, material of abnormal thickness will be required to withstand the pressure without rupturing. Both of the latter two points—rigidity and material thickness—relate to user comfort, which has a number of aspects.

For one thing, the panel should be sufficiently pliable so that it will conform rather readily to the body contours. Otherwise it will present an uncomfortably stiff surface to the user. It should also be thin enough for efficient heat transfer through the material. At the same time, it should not be so pliable as to kink readily and thereby stop the flow of heat exchange liquid.

Again, the panel passages should not be made so wide as to give the panel a markedly "lumpy" surface contour. Not only is this uncomfortable to the user, but also it approaches the condition which exists if the liquid conducting passages comprise round tubes. In the latter case, a relatively large part of the surface area of the conducting passage cannot be contacted by the user's body, which means that the heat exchange efficiency of the panel is materially impaired. Furthermore, over-

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size passages adversely affect the heat exchange characteristics due to low velocity liquid flow. Also, the panel becomes unnecessarily heavy due to excessive amounts of liquid.

Yet another point to be considered involves the passage spacing and the relation between passage width and passage spacing. It will be noted that the width of the panel when perfectly flat (no heat exchange liquid in the passages) is not the same as when the passages are distended, as in Figure 2. In other words, when the liquid enters the passages, the panel material "bulges up" around the liquid, thereby tending to draw the edges of the panel inwardly. However, as there must be lateral connecting links (e.g., 24a in Figure 1) between longitudinal passages, the edges 17, 19 of the panel at right angles to the longitudinal passages cannot contract, as can the panel surface near the center. This will result in a tendency for the lateral passages to kink, unless there is sufficient separation between the passages to allow the material to form a fold or overlap along those edges at points where there are no lateral passages. Such folds will take up the differences in width between the edges and the center of the panel, without kinking of the lateral passages.

It has been found that a panel having the following structural features gives an excellent compromise for the conflicting requirements just outlined, particularly when made in a size adapted to fit the conventional bedpillow: panel material—polyvinyl plastic 0.012 inch thick; passage width (flat)— $\frac{5}{16}$ inch; spacing between passages— $\frac{3}{16}$ inch. Investigation has shown that passages less than $\frac{1}{8}$ inch wide introduce excessive pressure drop, while passages wider than $\frac{1}{2}$ inch create an uncomfortably lumpy panel surface when distended. In general, the spacing between passages should be of the same order of magnitude as the width of the passages in the flat, in order to avoid kinking of the lateral passages when the panel is conducting liquid. When the width of the space between passages is less than 75% of the width of the flat passages, kinking due to distension shrinkage tends to become a serious problem. On the other hand, a spacing in excess of 125% of the flat passage width results in uncomfortable variations in panel surface temperature and insufficient heat exchange surface.

The limits on the gauge or thickness of the panel material will depend to some extent on the intended use. For a pillow insert or mattress cover panel, for example, material of the type indicated above and between 0.010 and 0.015 inch thick has good pliability, good heat transfer and ample kink resistance. In a panel to be used as a rug or mat in a child's playpen, for example, a material of somewhat higher gauge would be suitable, as the surface rigidity would be less objectionable and would be preferable for better kink and abrasion resistance.

In connecting a panel of the foregoing type to circulate water drawn from a domestic water faucet, one of the problems encountered is related to the domestic water system pressure, the previously-mentioned desirability of having relatively low pressure drop across the panel itself, and the characteristics of the conventional water faucet. Ordinarily, the domestic water system pressure is of the order of twenty pounds per square inch or more and frequently runs as high as one hundred pounds per square inch. A typical and adequate flow rate through the panel in a system of the type under consideration is of the order of one gallon per hour. This means that the water faucet should be set for one gallon per hour flow rate and with a pressure drop across the faucet valve of eighteen pounds or more. Frequently, this is a difficult adjustment to make. At such a low flow rate, the faucet needs to be opened only a very slight amount; so slight, in fact, that the faucet valve washer frequently will swell shut a short time after an initial adjustment is made. On the other hand, opening the faucet further not only is wasteful of water but also will make the panel surface too cold when used for cooling. If the panel passages are

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made small enough to take up the pressure drop, the panel will be uncomfortably stiff and rigid.

To obviate this difficulty, in accordance with the present invention an artificial pressure drop preferably is introduced in the liquid circuit downstream of the faucet but upstream of the panel. For example, as shown in Figure 1, the panel inlet coupling tube 12 may be connected to the faucet connector 14 by a pressure reducing fitting in the form of a plug 15 adapted to be inserted in the coupling line 12 and having a longitudinal passage 32 of very small diameter—say, of the order of 0.03 inch. The other end of the fitting may be provided with an annular shoulder 34 seating in a groove in the connector 14. Alternatively, the same effect can be obtained by proper selection of the bore of the coupling tube 12, although this may be more difficult to select accurately due to variations in the length of the coupling tube 12 from one installation to another. In other words, it is sometimes preferable to place the restriction at a specific location and then make the coupling tube long enough to conduct the necessary amount of liquid without appreciable pressure drop. In either case, what is required is that the coupling between panel and faucet include a portion that has a smaller flow area, and, hence a greater resistance to flow per unit of circuit length than the flow resistance offered by a corresponding length of the panel passage. This will provide a pressure drop downstream of the faucet but upstream of the panel such that the faucet can be opened a reasonable amount with relatively low flow rate to the panel and with the major part of the total drop in pressure occurring between the faucet and the panel. In a more elaborate system, the restrictor may comprise a regulator for maintaining constant inlet pressure to the coupling line 12.

The faucet connector 14 preferably comprises a readily detachable fitting, such as a soft flexible rubber element which is hollow and of tapered cross-section. The inner surface of the connector may be provided with several series of spaced annular serrations 36 which will serve as seats adapted to yield slightly upon assembly to the faucet in order to seal tightly around the faucet nozzle 38. Being tapered, and formed of flexible material such as rubber, the wider end of the connector can be folded downwardly over the smaller diameter portion, as shown in Figure 1, to give access to the smaller diameter seats in the lower part of the connector body. Thus, the connector can be attached readily to faucets of different size.

From the panel 10, a return or discharge line 40 is provided to conduct liquid from the panel back to the drain (not shown) normally available below the faucet. For convenience in handling, the discharge line 40 preferably is joined to the supply tube 12 by a central connecting web 42 which terminates some distance from the faucet end, so that the discharge tube 40 can bend down readily towards the drain. This prevents the discharged liquid from flowing back along the outside of the tube 40.

With the connector 14 attached to a water faucet 16 as shown in Figure 1, the faucet can be turned on and adjusted to allow water to flow through the restrictor 15 and through the panel 10 at the rate necessary to maintain the desired panel surface temperature. It will be evident the panel can be used either for heating or for cooling, depending on the selected temperature of the tap water.

In Figure 3 there is shown an arrangement for regulating the temperature at the panel 10 by adjusting the flow rate. For this purpose, the inlet tube 12 is provided with an adjustable C-clamp 44 which the user can adjust to restrict the liquid flow, thereby to obtain the desired panel temperature. As the flow is decreased by adjusting the C-clamp, the temperature drop across the panel will increase, because the rate of heat extraction will be decreased. With this arrangement, however, it is possible to build up excessive pressure upstream of the regulating clamp 44, causing the coupling line 12 to rupture or the connector 14 to blow off the faucet. To

avoid this, there is preferably provided a pressure relief valve upstream of the adjusting clamp. The relief valve conveniently may be made a part of the restrictor fitting 15a, comprising a spring-loaded valve 46 located in a passageway 48 in the fitting body, and arranged to open when the pressure in the fitting exceeds a predetermined value to discharge water directly to the drain (not shown). The pressure at which the valve 46 will open can be readily set, of course, by suitable selection of the valve spring 50. The restrictor outlet passage 32 may be formed in a branch section 52 of the fitting, to which the coupling tube 12 is attached.

In order to have automatic rather than manual control of the panel temperature, the C-clamp 44 may be replaced by a thermostatically-acting clamp or valving means 54, as shown in Figure 4. In this case, the flow control element 54 preferably is located on the outlet line 40 of the panel, rather than on the inlet line 12, in order to sense and respond to the temperature of the liquid leaving the panel. This will give a more accurate and uniform control of the panel temperature than would a similar control on the inlet side, because the temperature of the panel liquid will depend on the way in which the panel is used as well as on the flow rate and the incoming liquid temperature. Therefore, it is preferable to control with respect to discharged liquid temperature, which reflects more accurately the temperature condition of the panel itself.

Illustratively, the thermostatic control 54 may comprise a housing 56 containing a pair of opposed dished bimetal elements 58, 60, between which the panel outlet tube 40 can be inserted. One of the bimetal elements (58) may be carried on a movable plate 62 which can be moved toward and away from the other element 60 by an adjusting screw 64. Depending on the relative coefficients of thermal expansion of the metal layers making up the elements 58, 60, the curvature of the elements will increase and decrease in response to changes in temperature of the liquid flowing through the outlet tube 40. The housing 56 can readily be made to slip on and off the tube 40, for ready interchange. When the panel is to be used for cooling, a control element would be used having elements which increase their curvature as the liquid temperature decreases. The user then can adjust the set screw 64 to the desired temperature, and thereafter the bimetal elements 58, 60 will flex to increase and decrease the flow as the temperature of the liquid leaving the panel rises and falls. When the panel is connected to a hot water faucet to be used for heating purposes, the user will substitute the type of thermostatic control in which the curvature of the bimetal elements increases in response to a temperature increase. As before, once the adjusting screw has been set, the control will adjust the liquid flow to maintain the selected panel temperature.

Of course, where the flow-adjusting control 52 is used on the outlet side of the panel, the relief valve 46 will be set to open at a fairly low pressure, say, of the order of two or three pounds per square inch, so that the pressure in the panel will not be great enough to make the panel uncomfortably stiff.

I claim:

1. In a personal thermal device, a thin, flat, heat exchange panel of flexible material for liable conformance to human body contours and having sufficient heat exchange surface area to contact a substantial portion of the user's body, said panel including means defining liquid conducting passages extending throughout said panel, a faucet connector comprising a hollow, flexible element adapted to be assembled to a water faucet, and liquid-conducting means connecting said panel passages to said faucet connector for conducting liquid to said panel from said faucet connector, said last named means including a portion of flow area substantially smaller than that of said connector and dimensioned to offer greater resist-

ance to liquid flow per unit of circuit length than the flow resistance offered by a corresponding length of said panel passages, and liquid conducting means connected to said panel passages for conducting away heat exchange liquid after flow thereof through said panel passages.

2. In a personal thermal device, a thin, flexible, heat exchange panel comprising superposed sheets of flexible, waterproof, thermoplastic material, said sheets being sealed together along their edges and along spaced lines intermediate said edges to define liquid conducting passages between said lines and between said sheets, a faucet connector comprising a hollow, flexible element adapted to be assembled to a water faucet, and liquid-conducting means connecting said panel passages to said faucet connector, said last named means including a pressure reducing element having a liquid conducting passage of diameter substantially smaller than the minimum inside diameter of said connector and dimensioned to offer greater resistance to liquid flow per unit of circuit length than the flow resistance offered by a corresponding length of said panel passages.

3. In a personal thermal device, a heat exchange panel comprising superposed sheets of flexible, waterproof material, said sheets being sealed together along their edges and along spaced lines intermediate said edges to define liquid conducting passages between said lines and between said sheets, said passages being not less than $\frac{1}{8}$ inch and not more than $\frac{1}{2}$ inch wide, said passages being spaced apart by an amount not less than 75% and not greater than 125% of the width of said passages, a faucet connector comprising a hollow, flexible element adapted to be assembled to a water faucet, liquid-conducting means connecting said panel passages to said faucet connector, said last named means including a portion of inside diameter substantially smaller than that of said connector and dimensioned to offer greater resistance to liquid flow per unit of circuit length than the flow resistance offered by a corresponding length of said panel passages.

4. In a personal thermal device, a liquid-conducting circuit comprising (1) a thin, flat heat exchange panel of flexible material for pliable conformance to human body contours and having sufficient heat exchange surface area to contact a substantial portion of the user's body, said panel including means defining liquid conducting passages extending throughout said panel, (2) a faucet connector comprising a hollow, flexible element adapted to be assembled to a water faucet, and (3) liquid-conducting means connecting said panel passages to said faucet connector for conducting liquid to said panel from said faucet connector, a fitting having a passageway therein communicating with said liquid-conducting means and having an outlet bypassing said panel, a pressure-responsive, normally closed valve in said passageway adapted to open in response to a predetermined pressure in said liquid-conducting means, means associated with said circuit downstream from said fitting and upstream from said panel passages for controlling the rate of flow of liquid through said circuit, and liquid conducting means connected to said panel passages for conducting away heat exchange liquid after flow thereof through said panel passages, wherein said circuit includes a flexible tube, and wherein said last named means comprises an adjustable clamp for selectively restricting said tube, and wherein said adjustable clamp includes a thermostatic element for controlling the restrictive action of said clamp as a function of the temperature of said tube.

5. An improved personal thermal system including a device comprising a thin, flat, panel of flexible material for pliable conformance to human body contours, said panel having sufficient surface area to contact a substantial portion of the user's body, said device including means defining a plurality of parallel tubular passages extending over substantially the entire area of said panel, said passages comprising incoming portions through

which heat exchange liquid flows throughout substantially one-half of its travel through said device and return portions closely adjacent to said incoming portions and through which said heat exchange liquid flows throughout the remainder of its travel through said device, means 5 for circulating said heat exchange liquid through said parallel tubular passages, liquid conducting means connecting said circulating means to said parallel tubular passages, and a manually operable control valve associated with said liquid conducting means and conveniently located with respect to said device for controlling the liquid flow through at least a portion of said device, said control valve including thermostatic control means 10 responsive to the temperature of the liquid leaving said portion of said device and progressively restricting the amount of liquid flowing through said portion in re-

sponse to increase in the temperature of the liquid leaving said portion.

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