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DRYING APPARATUS

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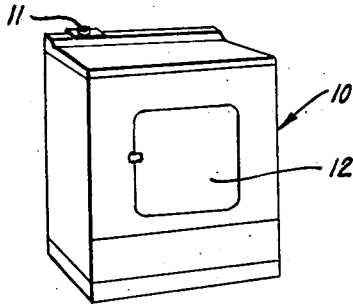


FIG. 1.

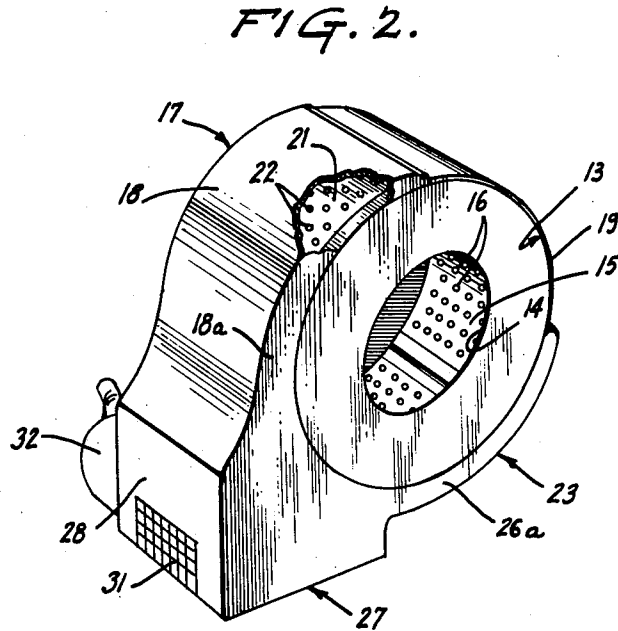


FIG. 2.

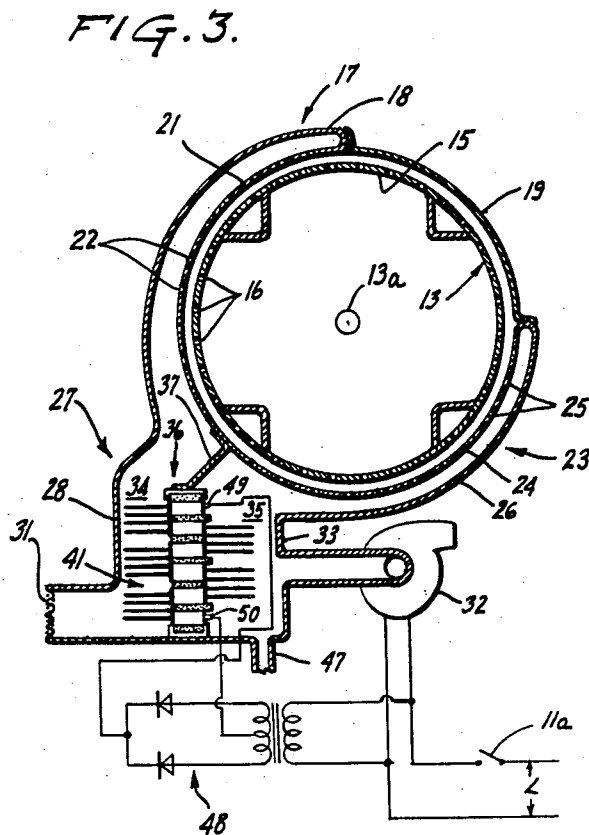


FIG. 3.

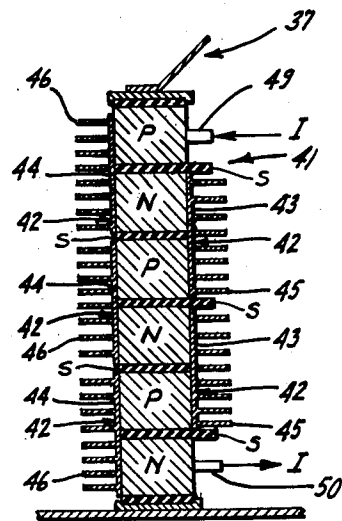


FIG. 4.

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1

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DRYING APPARATUS

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The present invention relates to drying apparatus, for example, laundry drying equipment, and more particularly to a system for drying fabrics by means of thermoelectric heat exchange apparatus utilizing the Peltier effect.

While of broader applicability, the present invention has particular utility in clothes-drying equipment. One known form of such equipment embodies perforate container means, for wet clothes, said container means being mounted in an enclosure through which is circulated heated ambient air having, initially, a relatively low vapor content. The vapor content of the aforementioned circulating air is greatly increased due to the moisture extracted thereby from the wet clothes and, in the interest of preventing the temperature as well as the relative humidity of the ambient atmosphere within the room from rising to undesirable levels, it is commonly the practice to provide heat exchange means in the drying equipment to cool the relatively warm vapor-laden air and condense the vapor entrained therein, prior to reentry of the circulating air into the ambient atmosphere.

It is therefore a broad objective of the invention to provide novel and efficient means for drying fabrics.

It is another objective of the invention to provide in a drying machine substantially unitary means for both heating the material to be dried and disposing of the moisture removed from the latter.

Still another object is to provide unitary and compact heat exchange means for treating the air circulating through a clothes dryer.

In accordance with a preferred embodiment of this invention, thermocouple panel means comprising a plurality of thermocouples having cold junctions lying to one side and hot junctions lying to the other side thereof is disposed in the circulating air stream of clothes drying apparatus. The arrangement is such that the side of the panel comprising the hot junctions is disposed in heat exchange relation with an inlet air stream, to heat the same, prior to its entry into a wet-clothes container means or chamber. The cold junctions of the thermocouples are disposed in heat exchange relation with the relatively warm, vapor-laden air being discharged from the chamber.

In operation of the drying apparatus, a suitable electrical current is passed through the thermocouples, whereby heat is generated at the hot junctions and given up to the relatively cool and dry inlet air stream. The air thus heated flows in heat exchange relation with the clothes to raise the temperature of the latter and dry the same. Vapor-laden air within the clothes chamber then flows outwardly from the latter and over the cold junctions whereby heat is absorbed from the air, and the vapor is thereby condensed. The condensate is disposed of in any convenient manner.

For a better understanding of the invention, reference may be had to the accompanying drawing wherein:

FIGURE 1 is a perspective showing of laundry apparatus embodying the invention;

FIGURE 2 is a somewhat enlarged perspective showing of apparatus contained in the equipment seen in FIGURE 1;

FIGURE 3 is a somewhat diagrammatic sectional showing of apparatus seen in FIGURE 2, and illustrating certain features of the present invention; and

2

FIGURE 4 is an enlarged fragmentary showing of a portion of the apparatus shown in FIGURE 3.

Now referring in more detail to the drawing, and first to FIGURES 1 and 2, in which the invention is depicted for exemplary purposes, as being embodied in laundry apparatus, it will be seen that the present invention comprises cabinet structure 10 having mounted thereon control means 11 and a door 12 that provides access to an opening 14, as seen in FIGURE 2, communicating with the interior of a clothes drying chamber mounted within the said cabinet structure. The clothes drying chamber comprises a horizontally extending perforate drum or cylindrical basket 13, which is seen in FIGURES 2 and 3 wherein there is illustrated only such portion of the apparatus housed within the cabinet structure 10 as is necessary to illustrate the invention. The drum 13 is mounted for rotating movements, about a horizontally extending hub 13a, by means (not shown) also disposed within the cabinet structure 10. Rotation of the drum may be effected by any suitable conventional motor-drive means selectively operable through control means 11.

As is well known in the art, the drum 13 is rotated in order to tumble the clothes, thereby uniformly to expose the fabrics or clothes being dried to circulating warm air and to facilitate the drying operation.

As is seen further in FIGURES 2 and 3, while the ends of the drum are imperforate, with the exception of the loading opening 14, the cylindrical surface portion 15 of the drum has perforations 16 to permit passage of air through the drum to dry clothes disposed therein.

Means providing for circulation of air through perforations 16 in the drum include duct means 17 having a curved wall portion 21. The wall portion 21 has perforations 22 formed therein and is disposed in close adjacency to an upper segment of the cylindrical surface portion 15 of the drum. Additional duct means 23, includes a wall portion 24 having perforations 25 formed therein, said portion 24 being disposed, in a manner similar to the disposition of duct means 17, along a lower segment of the cylindrical surface portion 15 of the drum. Outer walls 18, 18a and 26, 26a of the respective duct means 17 and 23 are substantially imperforate, and are so configured and arranged as conveniently to form, at lower portions thereof, chamber means 27 having, in a side wall portion 28 thereof, an air inlet opening 31. Blower means 32 is associated with an opening provided in a wall portion 33 of the chamber means 27.

A shroud 19 overlies the curved surface of the drum between the ends of duct means 17 and 23, and prevents escape of the circulating air through this portion of the drum.

Now referring more particularly to FIGURE 3, the chamber means 27 is divided into a pair of compartments 34 and 35 by wall or partition means 36 comprising a baffle portion 37 and, in particular accordance with the invention, a thermoelectric panel 41. As viewed in the drawing, left hand compartment 34 of chamber 27 is in air flow communication with the upper duct means 17, on the one hand and with the air inlet port 31 on the other. The lower duct means 23, the adjoining compartment 35 of chamber 27, and the blower 32 are in air flow communication with one another, as clearly appears in FIGURE 3.

As best seen in FIGURE 4, thermoelectric panel 41 comprises a plurality of thermocouples 42, of a known type to be hereinafter more fully described, supported within suitable framing structure including electrically non-conductive spacer elements S. Cold junctions 43 of the thermocouples 42 are disposed in the right hand compartment 35 and the hot junctions 44 are disposed in the left hand compartment 34.

Referring again to FIGURE 3, power supply means

for the blower 32, as well as for the thermocouple panel 41, includes an A.C. voltage source L connected in suitable electrical circuitry with: switch 11a of control means 11, blower 32, and with rectifier means 48. The rectifier means is further connected, to supply the desired direct current flow through each of the thermocouple junctions, to the terminal means 49 and 50 provided on thermoelectric panel 41.

As seen further in FIGURE 4, thermocouples 42 are made up of block-like elements, arranged in tiers in such manner that adjacent elements comprise materials having dissimilar thermoelectric properties. While but a single row of elements has been indicated, it is to be understood that a number of such rows may be placed side-by-side in the plane of the partition means 36. Each block-like element is designated by either the letter P or the letter N to indicate its thermoelectric property, and an electrically non-conductive spacer element S is interposed between each such P and N element. The terms P and N have found wide usage in the semi-conductor art, the former term designating a material having an abundance of "holes" and the latter term designating a material having an abundance of electrons. Semiconductive components including antimony and bismuth have been found suitable for use as the respective P and N type materials. The present invention resides in the combination of elements set forth in the appended claims, and not in the thermoelectric heat transfer apparatus, per se. Consequently, only a brief description of the operation of such apparatus is included herein. However, should a more detailed description be desired, reference may be had to the article entitled "Thermoelectric Refrigeration," by R. L. Eichor, appearing in the June, 1958, issue of "Refrigerating Engineering Including Air Conditioning," at pp 33-35, or to the text entitled "Semiconductor Thermoelements and Thermoelectric Cooling," by A. F. Ioffe, and published by Infosearch, London England.

Alternate hot and cold thermocouple junctions 44 and 43 are formed, respectively, by both thermally and electrically conductive, finned strap means 46 and 45 interconnecting P and N elements in series electrical circuitry. Copper has been found suitable for use as the strap means, and the construction and arrangement of the apparatus is such that the cold junction strap means 45 are disposed in compartment 35, and hot junction strap means 46 are disposed in compartment 34. When direct current is caused to flow from the P elements to the N elements, as indicated at I in FIGURE 4, the interconnecting strap means 46 become hot, and the current flowing from N to P causes the strap means 45 to become cold, in accordance with the known Peltier effect.

The left hand surface of the panel comprising strap means 46 therefore releases heat to incoming air being drawn, by blower means 32, through opening 31 and compartment 34. The air after being warmed flows through duct 17 and outwardly therefrom through perforations 21 thence through perforations 16 and into the clothes drying compartment within drum 13, while the latter is rotated by power applied, in known fashion, to the hub or axle 13a. Heat is given up by the warm air to the clothes as well as to moisture within the same, whereby the moisture is substantially completely vaporized. The vapor then flows with the relatively cooler air out of the drum through perforations 16 and into overlying perforations 24 of duct means 23, thence through the latter into right hand compartment 35. In this compartment the air and the vapor are cooled by cold junctions 43, the heat thus absorbed being transferred through the panel 41 and is rejected at the hot junctions 44 in accordance with the Peltier effect. Cooling of the vapor is effective to condense the same, the condensed vapor then flowing downwardly from the cold junctions and onto the floor of compartment 35, thence outwardly through drain pipe means 47 for disposal in any convenient manner.

Transfer of heat being pumped through the panel 41, to and from the respective hot and cold thermocouple junctions, is enhanced by the horizontally extending fins formed integrally with the thermally and electrically conductive strap means 45 and 46, the latter, together with the P and N elements, forming the respective cold and hot junctions 43 and 44. While, for convenience of illustration, the fins are shown in FIGURE 4 as being relatively short, actually, as is clear from FIGURE 3, it is preferably that said fins extend substantially across each of the compartments within which they are disposed and into the respective outlet and inlet air streams. While the exact course of the air flow paths over the fins has not been shown, it will be understood that in accordance with known principles the air will be so directed as to flow substantially parallel to the fins, in heat exchange relation thereto.

Although the fins have been, for the purposes of illustration, shown extending horizontally in parallel rows, it is contemplated that such fins may be arranged in other ways, for example in parallel rows that extend vertically; also, a plurality of spaced rod like elements may be used instead of the fins. Further, in order to ensure against short circuiting the adjacent cold junctions 43 by the condensate, the spacers S may be extended beyond the surfaces of strap means 45.

It will of course be understood that in order to ensure optimum operation of the clothes drying apparatus, thermal losses through the outer walls of duct means 17 and 23, as well as through walls of the chamber 27 and shroud 19, may be minimized by applying suitable thermal insulation to said walls. Further, it will be recognized that the air flow circuit may if desired be modified in such manner that the cooled and dehumidified air is caused to flow back in heat exchange relation with the hot junctions and is then repassed through the drum 13, rather than being exhausted to the atmosphere, as shown.

From the foregoing description it is seen that the invention has provided in a drying machine substantially unitary means for both heating the material to be dried and disposing of moisture removed from the latter. It is also evident that the invention has provided apparatus of the foregoing type having particular utility in the field of automatic clothes driers. It will be understood, of course, that modifications may be made in the illustrated embodiment without departing from the scope of the appended claims.

I claim:

1. In laundry apparatus, basket means for containing clothes to be dried by circulating heated air over the latter, said basket means having an inlet and an outlet passage for the circulating air, a pair of air duct means, one duct means of said pair being disposed in air flow communication with said inlet passage and the other duct means of said pair being in like communication with the outlet passage of said basket means, wall means separating said duct means, said wall means comprising block-like members of semiconductive materials disposed adjacent one another; electrically conductive means interconnecting said block-like members in series electrical circuitry to form hot thermocouple junctions to one side of said wall means and cold thermocouple junctions to the other side of said wall means, said electrically conductive means including fins extending therefrom and disposed in heat exchange relation with air flowing through said passages; and electrically non-conductive means separating said block-like members and including portions presented substantially in the direction of and disposed between the fins extending from the said cold junctions.

2. Laundry apparatus comprising: a rotatably mounted drum for containing clothes to be dried by circulating heated air over the latter, said drum including a cylindrical wall portion having perforations formed therein to permit passage of air therethrough; a drum enclosure including a cylindrical wall, said wall having a perforate

5

section and an imperforate section, each said section being disposed in close adjacency to the perforate wall portion of the drum; air duct means disposed in fluid flow communication with the perforate wall section of said enclosure, said duct means including an imperforate wall portion overlying and spaced from the perforate wall section of said enclosure, and spaced side wall portions extending transversely of said duct wall portion and of the perforate wall section of said enclosure, said imperforate and said side wall portions of the duct means including parts extending away from the perforate wall section of the enclosure; partition means extending away from said perforate enclosure wall section and disposed transverse said side wall portions of said duct means, said partition means separating the duct means into a pair of conduits, one of said conduits providing for air flow through the perforations disposed to one side of said partition means and into the drum, and the other conduit providing for air flow out of the drum and through the perforations disposed to the other side of said partition means; hot and cold thermocouple junctions arranged in said partition means in such manner that cold junctions are disposed in high heat exchange relation with air flowing through one of said conduits and the hot junctions are disposed in high heat exchange relation with air flowing through the other of said conduits; and means associated with said duct means and arranged to effect air flow sequentially through said other conduit, said drum and said one conduit.

3. Laundry apparatus comprising: basket means for containing clothes to be dried by circulating heated air over the latter, said basket means including a wall portion having perforations formed therein to permit passage of air therethrough; a basket means enclosure including a wall having a perforate section and an imperforate section, each said section being disposed in close adjacency to the perforate wall portion of the basket means; air duct means disposed in fluid flow communication with the perforate wall section of said enclosure, said duct

6

means including an imperforate wall portion overlying and spaced from the perforate wall section of said enclosure, and spaced side wall portions extending transversely of said duct wall portions and of the perforate wall portion of the enclosure, said imperforate and said side wall portions of the duct means including parts extending away from the perforate wall section of the enclosure; partition means extending away from said perforate enclosure wall section and disposed transverse said side wall portions of said duct means, said partition means separating the duct means into a pair of conduits, one of said conduits providing for air flow through the perforations disposed to one side of said partition means and into the basket means, and the other conduit providing for air flow out of the basket means and through the perforations disposed to the other side of said partition means; hot and cold thermocouple junctions arranged in said partition means and in such manner that cold junctions are disposed in high heat exchange relation with air flowing through one of said conduits and the hot junctions are disposed in high heat exchange relation with air flowing through the other of said conduits; and means associated with said duct means and arranged to effect air flow sequentially to said other conduit, said basket means, and said one conduit.

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