April 3, 1962 G. B. LONG ET AL 3,027,653

DOMESTIC APPLIANCE

Filed May 14, 1958 3 Sheets-Sheet 1

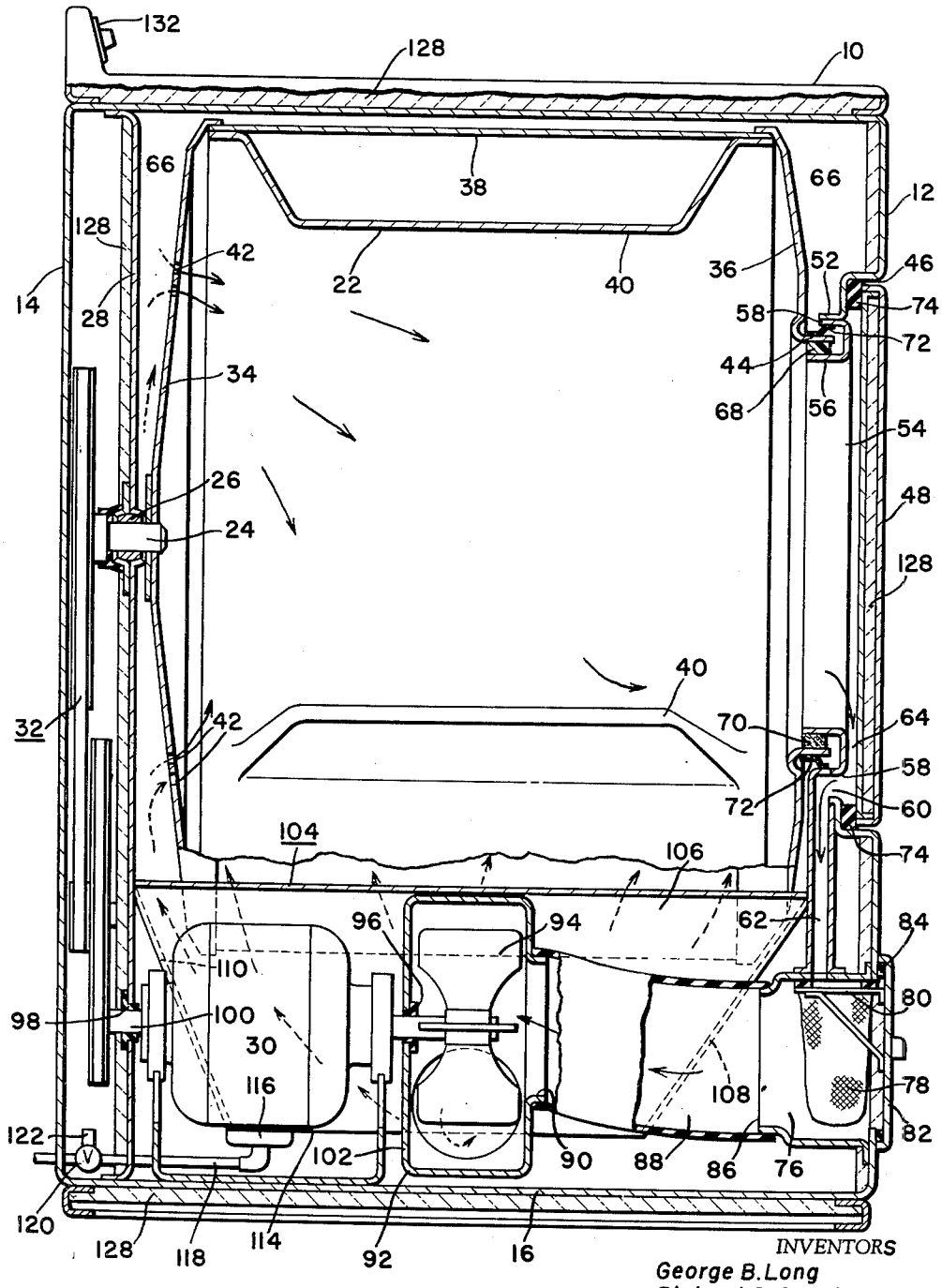

Fig. 1

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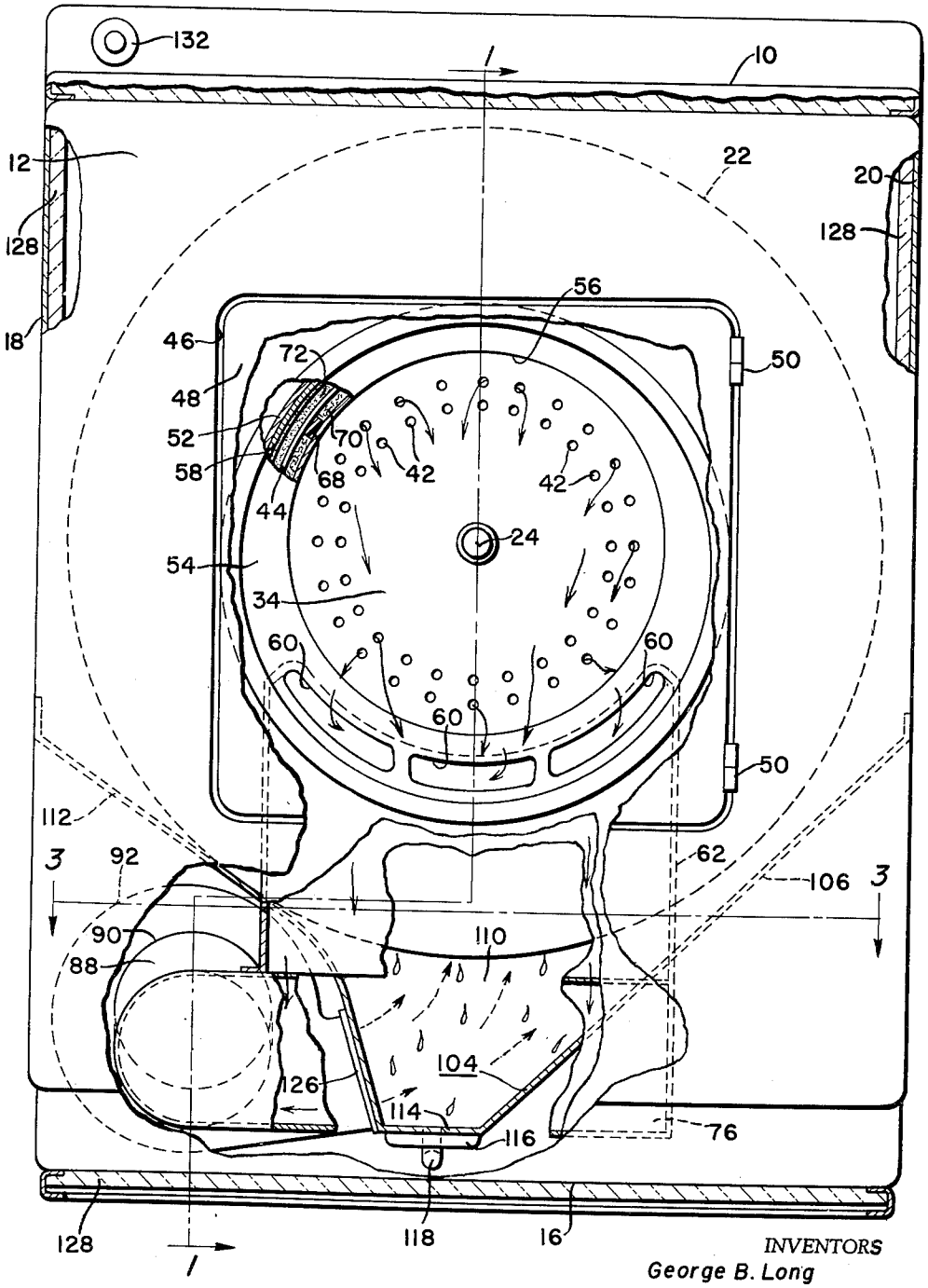

Fig. 2

←----HIGH PRESSURE
←——LOW PRESSURE

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3 Sheets-Sheet 3

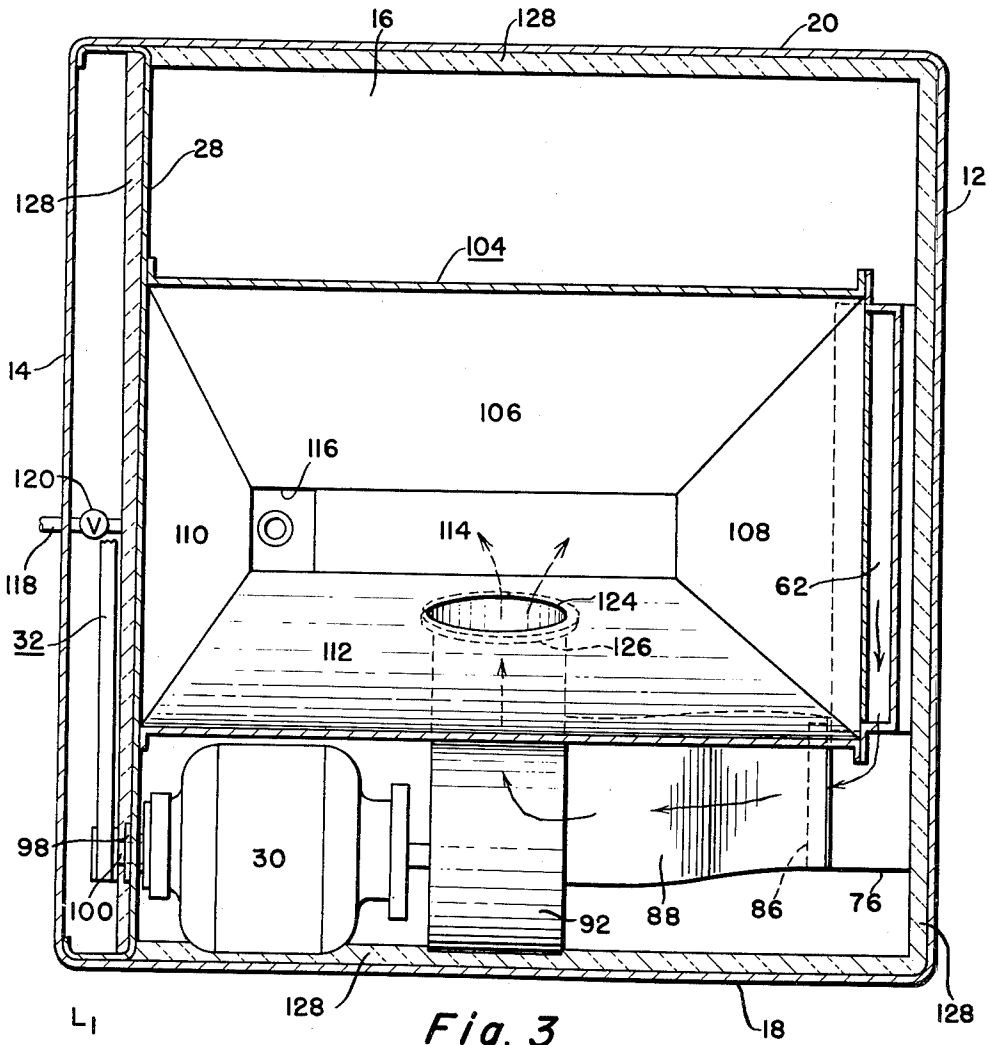

Fig. 3

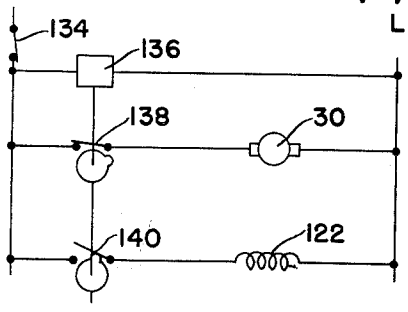

Fig. 4

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DOMESTIC APPLIANCE

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4 Claims. (Cl. 34—86)

This invention relates to a domestic appliance and more particularly to an improvement in clothes dryers.

It has long been the desire of the manufacturers of electrical clothes dryers to provide a machine which will dry clothes rapidly without unduly taxing the power supply normally available in residences. More particularly, an electric clothes dryer is desired which can operate on the conventional 115-volt electric supply to dry clothing as quickly as conventional dryers utilizing a 230-volt power source. It is current practice in the clothes drying art to heat a stream of air which is then passed over a container of clothing to be dried and then subsequently exhausted to the atmosphere. In this arrangement, the rate of drying depends on the amount of air passed over the clothing and the temperature of this air in relation to that of the clothing. But a system of this nature exhausts to the atmosphere all heat which is not utilized in raising the temperature of the clothing fabric to a point where the entrained moisture will be given off to the air flow. Where the dryer is not vented and the air is allowed merely to exhaust into the area in which the dryer is located, the room temperatures are uncomfortably increased and the moisture condenses on room surfaces surrounding the dryer along with any lint which is entrained in the air during the drying process. These are the alternatives facing an engineer who designs drying apparatus along conventional lines.

This invention relates to a new approach to drying fabrics wherein the heat lost during a drying process is held to a minimum and fabric-released moisture and lint are retained within the drying apparatus. By way of background, "drying" is the removal of an evaporable liquid, usually water. The damp fabric or material must be heated to a temperature above that corresponding to the vapor pressure of the surrounding atmosphere, or, the vapor pressure of the surrounding atmosphere must be maintained below the vapor pressure of the liquid in the fabric. It is the latter concept to which this invention is directed. This novel process could be broadly classified as vacuum drying. By using a sufficiently high vacuum, the boiling point of the fabric-entrained moisture is correspondingly reduced and the fabric can thus be dried rapidly at low temperatures with a minimum loss of energy. During such evaporation, the total heat expenditure may be considered as the sum of:

(1) Latent heat of vaporization (which in the instant process is recovered);
(2) Heat required to overcome hygroscopic attraction of the fabric (may be generally disregarded in the drying of clothing fabric);
(3) Heat required to raise temperature of the fabric and its entrained water to the temperature of evaporation. (To this, of course, must be added the amount of heat lost by radiation and convection through the walls of the drying apparatus).

Where vacuum dryers have been used in commercial applications, the total heat expenditure set forth above has been supplied by means of auxiliary heaters. This invention proposes to eliminate the need for such heaters by utilizing the heat of condensation to dry clothes in a domestic appliance.

Accordingly, it is an object of this invention to provide

a clothes drying apparatus having a high pressure section and a low pressure section in a recirculating air system wherein a clothes tumbling container is partially evacuated to dry the clothing.

It is also an object of this invention to utilize the reduced temperature created by the evacuation of the clothes container to condense moisture removed from the clothes, thereby recovering a substantial part of the heat of vaporization.

It is a further object to condense the moisture entrained in the low pressure air flowing from a tumbling drum upon the exterior surface of the tumbling drum whereby the heat of condensation is added to the fabric within the tumbling drum to facilitate the drying operation.

It is a more specific object to provide a clothes dryer wherein a tumbling drum is formed with orifices to effect a pressure drop between the interior and exterior of said drum and whereby a drying operation continues in the interior simultaneously with a condensing operation on the exterior.

It is a further object to provide a clothes dryer with a recirculating air system having a first part at a low pressure for drying the clothes and a second part at a high pressure for condensing the moisture removed in the drying process.

It is broadly an object of this invention to adapt a refrigeration process to drying clothes wherein the moisture in the clothes is vaporized and circulated through the tumbling drum as the refrigerant, the interior of the drum acting as the evaporator and the exterior of the drum as the condenser.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred embodiment of the present invention is clearly shown.

In the drawings:

FIGURE 1 is a sectional view, with parts broken away, taken substantially along line 1—1 of FIGURE 2;

FIGURE 2 is a front elevational view, with parts broken away, of a clothes dryer provided with this invention;

FIGURE 3 is a sectional view taken along line 3—3 of FIGURE 2; and

FIGURE 4 is a diagrammatic wiring diagram adapted for use with the clothes dryer of this invention.

In accordance with this invention, and with reference to FIGURE 1, a clothes dryer is illustrated having a top wall 10, a front wall 12, a rear wall 14, a bottom wall 16 and side walls 18 and 20. These walls or partitions enclose a tumbling drum 22 which is rotatably mounted on a shaft 24 journalled in a bearing 26 carried by an interior partition 28 running generally parallel to the rear wall 14 of the dryer and from top wall 10 to the base 16. To rotate the tumbling drum 22 a prime mover or motor 30 is adapted to rotate shaft 24 by means of a pulley system, shown generally at 32.

The tumbling drum 22 is formed with a rear wall 34, a front wall 36 and an outer peripheral wall 38. The peripheral wall 38 is imperforate and carries baffles 40 for agitating the clothes while the drum 22 is in motion. Apertures 42 are formed in the rear wall 34 of the drum and serve to admit air to the interior of the drum. Opposite the apertures 42 the drum front wall 36 is formed with a neck portion 44 which serves as a clothes loading access opening for the drum 22. Axially aligned with the opening 44, the front wall 12 is formed with an opening 46 closed by an access door 48 horizontally mounted at 50 to the front wall 12 of the dryer. Interposed between the flanged opening or neck 44 of the tumbling drum and an inturned flange 52 of the dryer wall 12 is a front baffle

54 having a collar portion 56 lying in concentric relation within the flanged drum collar 44. The baffle 54 is formed also with a reverse flange 58 which overlies the outer side of drum collar 44 and is spaced therefrom. To provide air passage through the front baffle 54 a series of ports 60 are formed in a bottom portion thereof and provide entrance to a front duct 62 for air proceeding from tumbling drum 22 by way of passageway 64.

Baffle 54 serves also the purpose of rotatably supporting the flanged collar 44 of the tumbling drum and sealing the interior of drum 22 from the area 66 immediately adjacent the interior of the drum. To effect this relationship a plurality of nylon blocks 68 are spaced about the flange 56 of collar 54. These blocks serve to rotatably support the flanged opening 44 of the tumbling drum. A fibrous sealing material 70, such as felt, is interspersed between the nylon block 68 to prevent air flow between the flange 56 and collar 44. As further assurance against air leakage between the area 66 surrounding the drum 22 and the interior of the drum, an annular seal 72 is interposed between baffle flange 58 and the outside of drum collar 44. Sealing the cabinet opening 46 against air flow during dryer operation is a door seal 74 between the dryer door 48 and the front wall 12.

The front duct 62 serves to direct air from the tumbling drum toward a chamber 76 wherein a lint collector 78 is retained. The lint collector 78 may be in the form of a nylon bag interposed in the air flow path, or a lint burner, as taught in copending application Serial No. 635,635, filed January 23, 1957. For facilitating periodic cleaning of the lint collecting means, the bag 78 is carried on a framework 80 affixed to a door panel 82 which is adapted to slidably remove the lint collecting means 78 from the chamber 76. A seal 84 between panel 82 and the dryer wall 12 serves also to prevent air flow between the interior and exterior of the dryer. The lint collecting chamber 76 is formed with a flanged opening 86 to which is attached a flexible conduit 88 leading to the inlet 90 of a centrifugal blower 92. The blower 92 should be of substantial capacity and is shown with a paddle-wheel 94 only for purposes of illustration. The prime mover or motor 30 utilized in rotating the tumbling drum 22 may also serve as the driving force for the impeller 94. Again, with reference to effecting as air-tight a system as possible, seals 96 and 98 are placed about the motor shaft 100 where it projects through blower housing wall 102 and support partition 28.

Disposed beneath the tumbling drum 22 is a collecting pan, shown generally at 104 in FIGURE 3. The collector 104 has sloped side walls 106, 108, 110 and 112 which lead to a bottom trough portion 114. The trough portion 114 is sloped slightly to drain toward a condensate collecting sump 116 at one end thereof. To provide for draining the sump 116, a conduit 118 leads therefrom to a remote drain. Selective control over drainage of sump 116 is provided by a valve 120 operated by solenoid 122. The collector pan wall 112 is provided with a port 124 to which the flange opening 126 of the blower outlet is attached. In view of the slope of collector pan wall 112, it should be apparent that the outlet of blower 92 is aimed in a manner to cause air flow to impinge upon that portion of the peripheral wall 38 of drum 22 which is adjacent the port 124 at any particular instant. The collector pan 104 is adapted to extend from the rear support partition 28 to the front duct 62 and thus effects a complete catch-basin for anything dropping from the exterior surface of the tumbling drum.

A complete coverage of insulation 128 surrounds the area enclosing the tumbling drum to insulate against both heat transfer and the interflow of air. This feature is important to effect operating economies and efficiency in the functioning of this invention. A pressure differential is required to exist between the exterior and interior of the tumbling drum to cause a rapid evaporation of the moisture in the clothing being dried. Further, a temperature differential is of prime importance to facilitate the maintenance of a drum temperature which is below the dew point of the moisture-laden air which blows upon the exterior surface of the drum. These procedures are served by adequately isolating the clothes drying system from the surrounding atmosphere. To particularize, insulation 128 in the form of a blanket should be placed on cabinet top panel 10, front wall 12, side walls 18 and 20 and base 16. To complete the circumscribing blanket of insulation, the partition or bulkhead 28 and the access doors 48 and 82 should be covered as well. Where shafts or conduits pass through the walls of the cabinet, air-tight seals such as the aforesaid seals 96 and 98 should be installed and the insulation urged tightly therearound to minimize heat transfer.

The operation of a dryer embodying the novel concepts of this invention will be most clearly understood with reference to the wiring diagram of FIGURE 4 in conjunction with the structure described hereinabove. A load of damp clothing or moist fabric is placed within the tumbling drum 22 through the loading or access door 48. The door 48 is closed tightly against the air-tight door seal 74 and a drying cycle initiated by turning a dial 132 to the desired drying intervals. The setting of the dial 132 acts to close timer switch 134 to energize a timer motor 136 from a conventional residential power source L_1 and L_2. Simultaneously, timer switch 138 is closed to start the prime mover or motor 30 which, in turn, operates the air circulating means or blower 92 as well as rotating the tumbling drum 22 by way of pulley system 32. With the blower 92 and drum 22 in operation, air is drawn out of the tumbling drum into front duct passageway 64 through front baffle ports 60 and thus into the front duct 62. Intercepting air flowing downwardly through duct 62 is a lint collector 78 slidably disposed in a lint collecting chamber 76. For purpose of clarity, the lint collecting means has been shown as a bag of nylon or other suitable material supported on the frame of a lint collector access panel 82 which is sealed air-tight against the front wall 12 of the dryer cabinet. However, it should be understood that any conventional collector or air strainer could be used to remove lint which has been entrained in the recirculating air during the clothes tumbling operation. Furthermore, the concept of this invention could be adequately served with the location of a lint collecting and burning arrangement within the chamber 76, such as is taught in the aforementioned copending application S.N. 635,635. The recirculating air now leaves the lint collecting chamber 76 through a flanged opening 86 therein and proceeds through a flexible conduit 88 to the inlet 90 of the blower 92. It is apparent that a minus pressure will exist in the tumbling drum and in those elements of the air circulating system just set forth, due to the evacuating effect of the blower. But to make the dryer operable, there must be a pressure differential within the air circulating system. In this respect, the system compares favorably to a refrigeration cycle with the interior of the tumbling drum serving as the evaporator. If the novel system here advanced is to be effective as a clothes drying apparatus, there must be means whereby the moisture evaporated from the clothing within the tumbling drum is removed from the air before it repasses over the tumbling clothes. For this purpose, and to effect a high pressure portion of the recirculating air system, a plurality of orifices 42 are included.

As aforesaid, the interior of the tumbling drum 22 is under a vacuum in response to the efforts of blower 92 and the orifices 42 serve as the sole means for admitting air into the low pressure portion of the air system. Since the pump 92 is expelling air through outlet 126 under pressure upon the exterior surface of the tumbling drum 22, this pressurized air will lie adjacent the orifices 42 in that portion of the high pressure area or zone 66 interposed between the bulkhead 28 and the rear wall 34 of the tumbling drum. In proceeding from the zone 66 to the interior of the tumbling drum 22 by way of orifices

42, a pressure drop will occur. It is imperative for the operational efficiency of this dryer that the pressure drop occur at this point. Therefore, the design of a dryer embodying the novel concepts set forth here must assure that the restriction afforded the flow of air is greatest at these orifices 42. In other words, the total opening area of orifices 42 must be less than the combined total opening defined by front baffle opening 60 and/or passageway 64. Where the orifices 42 define a combined area no greater than one-half the size of the openings on the outlet side of the tumbling drum, the dryer was found to function adequately. Thus, it is seen that a recirculating air system has been provided for drying clothes which consists of a low pressure or liquid evaporation portion and a high pressure or liquid condensing portion. A low pressure exists in the interior of the tumbling drum 22, the flanged opening collar 56, passageway 64, front duct 62, lint collecting chamber 76 and conduit 88 attached to the inlet of the blower 92. High pressure, on the other hand, is effected from a point adjacent the outlet 126 of the blower and equally throughout the zone 66 existing between the dryer cabinet and the tumbling drum 22. At two points only, is the pressure varied—in passing between the inlet and the outlet of the blower 92 and in passing through the orifices 42. To prevent the flow of high pressure air to the low pressure portion of the system, seals such as 72 of rubberized felt or other suitable material must be installed at all connections where such interflow could occur.

In accordance with the law of partial pressures the broad concepts of the subject drying cycle may be explained thusly. The saturation point of air varies and is determined by its pressure and temperature. Air entering the tumbling drum 22 through orifices 42 has a partial pressure of water vapor slightly less than the equilibrium vapor pressure of the water in the clothes. This slightly pressure differential will cause the air being circulated over the clothes to pick up water vapor from the clothes. The air and water vapor mixture is then drawn from the drum by the blower 92 and compressed. After compressing the air, the partial pressure of water vapor in the compressed air exceeds the equilibrium pressure corresponding to the temperature of the relatively cold exterior surface of the drum 22. Conditions (high pressure—low temperature) are thus established under which the compressed air has a lower capacity for moisture outside the drum than within and the moisture drops out.

With the aforesaid pressure systems established, the following drying cycle exists. The evacuation of the interior of the tumbling drum 22 causes the moisture to evaporate from the clothes to be dried into the air passing through the tumbling drum. As is well known, evaporation is a cooling process and the surfaces of the tumbling drum 22 are proportionately cooled as the clothing gives up its moisture. Of course, a certain small amount of lint is evolved from the tumbling operation and this lint is carried by the moisture-laden air flow into the lint collecting chamber 76, at which point the lint is removed. In passing through the blower 92 the moisture-laden air is heated due to the work of the blower, and is projected under pressure from the outlet 126 of the blower upon the peripheral wall of the tumbling drum. Since the tumbling drum is cool and the pressurized moisture-laden air is relatively warm, the moisture entrained in the air will condense upon the exterior surface of the drum 22, thereby giving up to the drum the heat of condensation which further speeds the vaporizing of the moisture from the clothing within the drum. The beads of condensate removed from the recirculating air fall into the catch-basin or collector 104 to form a condensate pool at the bottom thereof in trough 114. The recirculating air, pressurized at this point and with the moisture thus removed, now proceeds through the orifices 42 at which point a pressure drop occurs. The air is thus placed in a low pressure condition to effect further evaporation of the moisture from the clothes. This drying cycle continues for the time period selected on dial 132 and/or until the clothing is dried. During this operation a timer switch 140 has remained open to close tightly the valve 120 on the condensate line 118. The function of this valve should be apparent in that the conduit 118 would provide a point of pressure leakage which could detract from the operating efficiency of the drying cycle. As the time motor 136 progresses to the finish point selected by the operator, switch 140 is closed to energize solenoid 122 and open valve 120. The condensate collected during the drying process in the collector pan 104 will then flow by gravity from the dryer to any suitable remote drain. The pressure sealed door 48 may now be opened for removal of the clothes. Upon the initiation of any subsequent drying cycle, the condensate line valve 120 will be closed. It is important to recognize that the drying process taught hereinabove is accomplished with a lower energy consumption than is necessary with the conventional heated air dryers. In the instant process only the compressor or blower dissipates heat which could find its way into the surrounding atmosphere. On the other hand, the heaters in conventional dryers (approximately 4000 watts) produce much wasted energy and add unwanted heat to the laundry area. Thus an improved drying concept is propounded in which clothing is dried more efficiently in a room which is not subject to the uncomfortable increases in ambient temperature so prominent with heated air dryers.

While the embodiment of the present invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. A dryer of damp fabrics comprising a cabinet, a tumbling drum rotatably mounted in said cabinet, said tumbling drum having a rear wall, a front wall and an imperforate peripheral wall, an access opening in said front wall, a plurality of orifices in said rear wall, a hingedly mounted door on said cabinet axially aligned with said access opening, a lint collecting chamber having therein a removable lint trap, a front duct connecting said access opening to said chamber, a condensate collector below said drum, a sump in said collector, a pipe connected to said sump, a solenoid actuated valve for selectively opening said pipe to drain said sump, a blower having its inlet connected to said chamber and its outlet adjacent said drum, power means for rotating said drum and blower, said blower evacuating said drum to remove moisture from said fabrics and impinging upon said peripheral wall to condense said moisture in a manner to add the heat of condensation to said drum, and means for insulating said cabinet against heat or pressure transfer during operation of said power means.

2. A dryer of damp fabrics comprising a cabinet, a tumbling drum rotatably mounted in said cabinet, said tumbling drum having a rear wall, a front wall and an imperforate peripheral wall, an access opening in said front wall, a plurality of orifices in said rear wall, a door on said cabinet aligned with said access opening, a lint collecting chamber, a front duct connecting said access opening to said chamber, a condensate collector adjacent said drum, a pipe connected to said collector, a selectively actuated valve for opening said pipe to drain said collector, a blower having its inlet connected to said chamber and its outlet facing said drum, power means for rotating said drum and blower, said blower decreasing the pressure on the inside of said drum to remove moisture from said fabrics and increasing the pressure on the outside of said drum, whereby said moisture is condensed in a manner to add the heat of condensation to said drum, and means for insulating said cabinet during operation of said power means.

3. A dryer of damp fabrics or like material comprising a container, a fabric receptacle movably mounted in said container, an access opening in said receptacle, a plu-

rality of orifices in one portion of said receptacle, a door on said container connecting with said access opening, a duct communicating with the inside of said receptacle through said access opening, a condensate collector associated with said receptacle, a drain line connected to said collector, a selectively actuated valve for opening said drain line to drain said collector, a blower having an inlet connected to said duct and an outlet facing the outside of another portion of said receptacle, power means for moving said receptacle and blower, said blower reducing the pressure on the inside of said receptacle to vaporize moisture from said fabrics and introducing said vapor to the outside of said receptacle to condense said moisture in a manner to add the heat of condensation to said receptacle, and means for insulating said container.

4. A dryer of damp fabrics or like material comprising a container, a fabric receptacle movably mounted in said container, an access opening in said receptacle, an orifice in said receptacle, a door on said container connecting with said access opening, air passage means communicating with the inside of said receptacle, a condensate collector associated with said receptacle, a drain line connected to said collector, a selectively actuated valve for opening said drain line to drain said collector, a blower having an inlet connected to said air passage means and an outlet facing the outside of said receptacle, power means for moving said receptacle and blower, said blower reducing the pressure on the inside of said recepacle to vaporize moisture from said fabrics, increasing the pressure on the outside of said receptacle and introducing said vapor to the outside of said receptacle to condense said moisture in a manner to add the heat of condensation to said receptacle, said orifice separating the zone of reduced pressure on the inside of said receptacle from the zone of increased pressure on the outside of said receptacle, and means for insulating said container.

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