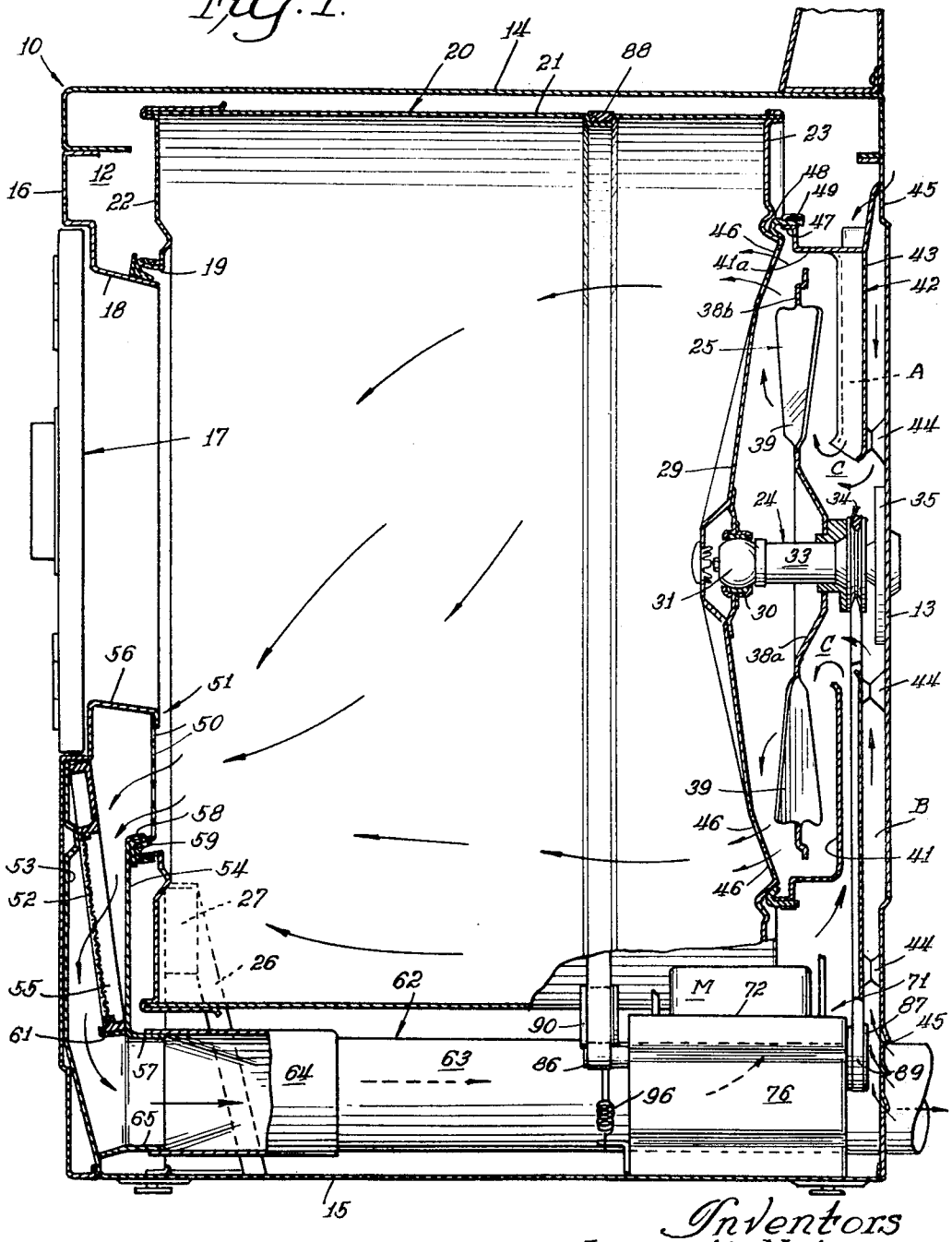
April 7, 1970 J. K. NELSON ET AL 3,504,444

AIR CIRCULATION ARRANGEMENT FOR DRYERS

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Fig. 1.



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AIR CIRCULATION ARRANGEMENT FOR DRYERS

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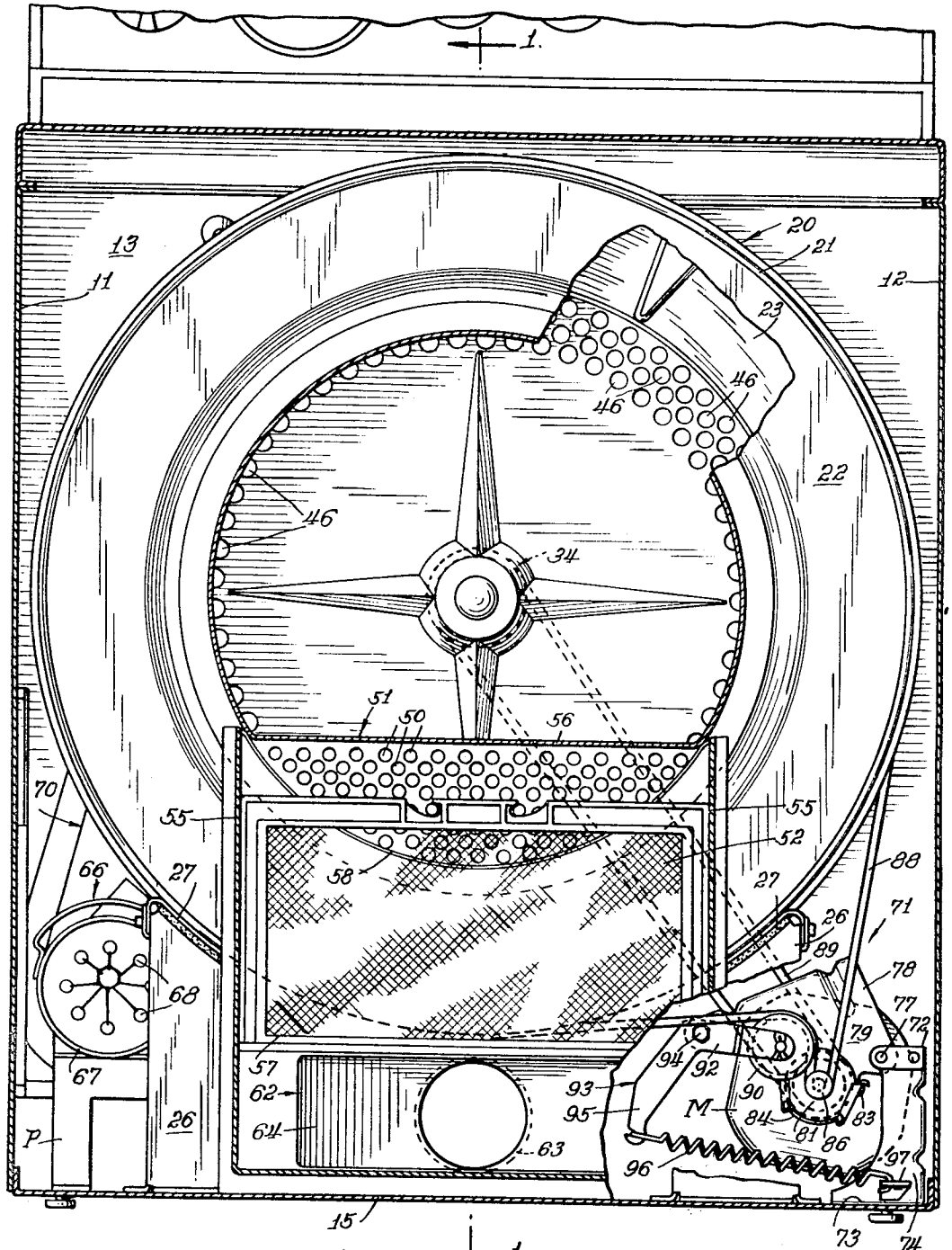


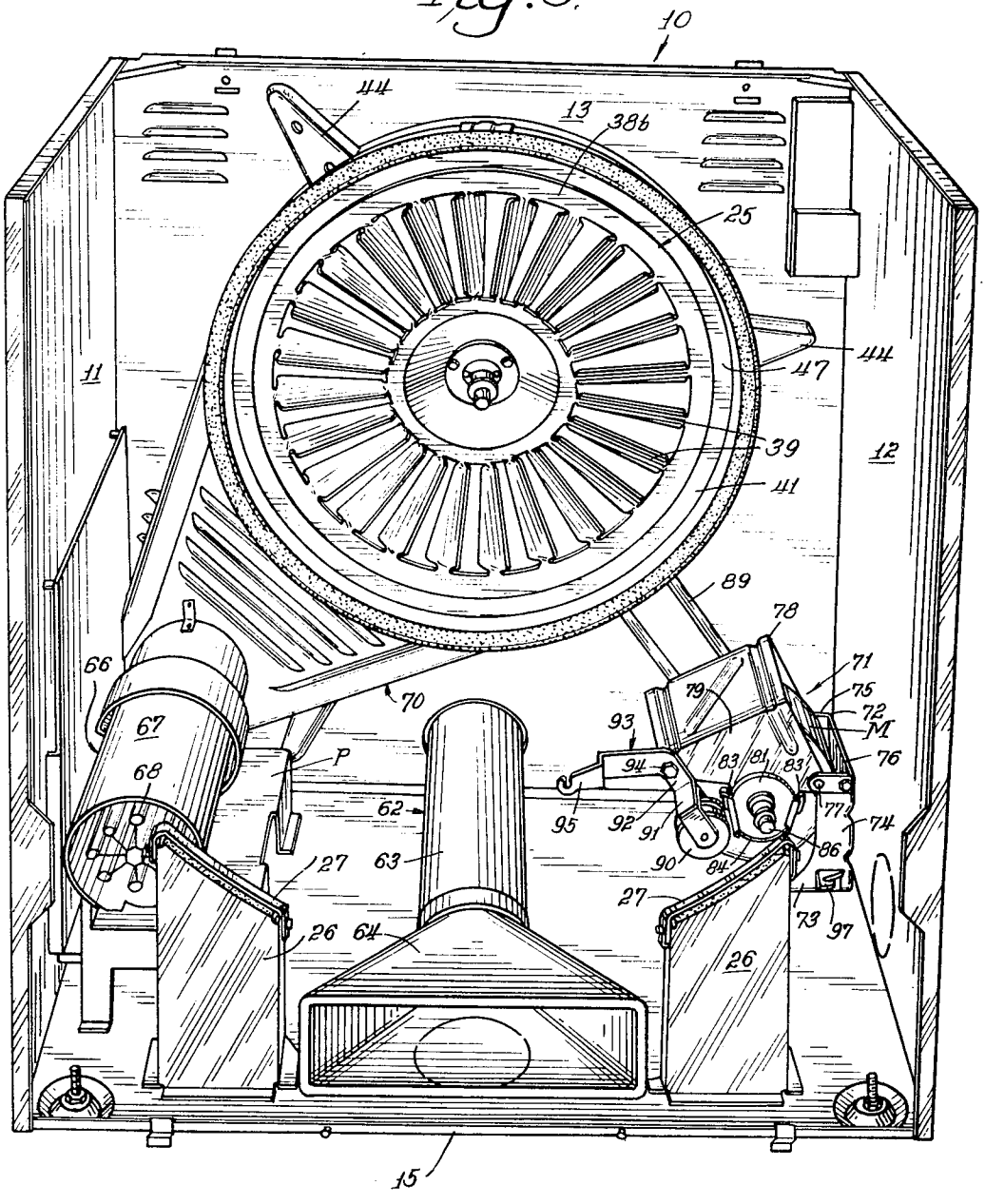
Fig. 2.

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Fig. 3.



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Fig. 4

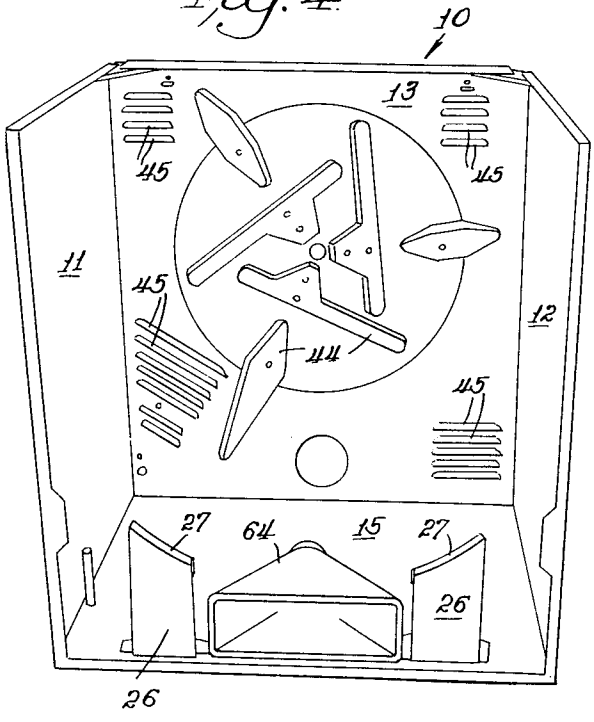


Fig. 5

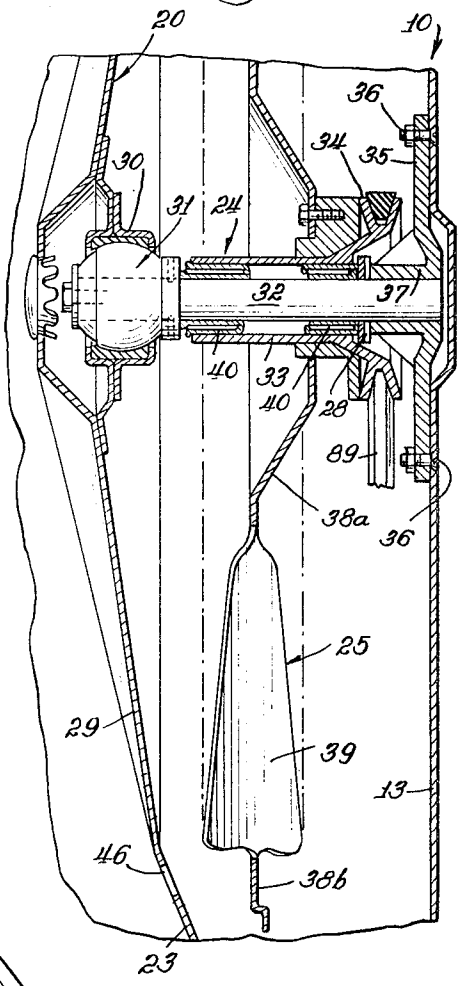
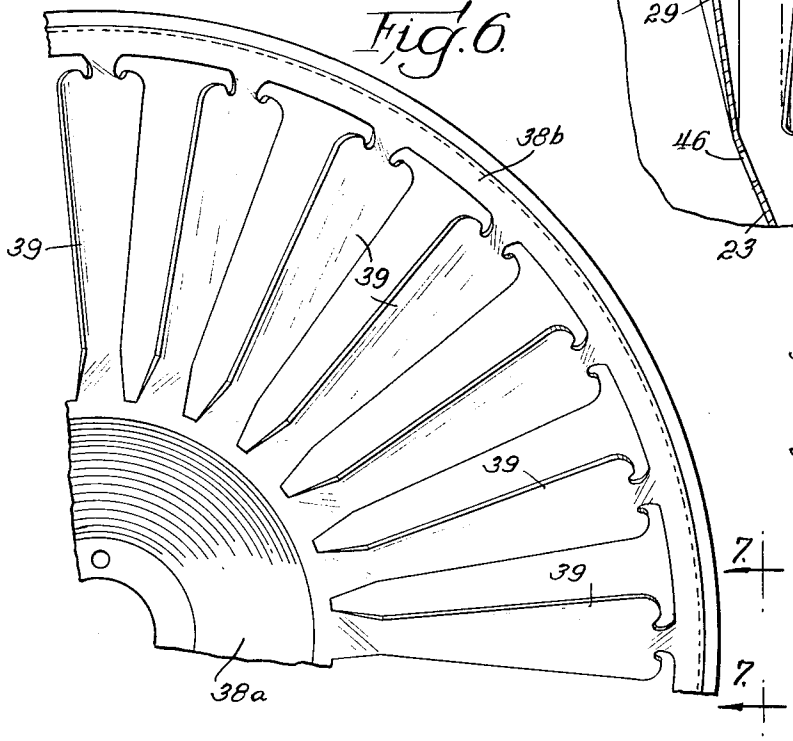


Fig. 6



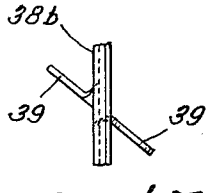


Fig. 7

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AIR CIRCULATION ARRANGEMENT FOR DRYERS

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Int. Cl. F26b 21/02

U.S. Cl. 34—131 12 Claims

ABSTRACT OF THE DISCLOSURE

A clothes dryer having a cabinet receiving a clothes-containing cylinder and a propeller-type fan which are rotatable about a horizontal axis, the fan being located between adjacent rear cabinet and cylinder walls with the cabinet wall having a circular axial orifice affording an air inlet radially inwardly of the fan blades, and the cylinder wall having air discharge openings circumferentially spaced about the axis and located radially outward of, but adjacent to, the outer tips of the fan blades.

This invention relates to an improved air circulation arrangement for a clothes dryer.

There are two basic ways in which a fan of any kind may be applied to a clothes dryer system. These may be called a blow-through configuration and a draw-through configuration. In a blow-through configuration, the air is drawn from the atmosphere through the fan and through a heater, either upstream or downstream of the fan, and then passes from the fan into the clothes dryer cylinder, through the clothes, and is exhausted. In a draw-through configuration, the air is drawn through a heater, through the clothes dryer cylinder containing the clothes, and then passes through the fan and is exhausted to the atmosphere. From several considerations, it is believed the blow-through configuration is more advantageous and, accordingly, the invention is directed toward that configuration and does not apply to draw-through type air systems.

In a blow-through fan configuration in a clothes dryer, such as disclosed in U.S. Patent 2,798,307 issued July 5, 1957, and manufactured and sold for many years by Borg-Warner Corporation, it is advantageous to locate the fan on the rear face of the clothes dryer cylinder. This minimizes the amount of duct work required, the fan action itself can be used to achieve an even distribution of the air flowing through passages in the back of the clothes dryer cylinder, and the fan can be readily belted so that it is driven by the motor that also rotates the cylinder. The air flow requirements are relatively high pressure and relatively low flow. For example, in such clothes dryers with a typical clothes load, the fan is required to generate about 1.50 inches of water pressure, and the flow is about 160 cu. ft. per min. Usual considerations of fan application would dictate a forward curve centrifugal impeller be used for such an application. However, the disadvantage of such an impeller is that it works effectively only when provided with a scroll-like housing that effectively converts its velocity energy into pressure energy before discharge from the assembly. Thus, the air is discharged in a single direction, whereas, in the dryer, it is desirable to discharge the air equally in all directions.

Therefore, the only advantageous type of centrifugal fan for this application would be a radial-bladed or backward-curved fan that is capable of converting its velocity energy into pressure within the blading itself. For example, a bladed fan is used in the clothes dryer shown in the above U.S. Patent 2,798,307.

SUMMARY OF THE INVENTION

A general object of the invention is to provide a new and improved air circulation system for a clothes dryer.

A more particular object of the invention is to provide a novel air circulation system for a clothes dryer and featuring an improved blow-through fan configuration.

Another object of the invention is to provide a unique air circulation arrangement for a clothes dryer and providing optimum performance by insuring maximum air flow and distribution while having an acceptable noise level.

Another object of the invention is to improve clothes dryers by the provision of an air circulation arrangement in which the dryer clothes-containing cylinder and a propeller-type fan are housed in a cabinet and rotatable about a common horizontal axis, with the cabinet and cylinder having adjacent walls providing a chamber for the fan, the cabinet wall having a circular air inlet orifice radially inwardly of the fan blades and the cylinder wall having circumferentially spaced air exit openings located radially outwardly of the fan blades.

Another object of the invention is to provide an air circulation arrangement for a clothes dryer having a rotating clothes-containing cylinder with a fan being located adjacent the rear wall of the cylinder and operable to blow warm air into the cylinder through openings in the wall, the fan being characterized by a multiplicity of blades similar to a propeller fan by being formed with at least the outer blade portions being pitched at an angle to the radial direction thereof in a manner to impart an axial component toward the cylinder wall openings back to the air leaving the blades, the cylinder wall openings being arranged in a pattern having its inner boundary approximately at and outwardly of the radially outer ends of the air-moving portions of the fan blades, with the air inlet to the fan being provided by a circular opening radially inward of the air-moving portions of the fan blades.

The novel features which are characteristic of the invention are set forth with particularity in the appended claims. The invention both as to its organization and operation, together with further objects and advantages thereof, will best be understood by reference to the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a vertical sectional view of a clothes dryer embodying the air circulation arrangement of the invention, and taken along the plane of the line 1—1 of FIGURE 2;

FIGURE 2 is a front elevational view of the dryer shown in FIGURE 1, the front panel being removed and certain parts broken away and partly sectionalized to illustrate details of the dryer;

FIGURE 3 is a perspective view of the dryer, with the basket removed to more clearly illustrate details of the air circulation arrangement including the fan drive;

FIGURE 4 is an enlarged vertical sectional view of the basket rear support and fan mounting assemblies;

FIGURE 5 is a perspective view of the cabinet;

FIGURE 6 is a front elevational view of the fan; and

FIGURE 7 is an edge view of one of the fan blades, taken along the plane of the line 7—7 of FIGURE 6.

Referring now to the drawings, the domestic clothes dryer is provided with a cabinet generally indicated at **10** having spaced side walls **11** and **12**; a rear wall **13**; top and bottom walls **14** and **15**; and a front wall **16**. The front wall **16** has a door **17** hinged thereto and closing an

opening, defined by a cylindrical flange **18**, of the front wall **16**, providing access to the front opening **19** of a rotatable clothes container or basket **20**, in the form of a cylinder, for loading and unloading clothes in the basket.

The basket is mounted for rotation about a substantially non-vertical axis which, in the present case, is preferably horizontal. More particularly, the basket is substantially cylindrical in shape, having a cylindrical wall **21**; a front wall **22** having the opening **19** receiving the flange **18** of the cabinet front wall **16**; and a rear wall **23** having a shaft and bearing assembly **24** for the basket **20** and a fan or blower **25**. The basket is supported at its front end by spaced supports or skids **26, 26** mounted on the cabinet bottom wall **15** and having arcuate upper surfaces conforming to the curvature of the cylindrical wall **21** and provided with shoes **27, 27** of suitable bearing material engaging the basket. The rear end of the basket is supported by the shaft and bearing assembly **24** and, as seen in FIGURES 1 and 5, the basket rear wall **23** has conically-shaped depressed portion **29** providing a mounting means in the form of a sheet-metal hub **30** secured thereto, as by welding, and which hub receives a ball-like bearing **31** secured to a shaft **32** extending rearwardly through a hollow cylindrical portion **33** of a pulley **34** and into a supporting bracket **35** fixed to the rear wall of the cabinet by bolt and nut assemblies **36** as shown in FIGURE 5. The shaft **32** is fixed by pins **28** to the radially-inwardly extending cylindrical portion **37** of bracket **35**.

The blower or fan assembly **25** comprises a circular sheet-metal plate having a frusto-conical center portion **38***a* and radially outer cut-out portions to define a plurality of radially-extending blades **39** each twisted from the plane of the plate and having their radially outer ends connected to and circumscribed by a circular rim **38***b*. It will be observed the plate is formed as a stamping and in a manner that 60% of the projected face area of the plate is devoted to the fan blades, as shown in FIGURES 2, 3 and 6. Referring to FIGURE 5, the center portion **38***a* of the plate is secured to the pulley **34** rotatably mounted on spaced bearings **40, 40** on shaft **32**. The fan is confined between and enclosed by the basket rear wall **23**, particularly the conical portion **29** thereof, and the front plate **41** of a duct assembly **42** (FIGURE 1), the rear plate **43** of the duct assembly being spaced from the front plate **41** to provide a passage A therewith. The plate **43** is connected to bosses **44** (FIGURES 1 and 4) formed in and projecting from the cabinet rear wall to provide passages B for the inflow of ambient air by the fan from vents **45** in the cabinet rear wall and through a plurality of circumferentially and radially spaced openings **46** in the basket rear wall and into the basket interior. As seen in FIGURES 1 and 3, the outer edge of the duct plate **41** is inwardly bent to provide a cylindrical portion **41***a* having a radially outer annular flange **47** for mounting an annular felt seal **48** fixed thereto by a band **49**, the seal engaging the basket rear wall to confine the air between the basket rear wall and the plate **41** for flow into and through the openings **46** in the basket rear wall. It will be noted that the circular rim **38***b* lies closely adjacent to the cylindrical portion **41***a* of the duct plate **41** to prevent recirculation of air. The air flows through the basket, and also the openings **50** in an upper collector duct assembly **51** secured to the front wall of the cabinet and providing a passage for flow of air from the basket through a removabie lint screen or trap **52** supported in the duct. As seen in FIGURES 1 and 2, the duct assembly **51** is a rectangular shaped box-like structure having front and rear walls **53, 54**; side walls **55**; and top and bottom walls **56** and **57**, the front wall **53** being secured to the cabinet front wall, the rear wall **54** having the openings **50** defined by an arcuate flange **58** and engaging an annular seal **59** mounted on the cylindrical portion **19** of basket **20** defining the clothes-receiving opening of the basket. The rear wall **54** has its lower portion provided with a flange **61** forming a ledge for supporting the lint screen **52** which is disposed with respect to the duct walls so as to filter lint in the air flowing from the basket through the duct assembly **51**.

The air-circulation system further includes a second duct assembly **62** including a cylindrical conduit **63** connected to a funnel-shaped member **64** having a rectangular end receiving a complementary-shaped portion **65**, defining the bottom opening of the duct assembly **51**. The conduit **63** extends through the rear wall **13** of the cabinet and is connected, in conventional manner, to a standard vent or flue pipe for conducting the moisture-laden exhaust to the outside of the house.

While ambient air is drawn into the dryer by the fan through the cabinet rear wall, an air heating assembly **66** comprising, in general, a cylindrical housing **67**, which may contain either a conventional electrically-energized heater **68**, as shown, or gas-fired heating means, is effective to heat air drawn into and circulated through the housing **67** by the operation of the fan.

The heating assembly **66** is supported on a pedestal P mounted on the bottom wall **15** of the cabinet. The housing **67** extends rearwardly and is connected to a triangular-shaped housing **70** (FIGURE 3) forming portions of, and connected to, the front and rear plates **41** and **43** of the duct assembly **42**, so that the fan is effective to draw heated air in housing **67**, through housing **70**, into the passage A for mixture of the heated air with the exterior ambient air drawn through passage B, the air mixture being forced into the basket through the openings **47** in the basket rear wall **29**.

A belt drive system for the basket and fan is shown in FIGURES 1, 2 and 3, the belt drive system being generally indicated at **71** and comprises a bracket **72** having a bottom wall **73** secured to the cabinet bottom wall **15**; spaced side walls **74** and **75**; and a wall **76** extending between and connecting the side walls and merging with the bottom wall. The bracket **72** has aligned openings in the upper offset ends of the side walls **74** and **75** receiving pivot members **77** fixed to and projecting outwardly of an inverted U-shaped motor support **78**.

The side walls **79** and **80** of the support **78** have their lower ends formed to provide downwardly facing arcuate recesses receiving rubber bushings **81** mounting hubs projecting laterally from the casing of motor M. The bottom ends of each arcuate recess is defined by oppositely extending lugs **83, 83** projecting into slots at each end of an arcuately curved spring retainer or clip **84**, the retainers **84** extending under and engaging the motor hub bushings **81** and holding the motor on the support **78**. The motor drive shaft **85** extends outwardly of the hub bushings **81** on opposite sides of the motor and have connected thereto drive pulleys **86, 87**.

As shown in FIGURES 1 and 2, a V-belt **88** passes around and engages the cylindrical outer surface of the basket. A V-belt **89** is mounted on the drive pulleys **34** and **87** and is operative to rotate the fan or blower **25**. An idler pulley **90** engages belt **88** and is rotatably mounted on a bifurcated portion **91** of an arm **92** of a lever **93**, the lever being pivotally supported, intermediate its ends, on the motor support side wall **79** by a shoulder bolt and nut assembly **94**. The lever has the end of its other arm **95** provided with a slot receiving one end of a tension spring **96**, the opposite end of the spring engaging a hook member **97** fixed to the side wall **74** of the bracket **72**.

In the operation of the basket and fan drive assembly, rotation of the motor drive shaft in a direction to rotate the pulleys **86** and **87** causes the pulley **86** to activate the belt **88** to drive the basket to tumble the clothes in the basket, while the pulley **87** activates belt **89** to drive the fan to circulate air through the basket and dryer as indicated by the arrows in FIGURE 1.

The improved air circulation arrangement of the present invention is characterized by the novel fan and hous-

ing configuration employed in the dryer and providing an increase in air flow by a fan occupying the same or less space than previously-known centrifugal or axial flow propeller fans, and at an equal or lower noise level.

Referring to the drawings, the propeller type fan **25** is steeply pitched and is designed to function partially as a centrifugal fan and partially as an axial-flow fan. The use of a steeply pitched propeller fan in both its centrifugal and its axial-flow aspects is known in other fields and is sometimes called a "mixed-flow fan." However, in all cases of which we are aware, the axial-flow aspect occurs at the entrance where the angle to the blading assists the entrance of air. The air is then discharged from the fan radially in a centrifugal manner.

While the dryer fan **25** has both centrifugal and axial-flow aspects, this action is completely different than that in a conventional mixed-flow fan. In fan **25**, the centrifugal effects occur in the inlet condition, and no benefit is derived from the pitch of the blading insofar as the inlet air is concerned. The axial-flow aspects impart a forward angle to what would otherwise be the entirely radial exit of the air from the fan. This is advantageous in directing the air toward the entrance holes **46** in the dryer drum. Thus, while a conventional mixed flow fan has a propeller action that assists the air entering axially and has a centrifugal action that imparts energy to the air discharge radially, fan **25** uses the centrifugal action entirely in the entrance condition, and the combination of the centrifugal and propeller action is used to give a combination of a radial and axial direction to the discharge air. No knowledge is had of a fan with such an action being used in any application—in fact, in most applications, this action would not be advantageous. However, in the case of clothes dryers, there are advantages to this arrangement over and above those provided by configurations that have heretofore been used.

As previously pointed out, the air circulation arrangement contemplates a blow-through fan configuration in a clothes dryer, having an increase in air flow in a fan occupying minimum space in the dryer and having a low acceptable noise level. Since the air, after leaving the fan blades, has to turn toward and flow outwardly along the cylinder back wall **29** in order to enter through the openings **46**, it can be seen that a fan with angled bladings will contribute to this end. The fan **25**, evolved experimentally, was found to have an optimum blade angle of 50°. In order to generate the required pressure, a large number of blades was used and a high degree of blade solidarity. That is, it was found desirable to leave as little space as possible between the blades that could not contribute to imparting energy to the air. In order to achieve the desired pressure, it was also found most advantageous to use a very small inlet C so that the inlet of the fan is actually entirely inside the inner radial extent of the blading. The consequent long radial passage makes maximum use of the effect of conversion of velocity energy to pressure energy during the centrifugal action. The use of a large number of relatively narrow blades permits the fan to be fitted in a small axial depth, which is advantageous from the standpoint of allowing the largest possible size of container cylinder for the clothes in a given housing dimension. The fan **25** is also designed so that its multi-bladed arrangement is similar to a propeller-type fan in that at least the outer portion of each blade is pitched at an angle to the radial direction in such a way as to impart an axial component toward the air exit passages or openings **46** in the rear cylinder wall to the air leaving the blades, the openings **46** being arranged in a pattern having its inner boundary approximately at the radial extent of the fan and extending outwardly therefrom, and the inlet C to the fan comprising a circular orifice having its outward extent within most or all of the radial extent of the fan blades.

One of the important aspects of the fan system described here is the relationship of the over-all noise level generated by the fan system to the performance of the dryer. Within the limits of the mechanical strength of the parts, any desired air flow can be generated from any fan system by merely increasing the speed of the fan to a level at which this air flow is achieved. Thus, the air flow achieved in the disclosed dryer could have been achieved in the dryer design of U.S. Patent 2,798,307 merely by increasing the speed of the fan. However, in doing so, the noise level would be raised to an objectionable degree. Thus, one of the objects of the present fan design is to achieve a better noise level for the same operating characteristics. It was found that with the clothes dryer fan of U.S. Patent 2,798,307 operating at a speed that would produce the same air flow as the fan **25**, the noise level was 4 decibels higher. This illustrates that this application of propeller-like blading of fan **25**, in place of the centrifugal blading disclosed in the identified U.S. patent, is more efficient with respect to noise.

This combination of a many-bladed propeller type of fan to a clothes dryer in a configuration in which a small inlet orifice C is used in such a way that the majority or all of the radial extent of the fan blades is radially outside the dimensions of the orifice, and in which the discharge openings **46** into the clothes dryer cylinder are in a radial pattern at the vicinity of and extending beyond the blade tips, is believed to be novel and makes possible a dryer that is more compact, has a higher air flow, and has a lower noise level for the same performance than those that have been constructed heretofore.

While in accordance with the patent statutes the improved air circulation system has been described in what at present is considered to be the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is therefore aimed in the appended claims to cover all such equivalent variations as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a fabric dryer, a casing; a cylindrical fabric container mounted in said casing for rotation about a generally horizontal axis; means defining a substantially closed chamber and including an end wall of said container and a stationary wall supported in said casing adjacent said end wall, said stationary wall having an axially disposed opening therein defining an air inlet into said chamber, said end wall having a plurality of outlet openings therein spaced radially outwardly from and extending circumferentially of said axis defining an air outlet from said chamber for entrance of air into said container; and, a fan of the propeller type rotatably mounted in said chamber about said axis, said fan comprising a plurality of radially extending blades, each of said blades including an outer portion extending to the blade tip disposed at an angle to the radial direction wherein said air inlet opening is disposed radially inwardly of said blade outer portions and said air outlet openings are spaced radially outwardly of said blade tips.

2. In a fabric dryer as defined in claim **1** wherein said fan includes a circular rim connected to the blade tips and disposed in close proximity to the stationary wall to prevent recirculation of air in the chamber.

3. In a fabric dryer as defined in claim **2** wherein the fan blades are disposed radially outward of the air inlet, and the air outlet openings are disposed radially outwardly of, but closely adjacent to, the blade tips; and the blades occupy a major portion of the fan area with each fan blade being disposed at an angle between 40° to 60° to a plane normal to said axis.

4. In a fabric dryer as defined in claim **3** wherein the fan blades are disposed radially outward of the air inlet, and the air outlet openings are disposed radially outwardly of, but adjacent to, the blade tips; and the fan

includes a circular rim connected to the blade tips and disposed in close proximity to the stationary wall to prevent recirculation of air in the chamber, with the blades occupying about 60% of the fan area and with each fan blade being disposed at an angle of about 50° to a plane normal to said axis.

5. In a fabric dryer as defined in claim **1** wherein said fan is of the propeller type having its blades disposed at an angle to a plane normal to said axis to provide both centrifugal radial air flow and propeller axial air flow, with centrifugal air flow occurring in the air inlet, and with both centrifugal air flow and propeller air flow occurring in the air discharged from the fan to provide a combination of radial and axial direction to the discharged air to direct the air toward the air outlet passages in the container end wall.

6. In a fabric dryer as defined in claim **5** wherein the fan blades are disposed radially outward of the air inlet, and the air outlet openings are disposed radially outwardly of, but closely adjacent to, the blade tips.

7. In a fabric dryer as defined in claim **5** wherein said fan includes a circular rim connected to the blade tips and disposed in close proximity to the stationary wall to prevent recirculation of air in the chamber.

8. In a fabric dryer as defined in claim **5** wherein the blades occupy about 60% of the fan area.

9. In a fabric dryer as defined in claim **5** wherein each fan blade is disposed at an angle of about 50° to a plane normal to said axis.

10. In a fabric dryer as defined in claim **5** wherein the blades occupy a major portion of the fan area and each fan blade is disposed at an angle between 40° to 60° to a plane normal to said axis.

11. In a fabric dryer as defined in claim **5** wherein the fan blades are disposed radially outward of the air inlet, and the air outlet openings are disposed radially outwardly of, but closely adjacent to, the blade tips; and the blades occupy a major portion of the fan area and each fan blade is disposed at an angle between 40° to 60° to a plane normal to said axis.

12. In a fabric dryer as defined in claim **5** wherein the fan blades are disposed radially outward of the air inlet, and the air outlet openings are disposed radially outwardly of, but closely adjacent to, the blade tips; the fan includes a circular rim connected to the blade tips and disposed in close proximity to the stationary wall to prevent recirculation of air in the chamber; and the blades occupy 60% of the fan axis, with each fan blade being disposed at an angle of about 50° to a plane normal to said axis.

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