

June 13, 1972

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3,669,563

CENTRIFUGAL FAN

Filed Feb. 10, 1971

3 Sheets-Sheet 1

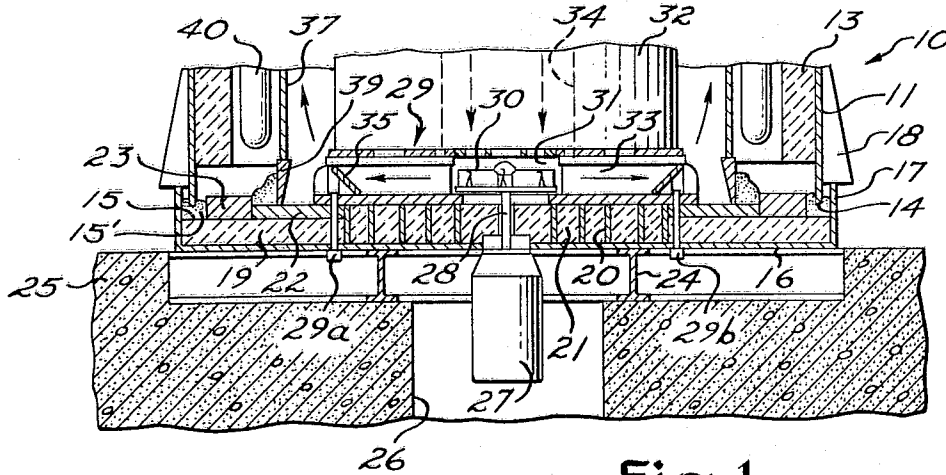


Fig. 1

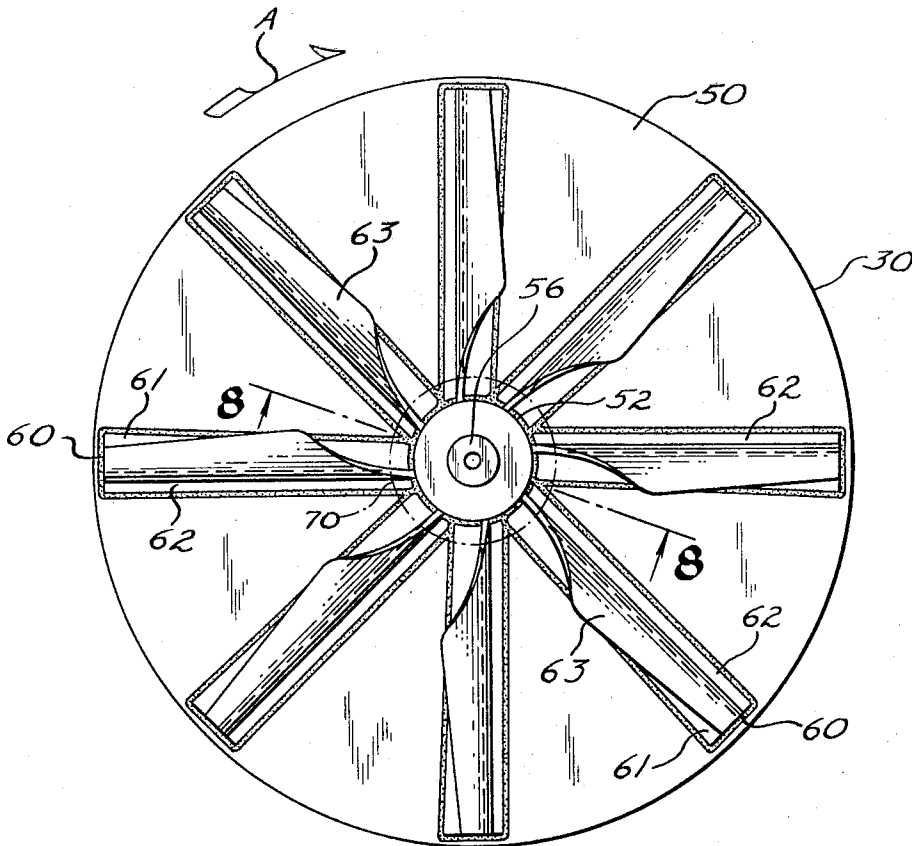


Fig. 2

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3 Sheets-Sheet 2

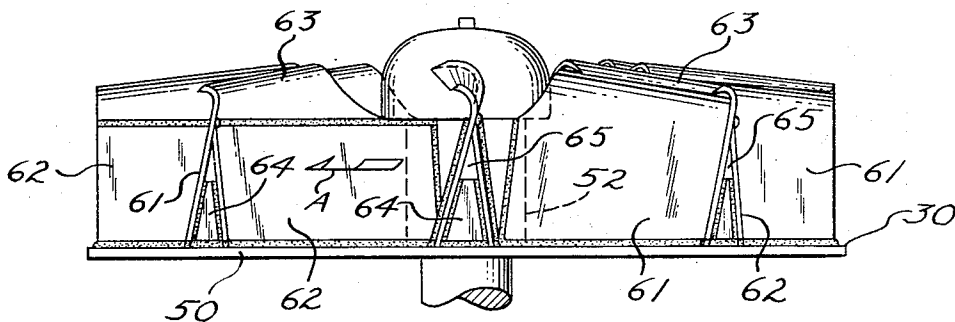


Fig. 3

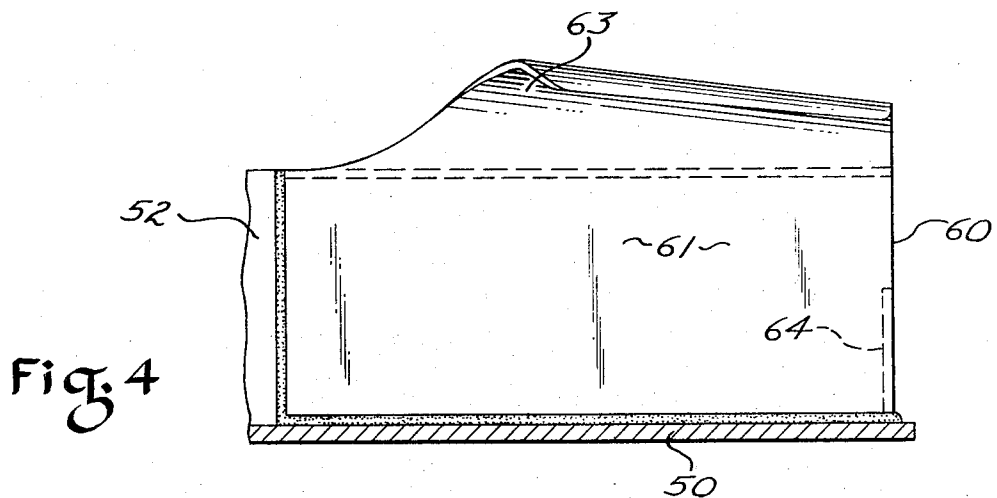


Fig. 4

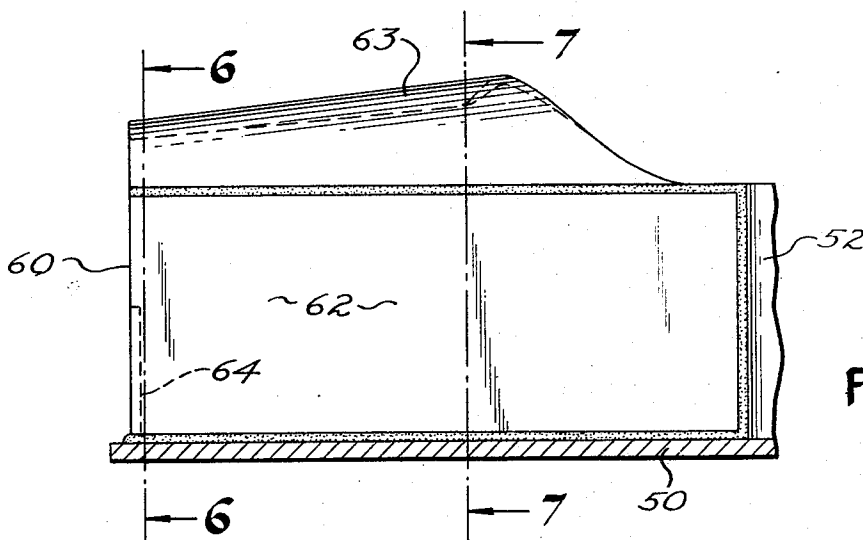


Fig. 5

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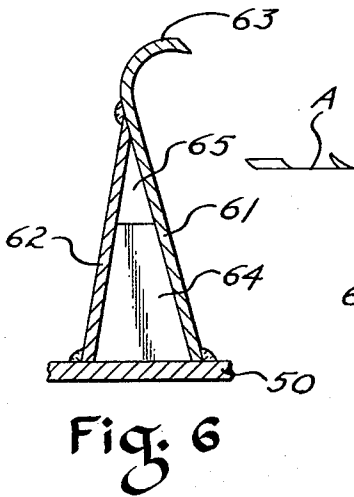


Fig. 6

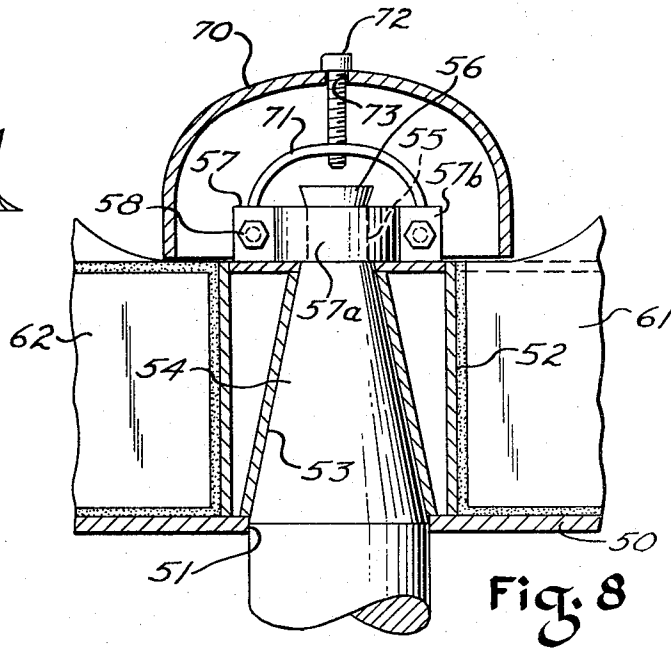


Fig. 8

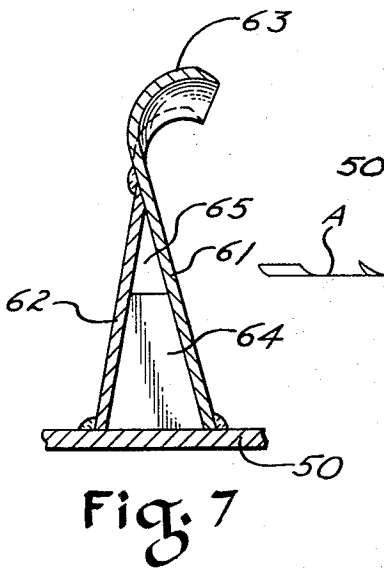


Fig. 7

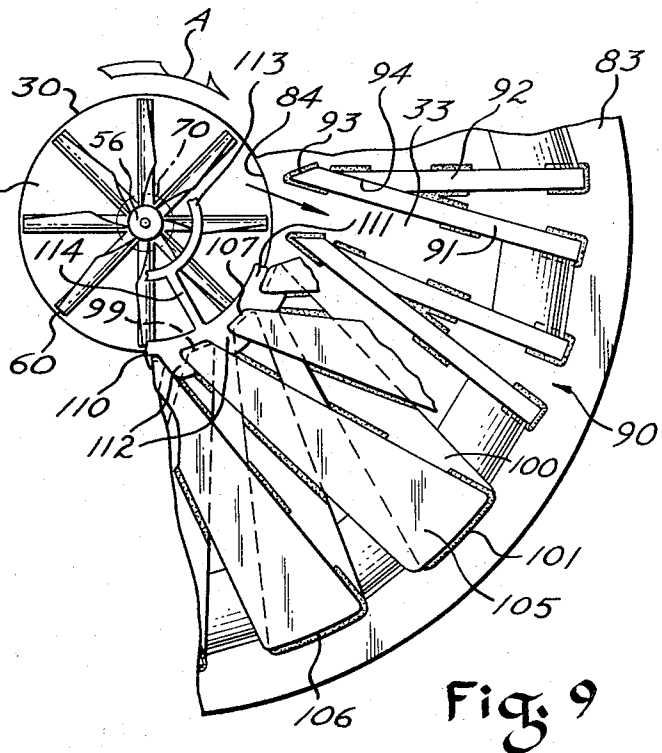


Fig. 9

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3,669,563

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Filed Feb. 10, 1971, Ser. No. 114,150

Int. Cl. F04d 17/08, 29/26, 29/00

U.S. Cl. 415-211

13 Claims

ABSTRACT OF THE DISCLOSURE

There is disclosed herein a centrifugal fan for circulating atmosphere gas in an annealing furnace. A circular base plate carries a plurality of radially disposed, upwardly projecting blades, each blade having a main blade portion providing a leading surface tilted backwardly and an upper edge portion curved forwardly with respect to the direction of rotation of the fan. Each blade is reinforced at its trailing side by a support which tilts forwardly and converges upwardly, the upper edge of the support intersecting and being secured to the main blade portion. The fan is disposed within a central opening of a full-flow load support diffuser having an intake opening equal to the diameter of the fan and substantially unrestricted outlet means.

This invention relates to a centrifugal fan or blower for circulating atmosphere gas for either heating or cooling purposes in an annealing furnace having a load support adapted to support a charge of coils stacked endwise within the furnace.

In a known form of the type of furnace referred to, coils of strip metal are stacked coaxially upon a suitable base structure, and a recirculating centrifugal fan or blower is disposed therebelow. Each coil has a coaxial central opening or eye, and the fan or blower is adapted to circulate a protective atmosphere gas upwardly around the outside of the coils and downwardly through the eyes of the coils whereby said coils are either heated or cooled. Coil separators or convector plates are preferably provided between adjacent coils to provide passage means allowing the gas to circulate between the coils and across the edges of the coil wraps. The stacked coils are preferably closed within a gastight inner cover which is, in turn, disposed within a suitable furnace having radiant tube burners or other suitable heating means for heating the inner cover and the atmosphere gas confined within the inner cover.

The base structure of this type of furnace preferably has a central opening in which the centrifugal fan or blower is disposed in line with the coil openings or eyes. The base structure is also provided with passage means whereby the atmosphere gas is dispersed radially outwardly to flow upwardly along the sides of the coils and inwardly across the ends of the coils where it is ultimately drawn back down into the fan or blower through the openings or eyes in the coils.

A fan or blower used in an annealing furnace is obviously subjected to substantially high temperatures whereby the same may tend to soften and warp in use. To provide sufficient strength for such fans, the blades are commonly mounted on a plate or ring at the bottom and are provided with an additional reinforcing ring or annulus connecting the upper edges of the blades. Also, to prevent overloading of the fan motor at low temperatures, it is the common practice to restrict the opening above the fan and also the outlet means through the base structure. Both the restricted opening and the reinforcing ring at the top of the fan substantially reduce

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the circulation of the atmosphere gas and thereby reduce the heating and cooling effectiveness of the circulating system.

The fan of the present invention is so designed that sufficient strength is provided without the need of a ring or annulus to connect the upper edges of the blades together. Additionally, it has been found that a fan of the present design draws less amperage at lower temperatures, while at the same time circulating a greater volume of air, than fans or blowers of known design. To operate at peak efficiency, the fan of the present invention needs a substantially large inlet preferably equal to the diameter of the fan and a larger, unrestricted outlet means radially outwardly from the fan. In the invention as herein illustrated, these two features are provided by a load support diffuser as set forth in copending application, Ser. No. 114,151, filed Feb. 10, 1971, having a central opening slightly larger than the diameter of the fan and large outwardly directed passage means appropriately angled to receive the outflowing gases. The fan of the present invention also includes a dome-shaped shroud in the center thereof adjacent to the upper edges of the fan blades to facilitate the downward flow of gas into the fan and at the same time protect the central portion of the fan from becoming entangled with one of the coil wraps, as will hereinafter become apparent.

The primary object of this invention is to provide an improved centrifugal fan or blower for circulating atmosphere gas in an annealing furnace in a more efficient manner.

Another object of the invention is to provide a centrifugal fan affording a completely free flow of air into the intake side thereof.

Yet another object of the invention is to provide such a fan having improved means for directing the air into the intake side of said fan.

Yet another object of the invention is to provide a fan as set forth above having an improved blade structure having great strength and resistance to distortion when subjected to extreme pressures and high temperatures.

Yet another object of this invention is to provide a fan as set forth above which can be operated at low temperatures in conjunction with a diffuser means having a full-flow inlet and outlet without overloading the motor.

Other objects and advantages of the invention will be apparent from the following description of one embodiment thereof as disclosed in the accompanying drawings, in which said drawings:

FIG. 1 is a fragmentary longitudinal section through the lower base portion of an annealing furnace containing a stack of strip steel coils disposed upon a load support above the centrifugal fan of this invention;

FIG. 2 is an enlarged top plan view of the fan of this invention;

FIG. 3 is a side elevation of the fan;

FIG. 4 is a still further enlarged elevation of one fan blade as seen from the leading face thereof;

FIG. 5 is a view of the trailing face of the blade of FIG. 4;

FIG. 6 is a vertical section taken substantially along the line 6-6 of FIG. 5;

FIG. 7 is a vertical section taken substantially along the line 7-7 of FIG. 5;

FIG. 8 is a vertical section taken substantially along the line 8-8 of FIG. 2; and

FIG. 9 is a top plan view of the fan and a portion of the load support, the same being somewhat enlarged with respect to FIG. 1 and on a smaller scale than FIG. 2.

Referring now to the drawings in all of which like parts are designated by like reference numerals, FIG. 1 is a

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sectional view showing the lower portion of a hood or bell type furnace 10 comprising a cylindrical body portion 11 and a suitable refractory lining indicated at 13. The cylindrical body portion 11 is preferably formed of heavy sheet metal and has a downwardly projecting, annular flange portion 14 which projects into a granular sealing trough 15 of a generally cup-shaped base 16. The base has an upwardly projecting, annular flange 17 having a slightly larger diameter than the flange portion 14 whereby said flange portion 14 is disposed generally within said annular flange 17. The body portion 11 is supported by radially projecting fins 18 the bottom edges of which seat upon the upper edge of the annular flange 17. The base 16 also includes a suitable refractory bottom lining 19 and a central support structure comprising concentric steel rings 20 having refractory material 21 disposed therebetween. An annular plate 22 surrounds the concentric rings 20, and a larger annulus 23 is disposed outwardly therefrom and forms the inner wall of the granular sealing trough 15. Said trough is filled with a suitable granular sealing material 15', such as sand, into which the flange portion 14 projects.

The base 16, as herein illustrated, is securely mounted upon I-beams 24 which are seated in a concrete floor 25 or other suitable supporting means. A central cavity 26 in the floor 25 affords space for mounting a motor 27 having a shaft 28 which projects upwardly through the central portion of the base 16 and the center of a load support diffuser 29. The upper end of the shaft 28 carries the centrifugal fan or blower of this invention indicated by the numeral 30. An atmosphere gas inlet 29a and an atmosphere gas outlet 29b project upwardly through the base 16 into the load support diffuser 29 at the periphery thereof.

The diffuser 29 supports a plurality of coils 32 of strip sheet metal stacked vertically and coaxially within the body portion 11, only the bottommost of said coils being shown in FIG. 1. It will further be understood that the coils are preferably separated by coil separators or convactor plates (not herein illustrated) as is well known to those familiar with the art. Each coil 32 defines a central opening or eye 34, the eyes of all of the coils being aligned to provide a central opening through the stack of coils.

A cylindrical inner cover 37 is disposed over the stacked coils 32, said inner cover having a lower, annular base portion 39 which seats upon the annular plate 22 outwardly of the gas inlet 29a and gas outlet 29b and is sealed thereto by granular sealing means, such as sand, indicated at 39'. In the form of the invention shown, heating means for the furnace comprise elongated, gas fired radiant tube heaters 40 which are evenly circumferentially spaced around the outside of the inner cover 37 within the refractory lining 13.

The centrifugal fan 30 is disposed within a central opening 31 of the load support diffuser 29. Said diffuser defines outwardly directed passages 33 disposed at the same horizontal level as the fan 30, the outer end portions of said passages having angled deflectors 35 affording outwardly and upwardly angled deflecting surfaces. The fan 30 is disposed coaxially with the coils 32 directly beneath the central eyes 34 whereby atmosphere gas within the furnace 10 is drawn downwardly through the eyes 34 and impelled outwardly through the passages 33 at the ends of which it is deflected upwardly by the deflectors 35 to the outside of the coils 32. Thus the fan is adapted to continually circulate the atmosphere gas downwardly through the middle of the coils and upwardly around their outer surfaces for the purpose of either heating or cooling said coils.

Referring now particularly to FIGS. 2-8, the centrifugal fan 30 comprises a circular base plate 50 having a central aperture 51 therein, a hub 52 being secured to the upper surface of said base plate coaxially with said central aperture. The hub 52 has an upwardly tapering, frustoconical inner bearing surface 53 adapted to seat a frus-

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toconical upper end portion 54 of the motor shaft 28. A cylindrical portion 55 of the shaft 28 projects upwardly above the frustoconical portion 54, and the uppermost end of said shaft is provided with a radially outwardly projecting flange 56. The cylindrical portion 55 above the hub 52 is gripped by a two-piece fan clamp 57 comprising complementary portions each having a semicircular central arch 57a and oppositely directed tabs 57b whereby the arch portions surround and grip the cylindrical portion 55 of the shaft 28 and are secured thereagainst by a pair of nut and bolt assemblies 58. Thus the fan is securely and rigidly held upon the upper end of the motor shaft.

As best seen in FIG. 2, the centrifugal fan 30 is provided with a plurality of fan blades 60 welded or otherwise suitably secured to the upper surface of the circular base plate 50 and radiating outwardly from the central hub 52. Each fan blade 60 is formed by a pair of upwardly converging walls and comprises a main blade portion 61 and an auxiliary, blade support portion 62. The main blade portion 61 is disposed on the front side of the blade and provides a leading surface with respect to rotation of the fan whereas the blade support portion provides substantially the trailing surface of each blade, a portion of the main blade portion projecting thereabove. The arrows A in FIGS. 2, 3, 6, 7, and 9 in each instance represent the forward direction of movement or direction of rotation of the fan blades.

As shown in FIG. 4, each main blade portion 61 is substantially the height of the hub 52 at its inner end where it is welded to said hub. Outwardly from the hub, each main blade portion curves upwardly at its upper distal edge and is provided with a forwardly curved, elongated scoop 63 which tapers downwardly and becomes progressively smaller radially outwardly from said hub. Each main blade portion 61 is welded or otherwise suitably secured along its lower edge to the upper surface of the base plate 50 and tilts backwardly with respect to the direction of rotation of the fan and with respect to the axis of the hub 52 preferably about 10° to 15°. Particularly as shown in FIGS. 6 and 7, it will be noted that the scoop 63 of each main blade portion 61 curves forwardly above the backwardly slanted leading surface of said main blade portion. The result is that the fluid encountered by the blade is lifted up toward the top of the blade and into the concave scoop from which it is expelled radially by centrifugal force.

The blade support portion 62 of each fan blade 60 is welded or otherwise suitably secured along its lower edge to the upper surface of the base plate 50 behind the associated main blade portion 61, said support portion being angled upwardly and forwardly at an angle of approximately 10° to 15°. The blade support portions 62 have smaller vertical dimensions than the main blade portions whereby the upper edges thereof intersect the backs of said main blade portions just below the scoops 63 at which point they are welded or otherwise suitably secured to said main blade portions. As shown, the blade support portions 62 are also welded at their inner ends to the hub 52. The outer ends of each associated pair of main blade and blade support portions are connected to each other by an upwardly tapering end plate 64 welded along its edges to the outer end edges of said main blade portion and said blade support portion. It will be noted that the end plates 64 do not entirely close the ends of the fan blades 50, said end plates extending only partway upwardly thereby affording triangular vents 65 at the outer end of each fan blade. The vents 65 afford means for trapped fluid to escape under conditions of high temperature thereby preventing exploding or buckling of the hollow fan blades due to gas expansion therein.

A central, dome-shaped shroud 70 is disposed over the upper end portion of the shaft 28 completely covering the fan clamp 57. The shroud 70 is supported by an arched bracket 71 secured at its ends between the tabs 57b and curved upwardly over the upper end of the shaft 28. A

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bolt 72 projects downwardly through a central aperture 73 in the shroud 70 and is thread fitted into the center of the arched bracket 71. The shroud 70 is provided for the purpose of preventing the innermost coil wrap of a coil 32, which sometimes tends to drop downwardly towards the fan, from becoming entangled with the rotating fan clamp 57 or like means used to secure the fan upon the motor shaft. The domed shroud also facilitates the flow of atmosphere gas into the fan.

The centrifugal fan of the present invention has been found to be substantially superior to fans of known design for use in annealing furnaces. Conventional centrifugal blowers or fans are commonly provided with annular reinforcing rings connecting the blades at or adjacent to the upper edges thereof. This has heretofore been considered necessary to enable the blades to hold up and retain their shape under the extremely high temperature conditions in which they operate. It is desirable that these fans be made in part at least out of sheet metal, as is the present fan, to maintain lightness of weight; but the tendency of such construction to buckle, warp, and distort under conditions of pressure and heat will be obvious. However, the use of reinforcing rings at the upper edges of the fan blades materially restricts the flow of air at the intake side of the fan and contributes to the general turbulence and instability of the flow of air into and out of the fan. The present construction involving essentially a hollow blade made of sheet metal and properly vented to prevent explosion or collapse is sufficiently strong and durable to make additional reinforcing rings unnecessary.

It has also been found that the fan of the present invention circulates the atmosphere gas at a greater rate than known blowers or fans and is most efficiently used with a full-flow type of diffuser having a virtually unobstructed inlet and outlet means for the flowing gas. As previously mentioned, the inlet and/or outlet areas are conventionally restricted due to a tendency of existing fans to overload the fan motor at low temperatures when such restriction is not used. Experience has shown that the fan of the present invention actually draws less amperage at low temperatures and at the same time delivers more air and can be used with the larger inlet and outlet means.

An example of a preferred type of load support diffuser for use with the fan of the present invention is illustrated in FIG. 1 and shown more in detail in FIG. 9. The load support diffuser 29 comprises a circular metal base plate 83 having a central aperture 84 through which the shaft 28 of the motor 27 projects. The base plate 83 seats upon the upper edges of the annular rings 20 with the outer circumferential edge portion thereof overlapping the annular plate 22. The centrifugal fan 30 is disposed above the level of the base plate 83 and circulates the protective atmosphere gas radially outwardly between circumferentially spaced, V-shaped flow dividers 90 which define the hereinabove referred to passages 33 therebetween. As herein illustrated, the flow dividers 90 are metal members which extend from points adjacent to the outer periphery of the base plate 83 inwardly to points adjacent to the inner periphery defining the central aperture 84 of said base plate. Each flow divider comprises a pair of inwardly converging walls 91 and 92 which, in the form of the invention herein illustrated, are made from heavy, thick bar stock disposed on one side edge thereof and welded to the upper surface of the base plate 83. The wall 91 is relatively longer than the wall 92 and extends inwardly to a point closely adjacent to the edge of the aperture 84, its inwardly directed portion having a short taper or bevel 93 to afford a sharp inner end to the flow divider 90. The arm 92 converges inwardly with the arm 91, intersecting the same adjacent to the bevel 93 and being itself angled or beveled at 94 adjacent to said wall 91 at an angle equal to its angle of convergence. The two walls 91 and 92 are rigidly welded together as well as being welded to the base plate 83.

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The flow dividers 90 are so disposed upon the base plate 83 that their center lines are skewed in the same circumferential direction with respect to true radii of the base plate. The said flow dividers are circumferentially spaced apart whereby to provide therebetween gas flow passages 33 which extend from a point adjacent to the central aperture 84 outwardly to a position adjacent to the outer periphery of the base plate 83. The passages 33 widen slightly in the outward direction, their outer end portions being provided with the outwardly and upwardly angled deflector plates 35. Each deflector plate 35 is preferably disposed at substantially at 45° angle and extends laterally substantially the full width of the passage between two adjacent flow dividers 90. By means of said deflector plates, the atmosphere gas flowing outwardly through the passages 33 is deflected upwardly around the outside of the coils 32. The gas flow passages 33 are angled or skewed with their inner ends being offset in a counterclockwise direction with respect to the outer ends thereof whereby they are adapted to receive outflowing gas impelled by the centrifugal fan 30 which rotates in a clockwise direction.

Each of the flow dividers 90 carries a flat bar 100 of substantially heavy metal stock, said bar tapering inwardly along its side edges and terminating at its inner, smaller end radially inwardly a slight distance beyond the inner ends of said flow dividers. The outermost edge 101 of each said bar is disposed radially outwardly from the outer ends of the flow dividers and radially outwardly beyond the outwardly and upwardly disposed edges of the deflector plates 35. The bars 100 are disposed substantially in alignment with the flow dividers 90 and completely cover the V afforded by the angled walls 91 and 92. Each bar 100 is substantially angled or skewed with respect to a true radius of the base plate 83, all of said bars being skewed the same amount in the same circumferential direction.

A second layer of flat bars 105 is superimposed upon the layer of bars 100. The bars 105 are the same shape as seen in plan view as the bars 100 but are skewed or angled in the opposite circumferential direction whereby each said bar 105 overlaps three of the bars 100. It will be noted that the outermost edges of the bars 105, indicated at 106, are inset slightly in a radial direction with respect to the outermost edges 101 of the bars 100 resulting in the innermost edges 107 of the bars 105 projecting inwardly beyond the corresponding innermost edges 99 of the bars 100. This overlapping effect facilitates the welding of the bars 100 and 105 to each other along edge portions thereof, the bars 100 also being suitably welded to the flow dividers 90.

A fan guard 110 may be carried over the centrifugal fan 30 for protecting the fan from the load carried by the support diffuser 29. Said guard comprises an outer ring 111 having outwardly projecting teeth 112 so shaped and angled that they are adapted to project between the inner ends of the bars 105 and rest upon portions of the bars 100 which they overlap. Thus the guard is supported at a plurality of points above the centrifugal fan 30. Said guard also has a thin inner protective ring 113 integrally connected with the outer ring by means of thin braces 114.

The teeth 112 of the blower guard 110 are not secured to the bars 100 but merely rest thereon whereby said guard can be readily lifted out to facilitate removal, repair, and inspection of the blower. The fan guard 110 is used in those situations wherein the inner wraps or coil tails of the coils 32 might possibly be drawn downwardly into the blower. This will be prevented by the radially disposed braces 114. In the fragmentary showing of FIG. 9, only a portion of the fan guard is shown but it will be readily understood that the rings 111 and 113 are circumferentially complete and are connected by a plurality of the braces 114. Said rings and braces are preferably small in cross section whereby to present only a minimal obstruction to the atmosphere gas flowing into the fan and not substantially disturb the preferred, full-flow conditions

in which the fan of the present invention operates most efficiently. It will be understood that the highly efficient fan of this invention as herein described and illustrated may be used with conventional load supports and diffusing means but the same is best and most efficiently used with one of the type illustrated in detail in FIG. 9 having large inlet and outlet means for the blower.

It will be further understood that many changes in the details of the invention as herein described and illustrated may be made without, however, departing from the spirit thereof or the scope of the appended claims.

I claim:

1. A centrifugal fan comprising a circular metal base plate; a central hub projecting from one side of said base plate; a plurality of circumferentially spaced blades mounted on said one side of said base plate, each blade extending substantially radially with respect to said hub; each blade being hollow and comprising a pair of converging walls projecting from said one side of said base plate whereby said blade is of inverted V-shape in cross section, one of said walls providing at least a substantial part of the leading surface of the blade and the other said wall providing at least a substantial part of the trailing surface of the blade with respect to the intended direction of rotation of said fan; each blade having a blade extension extending upwardly from the line of convergence of said walls and curved forwardly with respect to said direction of rotation of said fan to form a forwardly concave, elongated scoop along the distal edge of each blade; said one wall being tilted rearwardly with respect to said direction of rotation whereby fluid is directed away from said base plate and into said scoop from which the fluid is expelled radially outwardly by centrifugal force.

2. A fan as set forth in claim 1, each said scoop projecting a maximum distance from said base plate at a point adjacent to said hub and angled toward said base plate from said point to the outer end of said blade.

3. A fan as set forth in claim 1, said walls formed of sheet metal welded to said hub and base plate and along said line of convergence of said walls, said one wall comprising a single piece of sheet metal having a lower portion tilted backwardly and a forwardly curved upper portion forming said scoop.

4. A fan as set forth in claim 3, a tapered end plate secured across the outwardly disposed ends of said walls and only partially filling the V-shaped opening formed thereby whereby said blade is vented at the outer end thereof to equalize fluid pressure inside and outside the blade at all temperatures.

5. A fan as set forth in claim 1, said hub and base plate being centrally apertured; said fan mounted upon a drive shaft projecting into said hub; and a dome-shaped shroud disposed centrally over said projecting hub to facilitate the flow of fluid into said fan.

6. A centrifugal fan for circulating atmosphere gas in an annealing furnace, said fan comprising a horizontally disposed circular base plate; a central hub secured to the upper side of said base plate; a plurality of radially disposed fan blades mounted upon said upper side of said base plate; each said blade including a main blade portion comprising a strip of sheet metal secured along a lower edge thereof to said upper surface and at the inner end thereof to said hub, said main blade portion being tilted backwardly with respect to the intended direction of rotation of said fan; said main blade portion being curved forwardly along the upper edge portion thereof to provide a scoop; a blade support comprising a strip of sheet metal secured along a lower edge thereof to said base plate generally parallel with and spaced from the trailing side of each main blade portion and secured at the inner end thereof to said hub, said blade support being tilted forwardly with respect to the direction of rotation of said fan, the upper edge of each support being secured to the trailing side of the associated main blade portion below

said scoop to provide a hollow fan blade of inverted V-shaped form in cross section.

7. A centrifugal fan as set forth in claim 6, an upwardly tapered end plate secured across the outer ends of said main blade portions and said blade support and only partially filling the inverted V-shaped, radially outer open end of each blade whereby said blades are vented to equalize fluid pressure inside and outside of the blades at all temperatures.

8. A centrifugal fan as set forth in claim 6, each said main blade portion being substantially the height of said hub at the inner end thereof, its upper edge tapering in an upward direction radially outwardly of the hub and merging into said scoop, said scoop being angled, in a radially outward direction, toward said base plate whereby the outermost end of each blade is of smaller height than the portions inwardly thereof.

9. A centrifugal fan as set forth in claim 8, said base plate and hub being centrally apertured; a drive shaft projecting upwardly through said base plate and hub; and an upwardly convex, dome-shaped shroud disposed centrally over said hub to facilitate the flow of fluid into said fan and provide a central guard over said hub and shaft.

10. A centrifugal fan as set forth in claim 9: a full-flow load support diffuser for supporting a load to be annealed; said diffuser having a central opening at least as large as the diameter of said fan; said fan disposed within said diffuser and adapted to draw atmosphere gas downwardly into said diffuser and expel said gas radially outwardly whereby said gas will circulate upwardly around the outside of the load; said diffuser having means providing large flow passages extending outwardly from said central opening, the outer ends of said passages having deflector means therein for deflecting the gas upwardly.

11. A centrifugal fan as set forth in claim 6: said main blade portion being tilted backwardly with respect to the direction of rotation of said fan at an angle of substantially 10° to 15° with respect to the vertical.

12. A centrifugal fan as set forth in claim 6: said main blade portion and said blade support of each blade being tilted backwardly and forwardly, respectively, with respect to the direction of rotation of said fan substantially 10° to 15° with respect to the vertical.

13. A centrifugal fan as set forth in claim 6: a full-flow load support diffuser for supporting a load to be annealed; said diffuser having a central opening larger than the diameter of said fan; said fan disposed within said opening of said diffuser and adapted to draw atmosphere gas downwardly into said diffuser and expel said gas radially outwardly whereby said gas will circulate upwardly around the outside of the load; said diffuser having a flat base and circumferentially spaced wall means on said base extending from said central opening outwardly toward the periphery of said base; said wall means defining a plurality of large circumferentially spaced passages extending from said central opening outwardly, said passages being skewed in the same circumferential direction with respect to true radii of said diffuser, the inner ends of said passages being offset in a circumferential direction opposite to the direction of rotation of said fan to facilitate the flow of gas out of said fan.

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U.S. Cl. X.R.

415—213, 217; 416—185, 227