May 14, 1935. T. CHESTER 2,001,522

CENTRIFUGAL BLOWER

Filed May 3, 1932 2 Sheets-Sheet 1

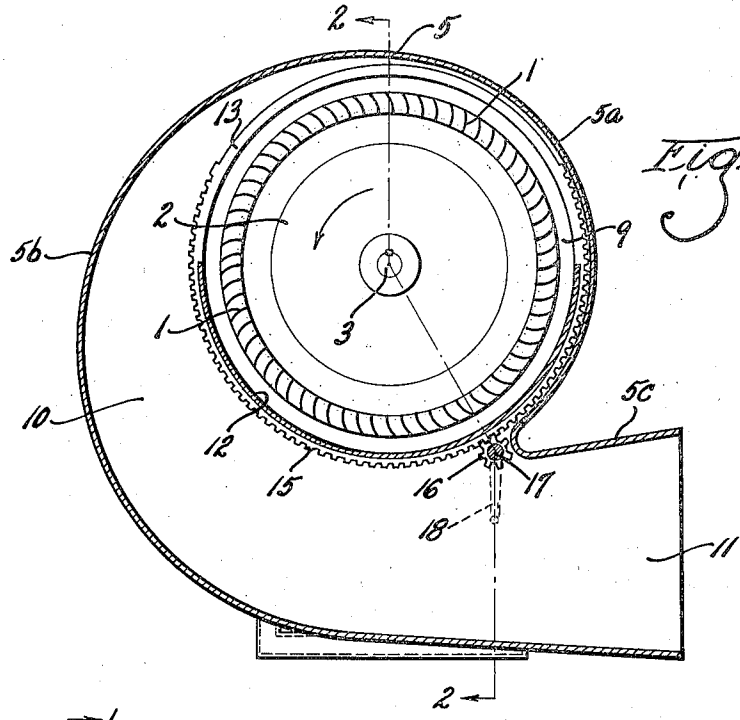


Fig. 1

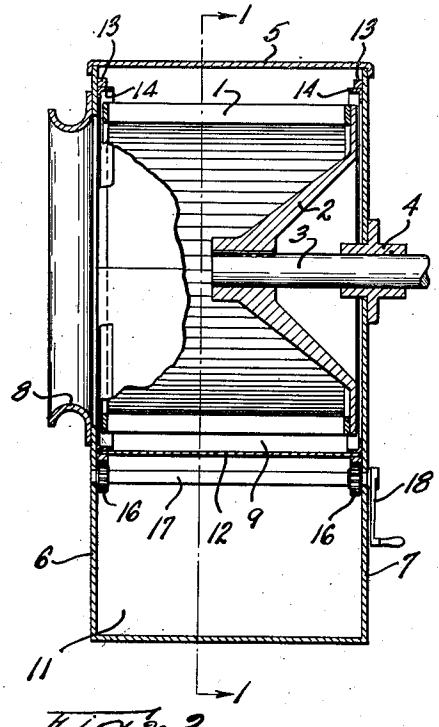


Fig. 2

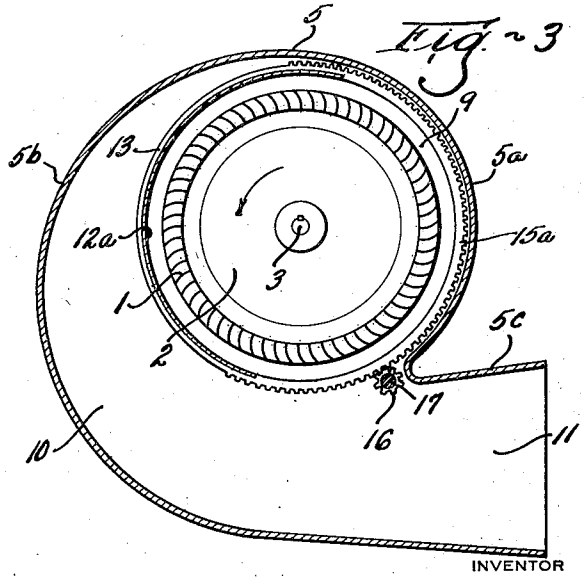


Fig. 3

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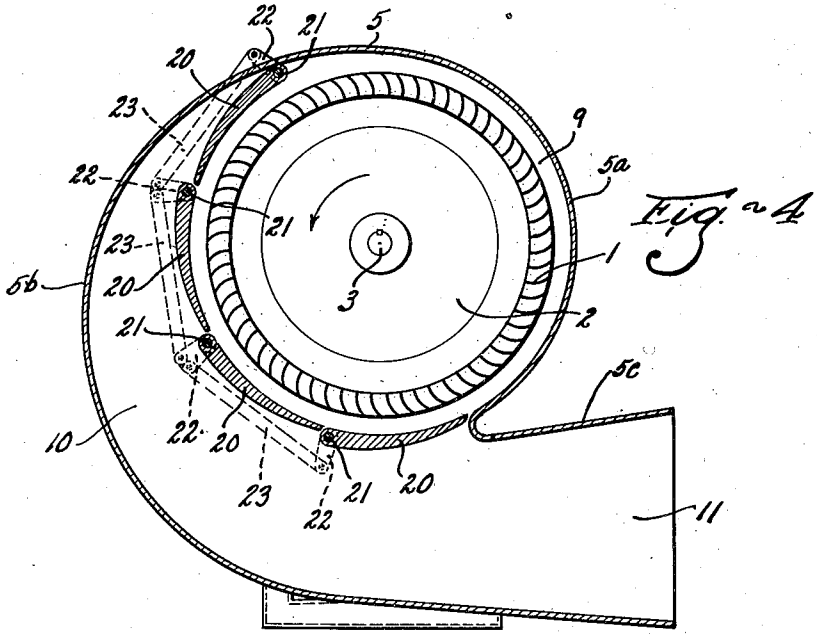


Fig. 4

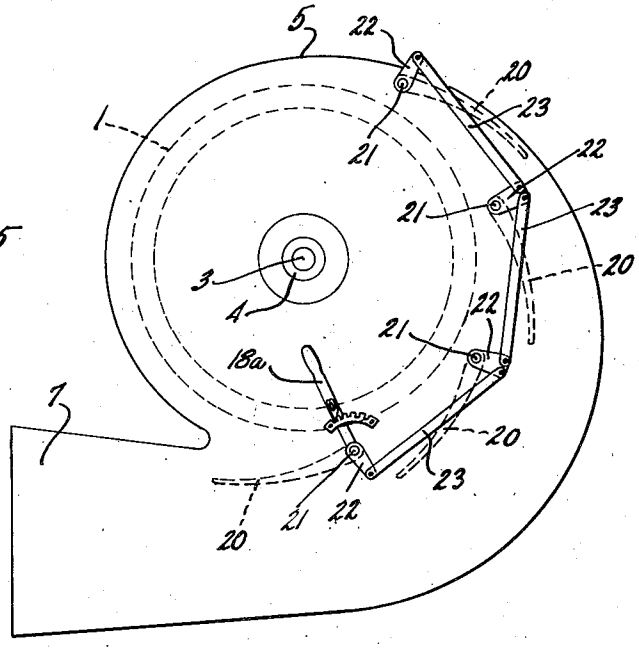


Fig. 5

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CENTRIFUGAL BLOWER

Thomas Chester, Detroit, Mich.

Application May 3, 1932, Serial No. 608,950

14 Claims. (Cl. 230—114)

This invention relates to that class of centrifugal apparatus such as fans, pumps, or, as otherwise hereinafter generally termed, blowers, uses of which are to pump, compress or expand, or otherwise generally to move, fluids which may be gaseous or liquid.

Such a blower usually comprises two principal parts, a rotatably mounted impeller and a stationary casing or housing therefor. The impeller is provided with a plurality of blades concentrically arranged about the axis of impeller rotation, as in a squirrel cage, so that upon rotation of the impeller centrifugal force is caused to act upon fluid between adjacent blades, forcing it out of the impeller in such a way that substantially tangential delivery is effected into the housing spaced about the impeller periphery.

The housing is arranged about the impeller and its function is to take the fluid discharged therefrom and lead all of its component portions to a common mouth, the blower outlet. The housing is, therefore, generally of expanding or spiral form having a wall peripheral of the impeller, in the contemporaneous art starting from a point adjacent the impeller, leading thereabout while receding therefrom, and terminating at the mouth of the housing, which mouth is between the two ends of the spiral wall and thus directed generally tangentially of the impeller.

In the early prior art relating to blowers the best efficiencies were obtained when impeller peripheral widths were small in relation to their diameters over the outer tips of the blades or vanes, thereby permitting the use of large intake openings with lower inlet losses, and at the same time the impeller widths were considerably less than the housing widths. With anything approaching equality between peripheral widths and housing widths, the blade area, that is, the circumferential area of the impeller around the tips of the blades, would be too large in relation to the inlet and outlet areas of the housing. This resulted in excess radial outward flow of fluid at certain portions of an impeller circumference, and inward flow or regurgitation at other portions, although this action was not so identified. It was noted, however, that the power consumption was increased, with corresponding lowering of the mechanical efficiency, and this gave rise to a narrowing of impeller widths for the purpose of reducing the ratio of blade area to housing inlet and outlet areas.

It will be evident that in the case of an impeller rotating within a considerably wider housing the fluid which is discharged from the impeller periphery is forced between what may be considered side currents or flanking streams moving at a different velocity. The flanking streams tend to flow to the housing outlet in paths determined by the scroll or housing spiral, so that at any point their direction of movement tends to be parallel momentarily to a tangent to the impeller circumference at its nearest point. But the fluid which leaves the impeller at a high velocity is outwardly inclined at a considerable angle to a tangent to the impeller circumference at the point of departure. In this way there is confliction due to dissimilar velocities and directions of the fluid freshly discharged from the impeller and the flanking streams previously discharged. The molecular collisions and eddying thereby produced, absorb energy and reduce mechanical efficiency.

According to this invention, the side walls of the housing may closely overlie the impeller so that this eddying is reduced.

It will be apparent that where the housing peripheral wall most closely approaches the impeller, a throat is formed whose purpose is to provide a cut-off on one side of which the fluid leaving the impeller passes directly into the mouth of the housing, the outlet of the blower, and on the other side of which the fluid leaving the impeller passes through the entire spiral, changing its direction of flow almost 360° before reaching the mouth.

By this arrangement, the fluid which has been discharged by the impeller and is in motion within the housing thereabout has a path which is at best eccentric to the impeller.

Also, as the resistance to the flow of fluid from the blower outlet is increased, simultaneous increase in turbulence occurs in the vicinity of the cut-off of the blower. With ordinary blowers operated under such increased outlet resistance conditions, the fluid which is rotating within the housing externally of the impeller can only partially escape through the blower outlet. The remainder of the fluid which is unable to escape through the outlet on account of increased resistance to flow strikes the cut-off and rebounds in various directions and this causes churning or turbulence. Under high outlet resistance conditions a large amount of the fluid which is rotating externally of the impeller rebounds from the cut-off and is forced to reenter the impeller in a radially inward direction. This reentry of fluid results in lower efficiency, since additional power has to be expended in again throwing off the fluid centrifugally from the impeller. This

radially inward reentry of fluid to the impeller is known as regurgitation and while it occurs markedly in the vicinity of the cut-off it also occurs between each pair of adjacent blades of a blower impeller at other points in the circumference of the impeller than in the vicinity of the cut-off. Wherever such regurgitation occurs it causes efficiency losses through the production of power consuming eddies.

Performance characteristics of such blowers show that they have efficiency peaks dependent upon outlet resistance conditions, that is, the efficiency falls rapidly as the pressure head against which the blower operates is increased beyond or decreased below a certain amount relative to a certain peripheral speed. The variation in efficiency can be partly attributed to the prevailing amount of regurgitation at any particular head against which the blower must operate.

In addition to requiring expenditure of power more than once to deliver any particular portion of fluid from the impeller, regurgitation interferes with ideal stream-line action or uniformity of flow through the blower. Uniform flow is essential if high efficiency is to be attained; otherwise there will be considerable loss of energy in fluid friction.

Where there is little resistance against which the blower is operating, the falling off in mechanical efficiency cannot be entirely attributed to regurgitation. But I have perceived that this particular reduction in efficiency can be ascribed to the necessity of causing the fluid moving at high velocity to depart from travelling in a straight line as it endeavors to travel because of its inertia. Each portion of fluid leaving the impeller tends to continue in motion in its discharged direction. The impeller is discharging through its periphery, but the spiral of the housing must greatly change the direction of most of this discharged fluid. The amount of change is the greater as the point of discharge is removed in an arcuate direction towards the shallow end of the involute from the housing mouth, reaching a maximum of almost 360° at the cut-off. It follows, therefore, that the most efficient action is where the direction needs least to be changed. At points most removed backward from the mouth the change of direction need be so great that the efficiency is much reduced.

When the volumetric capacity of a blower is regulated by the usual operation of a valve or damper, any reduction of volume is effected by choking the flow of fluid. As with that method the impeller still has the same active circumferential area, its capacity is in excess of the area available for flow of fluid at the point of valve or damper restriction. In consequence of this, the described regurgitation and churning occur, and energy is wasted. When the volumetric capacity is reduced by a corresponding reduction of exposed impeller circumferential area, by the method disclosed by this invention, only the required amount of fluid is thrown off by the impeller, and regurgitation and churning are thereby prevented, and in this way a higher mechanical efficiency is obtained.

The zone of re-entry of fluid known as regurgitation, then, is very pronounced in the vicinity of the cut-off. The regurgitation is largely due to eccentricity of the housing in relation to the impeller, and the regurgitation increases with restricted flow conditions either on the discharge or on the inlet side of the blower.

An impeller having shallow-curved forwardly inclined blades produces a relatively great total pressure, and this is due to the fact that the fluid is ejected from the impeller with a forward motion much in excess of the forward motion of the impeller circumference.

Because of this enhanced delivery it is possible to deal with the amount of fluid which can enter through the inlet in efficient relation with the impeller circumferential velocity, with less than the entire circumference of the impeller discharging fluid, when shallow-curved forwardly inclined blades are used.

This permits of portional arcuate delivery of fluid from the impeller circumference, with the remaining arcuate portion inactive. The inactive arcuate portion can therefore be used as a sheath for a withdrawable concentric mask, which can be adjusted to cover or blank off a suitable amount of the normally active arcuate portion of the impeller, when reduced volumetric capacity is required.

In this way the relative arcuate portions of concentric and spiral housing can be adjusted as required, so that any required delivery of fluid between zero and full capacity can be obtained without regurgitation.

The general objects of this invention are to produce a blower of improved efficiency, by an arrangement based upon the above considerations.

According to this invention and as an object thereof I provide that the effective eccentricity or eccentric portion of the housing may be of a minimum necessary arcuate extent, such extent being adjustable according to the operating conditions imposed upon the blower. Thus though the impeller be operating when there is no demand upon the blower, there being no need for any eccentricity, I arrange for a disposition of the parts by adjustment to one wherein the impeller is entirely surrounded peripherally by an annular vortex chamber; when the demand upon the blower is maximum a maximum eccentricity may be provided by adjustment; and under intermediate conditions intermediate adjustments may be had.

More particularly, and as further objects of this invention, therefore, I provide that the impeller housing have a concentric or substantially concentric part with an arcuate peripheral wall substantially spaced from the impeller to provide an arcuate vortex chamber concentric or substantially concentric therewith, said housing having, for its remaining peripheral portion, a volute collector part with a peripheral wall receding radially from the impeller. The purpose of the vortex chamber is to avoid the production of shock, waste of energy, vibration, and consequent noise at the cut-off as the blades pass this point. Mask means are provided and arranged for adjustment to a closed position wherein the mask means comprises substantially a continuation of the concentric housing wall, so that the impeller is entirely surrounded peripherally by an annular vortex chamber. The mask means is arranged for adjustment from this closed position to other positions wherein are uncovered parts of the impeller periphery in varying arcuate amounts up to the maximum.

Another object of the invention is to combine a mask arrangement, wherein the described vortex chamber may be had, with an impeller having shallow curved forwardly inclined blades having

their concavities in the direction of impeller rotation, whereby the utmost efficiency will result, throughout the operating range of the blower.

Further objects are to provide improved mask means for the purpose described.

The exact nature of this invention together with further objects and advantages thereof will be apparent from the following description taken in connection with the accompanying drawings, in which Figs. 1 and 2 are sectional elevations of an embodiment of my invention in a blower, the plane of Fig. 1 being indicated by line 1—1, Fig. 2, and that of Fig. 2 being indicated by line 2—2, Fig. 1; Fig. 3 is a view illustrating a modification of the invention, and otherwise similar to Fig. 1; Figs. 4 and 5 are elevation views from opposite directions illustrating another modification, Fig. 4 being in section to show details of construction.

With reference now to the drawings and particularly to Figs. 1 and 2 thereof, the impeller of the blower illustrated comprises a plurality of blades 1 arranged as in a squirrel cage, carried by a member 2 secured upon a drive shaft 3 which in turn is mounted for rotation in suitable bearings as indicated at 4. The blades 1 are spaced about and longitudinally extending with respect to the impeller axis, that of the shaft 3. The shaft 3 and consequently the impeller as a unit, is to be driven counterclockwise Fig. 1; and it will be noted that the blades shown are shallow curved ones, forwardly inclined and having their concavities in the direction of impeller rotation.

The housing for the impeller comprises a peripheral wall 5 extending thereabout as indicated Fig. 1, and between a pair of end walls 6 and 7. The end wall 7 is substantially continuous while the end wall 6 has a circular inlet opening, which may be flanged as at 8 and of diameter corresponding with the inside diameter of the impeller. Preferably the end walls are located closely adjacent the impeller to provide a minimum running clearance therefrom, as shown in Fig. 2.

The peripheral wall 5 has a part 5*a* concentric with the impeller but substantially spaced therefrom to provide an arcuate vortex chamber 9 of substantial length. The wall 5 also includes a part 5*b* extending from the part 5*a* eccentrically or spirally of the impeller to provide a volute collector chamber 10. A third part 5*c* completes the wall 5 to provide an outlet 11 leading from the chamber 10.

The relative amounts of the impeller circumference over which the wall parts 5*a* and 5*b* extend are not confined to the particular proportion shown by the drawings, but may be of different arcuate extent dependent upon the circumstances, as will appear.

Within the housing wall 5 but substantially spaced from the impeller is a cylindrical mask 12 extending concentrically about the impeller through a substantial circumferential part of the latter, and laterally extending between the end walls 6 and 7 of the housing. This mask 12 is mounted for adjustment about the impeller axis and for the purpose is immediately carried by a pair of rings 13 between which it extends. Each of the rings 13 bears in suitable circular ways provided by bracket means 14 on the end walls of the housing. The rings 13 are toothed as at 15 to be engaged by pinions 16 on an adjusting shaft 17, which shaft extends through one of the housing walls and carries an actuating handle 18. Obviously the arrangement is such that manipulation of the handle 18 will control the position of the mask 12 about the impeller.

The arcuate lengths of the mask and of the concentric housing wall 5*a* are shown approximately equal, that the mask may be withdrawn from the volute chamber 10 to underlie the housing wall 5*a*; so that the lengths shown are substantially 180 degrees and the mask at the other end of its range of adjustment substantially blocks off the volute chamber 10 from the impeller. The gear teeth 15 are properly related with the mask 12 to provide such range of adjustment.

The parts are shown in an intermediate position of the mask. It will be apparent that when the mask is so positioned delivery will be had from the impeller into the volute chamber 10 only through that relatively small part of the impeller circumference uncovered, that is, that part from the joinder of the housing wall parts 5*a* and 5*b*, to that longitudinal edge of the mask underlying the wall part 5*b*. When the mask is fully withdrawn to substantially underlie the concentric part of the housing, maximum delivery will be had from the impeller. When the mask is at its opposite limit of adjustment there will be substantially no delivery into the volute chamber and the impeller will simply operate within the vortex chamber 9 which in effect will now entirely surround the impeller periphery.

Thus by manipulation of the handle 18 the mask 12 may be adjusted to vary the exposed circumferential area of the impeller in accordance with the fluid volumetric capacity required of the blower.

It will be noted that the parts are arranged for adjustment of the mask from open toward closed position in the direction contrary to that of the impeller motion, so that when the mask is in intermediate positions flow into the volute chamber 10 will be at the small end of the latter.

The arrangement of Fig. 3 is similar to that of Fig. 1 except that the relation between the mask 12*a* and its controlling gear teeth 15*a* is such that the mask will move from open toward closed position in the direction of impeller rotation, so that when the mask is in intermediate positions flow into the volute chamber 10 will be at the large end of the latter—that end nearest the outlet 11.

With reference now to Figs. 4 and 5, the general arrangement of the principal parts is similar to that already described, with the exception of the mask means. Here a plurality of curved vanes 20 are arranged to complete the annular volute chamber 9 about the impeller as indicated Fig. 4. Each vane is pivotally mounted at one end upon a shaft 21, that its opposite end may swing from the impeller as indicated Fig. 5.

Suitable means are provided for controlling the positioning of the vanes, that they may be opened or closed.

Each shaft 21 bears a lever 22, and these levers 22 are interconnected by links 23 whereby all the vanes will be similarly positioned with respect to the impeller and will open and close together. One of the shafts 21 bears a lever 18*a* by manipulation of which the vanes may be adjusted. As shown the described link work interconnecting the vanes is located outside the housing.

Obviously, by omission of the links 23 each vane 20 might be arranged for independent adjustment by its lever 22.

What I claim is:

1. In a blower of the class described and having a rotatable impeller with radially-shallow curved forwardly-inclined blades having their cavities in the direction of impeller rotation and

a housing therefor having side walls closely adjacent the ends of the impeller and a peripheral wall about the impeller, said peripheral wall including a cylindrical part concentric of the impeller and radially spaced therefrom, and said housing having a volute collector part leading to a discharge mouth, cylindrical mask means disposed in said housing to be cooperative with said cylindrical housing wall part to provide an annular vortex chamber of substantial radial dimension about said impeller, said mask means having port means and being arranged for adjustment thereof to control flow from said vortex chamber to said volute collector part of the housing.

2. In a blower of the class described and having a rotatable impeller with radially-shallow curved forwardly-inclined blades having their cavities in the direction of impeller rotation and a housing therefor having side walls closely adjacent the ends of the impeller and a peripheral wall about the impeller, said peripheral wall including a cylindrical part concentric of the impeller and radially spaced therefrom, and said housing having a volute collector part leading to a discharge mouth, cylindrical mask means disposed in said housing to be cooperative with said cylindrical housing wall part to provide an annular vortex chamber of substantial radial dimension about said impeller, said mask means having port means and being arranged for adjustment of the position of the port opening lengthwise of said volute housing collector part to control flow from said vortex chamber to said housing discharge mouth.

3. In a blower of the class described and having a rotatable impeller with radially-shallow curved forwardly-inclined blades having their cavities in the direction of impeller rotation and a housing therefor having side walls closely adjacent the ends of the impeller and a peripheral wall about the impeller, said peripheral wall including a cylindrical part concentric of the impeller and radially spaced therefrom, and said housing having a volute collector part leading to a discharge mouth, cylindrical mask means disposed in said housing to be cooperative with said cylindrical housing wall part to provide an annular vortex chamber of substantial radial dimension about said impeller, said mask means having port means and being arranged for adjustment about the impeller axis for adjusted disposition of said port means relative to said cylindrical part of said peripheral housing wall to provide controlled flow from said vortex chamber to said volute housing collector part adjacent the larger end of the latter.

4. In a blower of the class described and having a rotatable impeller with radially-shallow curved forwardly-inclined blades having their cavities in the direction of impeller rotation and a housing therefor having side walls closely adjacent the ends of the impeller and a peripheral wall about the impeller, said peripheral wall including a cylindrical part concentric of the impeller and radially spaced therefrom, and said housing having a volute collector part leading to a discharge mouth, cylindrical mask means disposed in said housing to be cooperative with said cylindrical housing wall part to provide an annular vortex chamber of substantial radial dimension about said impeller, said mask means having port means and being arranged for adjustment about the impeller axis for adjusted disposition of said port means adjacent the larger end of said volute housing collector part, as a valve to control flow from said vortex chamber.

5. In a blower of the class described, a rotatable impeller, a housing for said impeller having a substantially concentric part with a peripheral wall substantially spaced from the impeller to provide a vortex chamber of substantial radial dimension disposed peripherically about said impeller, and a volute collector part with a peripheral wall receding radially from the impeller, and terminating in a mouth, providing a discharge collecting passageway extending peripherally from said chamber to said mouth, and mask means comprising a plurality of louvers arranged in said passage in continuation of the peripheral wall of said concentric housing part to provide a radially deep vortex chamber of substantial volume extending entirely about the periphery of said impeller, said louvers being mounted for adjustment from said impeller to positions along paths of flow through said passage.

6. In a blower of the class described, a rotatable impeller, a housing for said impeller having a substantially concentric part with a peripheral wall substantially spaced from the impeller to provide a vortex chamber of substantial radial dimension disposed peripherally about said impeller, and a volute collector part with a peripheral wall receding radially from the impeller, and terminating in a mouth, providing a discharge collecting passageway extending peripherally from said chamber to said mouth, and mask means comprising a plurality of louvers arranged in said passage in continuation of the peripheral wall of said concentric housing part to provide a radially deep vortex chamber of substantial volume extending entirely about the periphery of said impeller, said louvers being mounted to swing about their rearward edges whereby their forward edges may be moved from said impeller.

7. In a blower of the class described, a rotatable impeller, a housing for said impeller having a substantially concentric part with a peripheral wall substantially spaced from the impeller to provide a vortex chamber of substantial radial dimension disposed peripherally about said impeller, and a volute collector part with a peripheral wall receding radially from the impeller, and terminating in a mouth, providing a discharge collecting passageway extending peripherally from said chamber to said mouth, mask means comprising a plurality of louvers arranged in said passage in continuation of the peripheral wall of said concentric housing part to provide in conjunction therewith an annular vortex chamber of substantial radial depth extending entirely about the periphery of said impeller, said louvers being mounted to swing about their rearward edges whereby their forward edges may be moved from said impeller, and gear means interassociating said louvers to open and close the same in predetermined sequence.

8. In a blower of the class described, a rotatable impeller with shallow, curved, forwardly inclined blades having their concavities in the direction of impeller rotation, a housing for said impeller having a substantially concentric part with a peripheral wall substantially spaced from the impeller to provide a vortex chamber of substantially radial dimension disposed peripherally about said impeller, and a volute collector part with a peripheral wall receding radially from the impeller, and terminating in a mouth, provid-

ing a discharge collecting passageway extending peripherally from said chamber to said mouth, and mask means comprising a plurality of louvers arranged in said passage in continuation of the peripheral wall of said concentric housing part to provide an annular vortex chamber of substantial radial depth extending entirely about the periphery of said impeller, said lovers being mounted for adjustment from said impeller to positions along paths of flow through said passage.

9. In a blower of the class described, a rotatable impeller, a housing for said impeller having a substantially concentric part with a peripheral wall substantially spaced from the impeller to provide a vortex chamber of substantial radial dimension disposed peripherally about said impeller, and a volute collector part with a peripheral wall receding radially from the impeller, and terminating in a mouth, providing a discharge collecting passageway extending peripherally from said chamber to said mouth, and mask means comprising a plurality of louvers arranged in said passage in continuation of the peripheral wall of said concentric housing part to provide a radially deep vortex chamber of substantial volume extending entirely about the periphery of said impeller, said louvers being mounted for adjustment from said impeller to positions along paths of flow through said passage, each louver being of ichthyoidal form in section and being mounted adjacent its large end to move thereabout, said large end being directed against the stream of flow.

10. In a blower of the class described, a rotatable impeller, a housing for said impeller having a substantially concentric part with a peripheral wall substantially spaced from the impeller to provide a vortex chamber of substantial radial dimension disposed peripherally about said impeller, and a volute collector part with a peripheral wall receding radially from the impeller, and terminating in a mouth, providing a discharge collecting passageway extending peripherally from said chamber to said mouth, and mask means comprising a plurality of louvers arranged in said passage in continuation of the peripheral wall of said concentric housing part to provide a radially deep vortex chamber of substantial volume extending entirely about the periphery of said impeller, said louvers being mounted for adjustment from said impeller to positions along paths of flow through said passage, each louver being of ichthyoidal form in section and being mounted adjacent its large end to move thereabout, said large end being directed against the stream of flow, and said louvers having such curvature that in closed position they will present a substantially cylindrical peripheral vortex chamber wall whereas in open positions they will gradually change the direction of flow there past.

11. In a blower of the class described, a rotatable impeller, a housing for said impeller having a peripheral wall substantially spaced from the impeller, and mask means comprising a plurality of louvers arranged to provide a vortex chamber of substantial radial depth extending entirely about the periphery of said impeller, said louvers being mounted for adjustment from said impeller to positions along paths of flow therefrom, each louver being of ichthyoidal form in section and being mounted adjacent its large end to move thereabout, said large end being directed against the stream of flow.

12. In a blower of the class described, a rotatable impeller, a housing for said impeller having a peripheral wall substantially spaced therefrom, and mask means comprising a plurality of louvers arranged between said impeller and said wall to provide a vortex chamber of substantial volume extending about the periphery of said impeller, and a collector chamber between said louvers and said wall, each louver having such curvature and being so disposed that fluid emerging from between a pair of adjacent louvers will have direction substantially parallel to that of the adjacent fluid in said collector chamber.

13. In a blower of the class described, a rotatable impeller, a housing for said impeller having a peripheral wall substantially spaced therefrom, and mask means comprising a plurality of louvers arranged to provide a vortex chamber of substantial volume extending about the periphery of said impeller, each louver being of ichthyoidal form in section and being mounted with its large end directed against the stream of flow and having curvature therefrom in the direction of impeller rotation.

14. In a blower of the class described and having a rotatable impeller with radially-shallow curved forwardly-inclined blades having their cavities in the direction of impeller rotation and a housing therefor having a volute collector part leading to a discharge mouth, cylindrical mask means disposed in said housing to provide an annular vortex chamber of substantial radial dimension about said impeller, said mask means having port means and being arranged for adjustment thereof to control flow from said vortex chamber to said volute collector part of the housing.

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