This invention relates to a blower unit, and particularly to a blower of the transverse or tangential flow type. Blowers which utilize a blower wheel and a cooperating housing to draw air radially between the blades on one side of the blower wheel and force this air outwardly therefrom between the blades at some other point in the blower wheel are termed cross-flow, transverse or tangential blowers, and for the purposes of the description herein, these blowers will be designated as tangential blowers. One important feature of the tangential blower is the capability of being lengthened to substantially any length to obtain a proportional increase in the total output without increasing the speed of rotation or diameter of the blower wheel. This enables use of the blower in heating or cooling units having long thin cabinets, and particularly in air conditioning cabinets having elongated and parallel inlet and outlet openings in the front, top or bottom thereof.

Most of these tangential blowers, especially those of simplified construction capable of mass production, have an unstable region in their performance curves so that when they are operated in systems which have a relatively high resistance to flow, the air output varies between two extremes for no apparent reason. Thus an undesirable ‘puffing’ occurs when the blower is operated in this unstable region, and the effect thereof is to make such a tangential blower unsuitable for use with these particular systems. In addition, many of these tangential blowers have an area adjacent the opposite ends of the housing and blower wheel wherein the air flow is quite low and unstable, and in some instances a below-atmospheric pressure may be created which causes reverse flow. This undesirable feature necessarily reduces output or requires that the blower wheel be rotated at higher speeds in order to achieve a higher output, and such an increase in speed requires additional power and may create noise above tolerable levels. The ultimate result is a substantial limitation in the applications and use of these tangential blowers.

Accordingly, an important object of this invention is to provide an improved blower of the aforesaid type capable to being mass produced at low cost and having a performance curve free of unstable region so that the blower can be used in air conditioning systems having relative high resistance to air flow.

Another important object of this invention is to provide an improved blower assembly of a tangential flow type which has uniform output flow across the entire outlet duct including the space immediately adjacent the end walls, thus creating a blower assembly of increased output for its size and speed of rotation.

Another object of this invention is to provide a blower assembly of the aforesaid type which is simple in design and can be mass produced from conventional sheet metal and/or plastics at comparatively low cost, and further to provide such a blower assembly which generates a higher total static pressure than a comparable simplified tangential blower assembly and as a result permits operation at a lower speed and reduced noise levels.

A further object of this invention is to provide a blower assembly of the aforesaid type having the drive motor mounted partially within one end of the blower wheel for cooling of the motor and increased compactness of the assembly, and particularly to provide a blower wheel and housing combination which utilizes the principles of both centrifugal and tangential blower wheels.

Other objects and advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

In the drawings—

FIG. 1 is a perspective view of a tangential blower in accordance with the invention;

FIG. 2 is a front elevation view, partially broken away, of the tangential blower shown in FIG. 1;

FIG. 3 is a perspective view showing the apparatus for mounting the drive motor on the end wall of the blower housing;

FIG. 4 is a sectional view taken essentially along the line 4—4 of FIG. 2;

FIG. 5 is a sectional view similar to FIG. 4 taken along the line 5—5 of FIG. 2;

FIG. 6 is an enlarged fragmentary view showing the lower edge of the inlet opening to the tangential blower wheel;

FIG. 7 is an enlarged sectional view of one of the blades of the tangential blower wheel;

FIG. 8 is a sectional view similar to FIG. 7 illustrating one of the blades of the centrifugal blower wheels;

FIG. 9 is a side view of another embodiment of the invention;

FIG. 10 is a fragmentary sectional view taken along the line 10—10 of FIG. 9;

FIG. 11 is a graphical illustration of the performance of a tangential blower constructed in accordance with the invention; and

FIG. 12 is a graphical illustration comparing the output of the invention with that of the prior art.

This invention contemplates a tangential blower of improved performance including a tangential blower wheel which is mounted for rotation at high speed in a volute shaped housing having a radial inlet opening which is coextensive with the blower wheel. Auxiliary air flow generating apparatus is used to create a positive flow of air along the end walls of the housing and its outlet duct so that the flow produced by the tangential blower wheel has no frictional contact with the side walls. The result is a blower having all the size and configuration advantages of a tangential blower with substantially increased output of the blower which is uniform across the entire outlet duct and has a performance curve which is stable throughout its effective range.

Referring to the drawing wherein preferred embodiments of the invention are shown, FIG. 1 illustrates the tangential blower unit 10 including the housing 11 having the elongated composite blower wheel or rotor 12 mounted for rotation therein and driven by the motors 14. The housing 11 includes a back wall 15 which is volute shaped and extends from the rolled upper edge 16, substantially directly above the axis of the rotor 12, to the point 18 (FIG. 4) where the volute or spiral curve terminates in the integral lower wall 20 of the outlet duct 21. The inner surface of back wall 15 follows a curve which is an approximation of a logarithmic spiral, and the space between the inner surface of the back wall 15 and the outer periphery of the rotor 12 defines a curved diffusion cone 22 of gradually increasing size. This diffusion cone extends through the high pressure outlet duct 21, and provides efficient conversion of velocity pressure to static pressure.

The ends of the housing 20 are closed by flat end walls 24 which, for purposes of description, are divided into
the spiral portions 26 and the outlet duct portions 27. The spiral portions 26 form the ends of the diffusion cone 22 partially surrounding the blower wheel 12, and the outlet portions 27 also define the axial ends of the cone 22, as well as the side walls of the outlet duct 21. The back wall 15 and the end walls 24 may be secured together by any conventional fluid tight expedient, for example, by deforming the edges of the back wall 15 over into contact with the end walls 24 as shown, and then brazing or spot welding these members together.

The flat top wall 30 forms the upper boundary of the outlet duct 21 and extends between substantially fluid tight and rigid connections with the upper edges of the outlet portions 27 and the walls 24. The rear edge 31 of the top wall 30 is closely spaced from the outer periphery of the blower wheel 12, and this edge is rolled, as shown in FIG. 6, for strength and noise reduction. The front edge 33 of the wall 30 forms the upper periphery of the outlet opening from the duct 21.

The housing 11 has an elongated rectangular low pressure inlet opening 35 defined between the rolled edges 16 and 31 of the top and back walls 15 and 30, and the innermost edges 37 of the shrouds 38 which extend in an axial direction inwardly from the spiral portions 26 of the end walls 24, as seen in FIGS. 1, 2 and 3. The shrouds 38 are preferably formed integrally with the back wall 15 and are connected to the top wall 30 in alignment with the edge 31 thereof so that the housing entirely surrounds each end of the blower wheel 12, as shown in FIG. 5. The circular inlet openings 40 are also provided centrally in the spiral portion 26 of the end walls 24 for the axial flow of air therethrough into the ends of the blower wheel 12. As indicated above, the rectangular outlet duct 21 is defined by the top and bottom walls 20 and 30 and the outlet duct portions 27 of the end walls 24.

The elongated rotor 12 includes a centrally positioned and elongated tangential blower wheel 42 having relatively short single inlet centrifugal blower wheels 44 rigidly secured to each end thereof for producing the auxiliary air flow along the end walls 24. The tangential blower wheel 42 includes a plurality of parallel and circumferentially disposed blades 45 each of which has its opposite ends secured to opposite ends of the plates 46. These blades may be brazed to the end plates 46, or they may be provided with end flanges which are secured to the end plates by deforming the outer periphery of the plates thereover, as disclosed in United States Patent of Wilken No. 2,537,505, issued January 9, 1951, or they may be attached in some other manner without departing from the scope of the invention. As well as in FIG. 7, the sheet metal blades 45 have smoothly curved surfaces which have a center of curvature at the point 48, and preferably have sufficient blade surface to allow the leading edge 50 thereof to have an angle of attack a of about 25° to 30°, whereas the trailing edge 51 extends substantially radially of the blower wheel 42. This blade configuration provides for maximum scooping action to draw the air into the interior chamber 52 of the blower wheel 42, as well as smooth outward flow therefrom, but it is within the scope of the invention to use a blade configuration capable of effecting the desired air flow through the tangential blower wheel 45.

As shown in FIG. 2, the centrifugal blower wheels 44 each include a plurality of parallel and circumferentially arranged blades 54 which are secured between an end plate 56 and an end ring 58 in a conventional manner. The blades 54 of these centrifugal blower wheels preferably have the configuration shown in FIG. 8 wherein the leading edges 60 thereof extend substantially tangentially of the blower wheel 44 and the trailing edges 61 extend substantially in a radial direction for smooth outward flow of air from the blower wheels 44.

It is stressed, however, that substantially any conventional single inlet blower wheel may be used in conjunction with the tangential blower wheel 42 without departing from the scope of the invention. Thus the centrifugal blower wheel 44 may have a diameter which is smaller or larger than that of the tangential blower wheel 42, although in practice it has been found that the length of the centrifugal wheels is desirably one-half the diameter thereof and the diameters of the blower wheels 42 and 44 are equal for convenience in fabrication and constructing the housing 11, as well as to create a satisfactory uniform flow from the outlet duct 21. The end plates 46 and 56 of the tangential and centrifugal blower wheels 42 and 44, respectively, are preferably secured together by a hub 62 which extends axially through both the end plates 46 and 56 and has the other peripheral portion thereof deformed to clamp these end plates tightly together, thus forming a substantially rigid composite blower wheel 12. This assembled blower wheel is mounted within the housing 11 by the motors 14 which have their drive shafts 63 extending inwardly of the housing 11 in an axial direction for engagement with the hubs 62.

The motors 14 are in turn supported partially within the inlet openings 40 and the centrifugal blower wheels 44 by brackets 66, which include annular portions 67 secured in clamping engagement with the bosses 68 on opposite ends of the motors 14, and ribs 70 which rigidly interconnect the annular portions 67. Each of the ribs 70 has an outwardly extending arm 72 which is rigidly secured to the adjacent end wall 24 by a connection with the smoothly rounded periphery 73 of the inlet opening 40, as seen in FIGS. 2 and 3. The motor support brackets 66 provide additional compactness to the blower hub 10, and insure proper cooling of the drive motors 14 since the air flowing through the inlet opening 40 to the centrifugal blower wheels 44 must flow around and over the surfaces of the motors 14. In particular, the support brackets may be of the construction shown and described in the United States patent to Burrowes 2,686,630, issued August 17, 1954.

While a pair of drive motors 14 has been shown and described, it is within the scope of the invention to use a single drive motor positioned as shown, or in any other conventional manner, in which case the opposite end of the rotor 12 is supported by a suitable axle and bearing arrangement. It is also within the scope of the invention to mount the drive motors 14 in any well known conventional manner, for example, by a remote mounting with an own connecting between the rotor 12, since it is necessary only that the drive motor ultimately rotate the rotor 12 at the required speed.

The axial lengths of the housing 11 and blower wheel 12 may be varied to achieve the desired air output capacity, and when the axial length of the unit is so increased, it may be necessary to reinforce the housing 11 to maintain rigidity thereof. Only the tangential blower wheel 42 and its coextensive inlet 35 need be lengthened to achieve a longer unit 10, since relatively short centrifugal blower wheels 44 are all that is required by the invention. Reinforcement of the housing 11 can be accomplished by securing braces to the outside thereof so that the smooth inner configuration of the housing is not obstructed. In addition, the tangential blower wheel 42 may be strengthened by adding radial support disks or bulkheads axially along its length, for example, conventional center disks of the type used in a double inlet centrifugal blower wheel could be used, as indicated at 84 in FIG. 9.

As noted above, the housing 11 and the rotor 12 define therebetween a gradually enlarging diffusion cone 22 that starts between the edge 16 and the adjacent periphery of the rotor 12, and extends through a curved path between the inside surface of the back wall 15 and the rotor 12. This cone continues through the outlet duct
whose top wall 30 is upwardly tapered, and thus provides for the smooth conversion of velocity pressure to usable static pressure in a compact space.

The housing 11 completely encloses the rotor 12, and the interior surfaces thereof are smooth for unobstructed flow of air within the housing. The inlet 35 is equal in length to the tangential blower wheel 44 whereas the outlet duct 21 is slightly longer than the axial length of the rotor, and the back and lower walls 15 and 20 are coextensive so that the gradually increasing diffusion cone 22 extends from above the rotor 12 through the outlet duct 21. The radial space between the edges 37 of the shrouds 38 at the periphery of the rotor 12 is shown as being open but it is within the scope of the invention to close the space with a suitable baffle secured to the edges 37 and terminating short of the adjacent portion of the rotor 12. In practice, it has been found that the inlet 35 can extend through about 180° from the edge 31 to obtain reduced but satisfactory performance. This satisfactory performance is also present when the shrouds 38 are removed, although the back wall 15 opposite the centrifugal blower wheels 44 cannot be removed without a substantial reduction in the air flow created by the wheels 44.

As shown in FIG. 6, the rear edge 51 of the top wall 30 is placed as close as possible to the periphery of the tangential blower wheel 42 without contacting therebetween so that the inlet 35 and outlet duct 21 are effectively separated. In practice it is found that a slight distance must be placed between the edge 31 and the blower wheel 44 so that the noise level created thereby is held to a minimum, although the rolled rear edge 31 also aids in reducing the noise created as the blades pass thereby at high speed.

In operation, when the composite blower wheel 12 is rotated at high speed by the drive motors 14 in a counterclockwise direction, as viewed in FIGS. 4 and 5, the tangential blower wheel 42 causes air to be drawn through the inlet 35 between the blades 45 and into the internal chamber 52 of this blower wheel 42. The air continues to flow across the internal chamber 52 and then outwardly between the blades 45 at a location remote from the inlet 35, and into the curved diffusion cone 22 wherein an efficient conversion of velocity pressure to static pressure is effected.

At the same time, the centrifugal blower wheels 44 on the opposite ends of the tangential blower wheel 42 are rotated at the same high speed causing air to be drawn through the internal inlet openings 40 in the end walls 24 and into the internal chamber 75 of the centrifugal blower wheels 44. The high speed rotation of these blower wheels rotates the mass of air in the chambers 75 causing the same to be thrown radially outward by centrifugal force, and the blades 54 also impart a tangential component to this radial flow thereby forcing the air into the diffusion cone 22 where the velocity pressure is again converted to static pressure.

The flow of air created by the centrifugal blower wheels 44 is stable throughout its range of operation and air flows adjacent the end walls 24 into the duct 21 so that there is no appreciable frictional drag on the air being pumped by the centrifugal blower wheel 42. As a result, the flow and static pressure is essentially uniform across the entire outlet duct 21.

The operation and advantages of the blower 10 can more fully be described and demonstrated in connection with the drawings of FIGS. 11 and 12. Thus, the graph in the graph of FIG. 12 wherein the distance between the end walls 24 is plotted along the abscissa and air flow rate at each point between the walls 24 is plotted along the ordinate, the curve 80 is a representation of a typical conventional tangential blower wherein the centrifugal blower wheels 44 or other auxiliary means are not utilized. This curve illustrates that the air flow is quite low adjacent the end walls 24 and gradually builds up and levels off through the central portion of the outlet duct 21.

On the other hand, the curve 81 illustrates the performance in a blower 10 in accordance with this invention, and it is seen that the air flow is essentially uniform across the entire length of the outlet duct 21. As a result the blower 10 has a capacity which is higher than a comparable blower without this invention by an amount equal to the shaded area between the curves 80 and 81. The advantageous result is that the blower wheels 42 and 44 of the blower 10 can be rotated at lower speeds to obtain the same quantity of air as the prior art devices with a resulting reduction in the noise generated by the blower wheel, or that a smaller blower unit can be used for a given installation.

Referring now to FIG. 11, the curves 84 and 85 illustrate the comparative performance, respectively, of a blower without the centrifugal blower wheels 44 mounted at opposite ends thereof and a blower 10 constructed in accordance with the invention. Thus the curve 84 indicates that the static pressure generated between the points a and b is unstable and actually fluctuates, for example at a static pressure of c, the flow would fluctuate between the rates d and e. As a result, the useful range of the curve is between the points b and f. On the other hand, the curve 85 is created by a blower unit of the same size and driven at the same speed but constructed in accordance with the invention. This curve is relatively stable throughout its entire range so that the blower 10 can be used at substantially any point along the curve between the points g and h, and thus can be used effectively with a system having a high resistance to flow as shown by curve 88.

If the blower is to be used with an air conditioning device having a system resistance which is plotted as the curve 88 of FIG. 11, it is readily seen that a blower without the centrifugal blower wheels 44 would be unsatisfactory since it falls in the unstable range a-b wherein the undesirable puffing occurs. However, the blower 10 would perform satisfactorily with higher flow and static pressure characteristics. As a matter of fact, for an air conditioning system of this type, an increase in the size of the tangential blower without the auxiliary blower wheels 44 would not solve the problem since it would also cause an increase in the length of the unstable region, and thus a comparable tangential blower without the invention could not be used in this system.

While the auxiliary air flow along the end walls 24 is created by the centrifugal blower wheels which are mounted on the tangential blower wheel, it is within the scope of the invention to use substantially any other known air flow producing expedient to create flow adjacent the end walls for achieving a uniform output. One important alternative structural arrangement of the composite blower wheel 12 is shown in FIGS. 9 and 10 and uses elongated blades 90 having an end ring 91 secured at each end thereof in a conventional manner to define axial air inlets 92, and center disks 94 mounted within the wheel defined by the blades 90 to separate the wheel into centrifugal blower wheel portions 95 at each end and a tangential blower wheel portion 97 intermediate the centrifugal portions. This structure is easier and cheaper to mass produce and requires more or less conventional blower wheel components.

In such a blower wheel, the blades of both the centrifugal and tangential portion would have the same curvature as dictated by the configuration of the tangential portion since the same configuration performs satisfactorily in the centrifugal portions. The end ring 91 and the center disks 94 may be similar to those shown and described in the United States patent to Wilken No. 2,852,182, issued September 16, 1958, and assigned to the assignee of this invention. In such a center disk,
the taps 98 formed in the outer periphery of the plates 100 are deformed into the openings 101 in the trailing edges 103 of the blades 90. The end rings 91 are spun onto the flanges 104 formed at each end of each of the blades 90.

The invention has thus provided essentially tangential blower units which will provide a uniform flow across the outlet duct over a wide range without the usual unstable region. Moreover, the invention provides a higher output flow at higher static pressures thereby enabling use of the invention in a wide range of present day equipment. Numerous features lend the invention to easy and inexpensive manufacture since there are no critical tolerances to meet as in many prior art devices. In addition, the drive motors are mounted for cooling and compactness of the unit without detracting from the performance of the blower.

Reference is made to my copending United States application for Air Moving Device, Serial No. 331,140, filed December 17, 1963, and assigned to the assignee of this invention.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form of apparatus, and changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. A blower assembly of the character described comprising, an elongated volute shaped housing having end walls at opposite ends thereof, an elongated blower wheel mounted in said housing and having a plurality of spaced parallel blade means, end rings at the ends of said blower wheel, two spaced radial partitions in said blower wheel separating the interior of said blower wheel into centrifugal sections between said end rings and partitions and a tangential section between said partitions, said partitions being imperforate so that they block any direct blow of air between said centrifugal and tangential sections, said end rings defining inlets in the ends of said blower wheel for air flow into said centrifugal sections, means in said housing defining a radial air inlet opening substantially coextensive with the axial length of said tangential section so that air flows into said tangential section between the portions of said blade means which define the sides of said tangential section, means defining an elongated outlet duct from said housing coextensive with said blower wheel for receiving air flow from said centrifugal and tangential sections along the entire length of said blade means, said volute shaped housing extending entirely around the portions of said blower wheel which defines said centrifugal sections except for said outlet duct to increase the efficiency of centrifugal sections of said blower wheel, means defining axial air inlet openings in said end walls in alignment with said inlets to said centrifugal sections, and drive means for rotating said blower wheel at high speed so that air is drawn into said tangential section of said blower wheel through said radial air inlet opening and expelled into the central portion of said outlet duct so that air is drawn into said centrifugal sections through said axial air openings and expelled into said outlet duct at opposite ends of said tangential section along said end walls to create uniform stable air flow across the width of said outlet duct.

2. A blower assembly as defined in claim 1 wherein said blower wheel is formed by securing the back plate of two single inlet centrifugal blower wheels to the opposite ends of a tangential blower wheel so that said back plates form said radial partitions.

3. A blower assembly as defined in claim 1 wherein said blade means includes individual blades which are secured together at their ends by said end rings.

4. A blower assembly of the character described comprising, an elongated volute shaped housing having end walls at opposite ends thereof, an elongated blower wheel mounted in said housing and having a plurality of spaced parallel blade means, end rings at the ends thereof, a radial partition in said blower wheel separating the interior of said blower wheel into a centrifugal section between one of said end rings and said partition and a tangential section on the other side of said partition, said partition being imperforate so that it blocks any direct flow of air between said centrifugal and tangential sections, said one end ring defining an inlet in the end of said blower wheel for air flow into said centrifugal section, means in said housing defining a radial air inlet opening substantially coextensive with the axial length of said tangential section so that air flows into said tangential section between the portions of said blade means which define the sides of said tangential section, means defining an elongated outlet duct in said housing coextensive with said blower wheel for receiving air flow from said centrifugal and tangential sections along the entire length of said blades, said volute shaped housing extending entirely around the portion of said blower wheel which defines said centrifugal section except for said outlet duct to increase the efficiency of centrifugal section of said blower wheel through said radial air inlet opening and expelled into the central portion of said outlet duct so that air is drawn into said centrifugal section through said axial air openings and expelled into said outlet duct at one end of said tangential section along said one end wall.

5. A blower wheel assembly as defined in claim 4 wherein said radial air inlet has its lower edge formed by the top wall of said outlet duct.

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