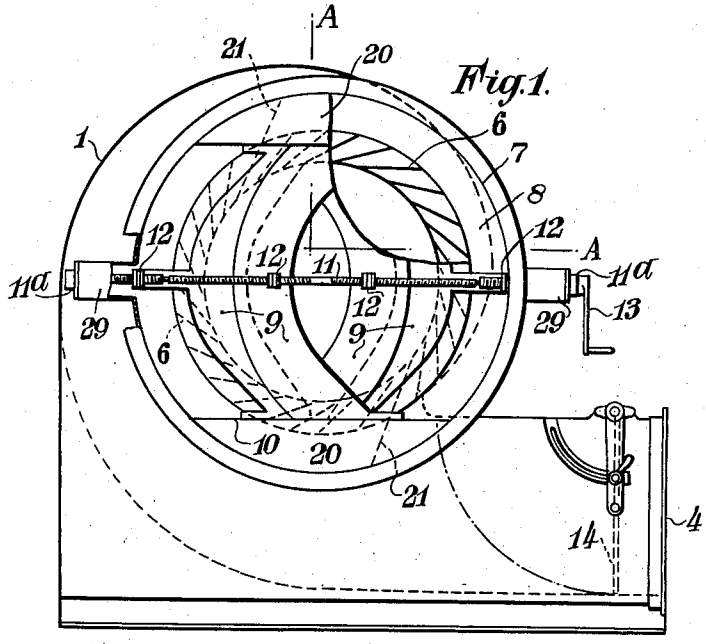
Dec. 13, 1938. J. WHITMORE 2,140,148

CONTROL OF CENTRIFUGAL FANS, PUMPS, AND THE LIKE

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Fig. 1.



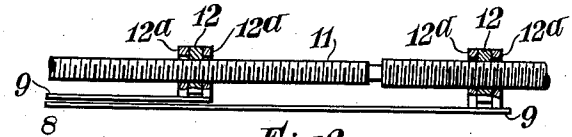


Fig. 3.

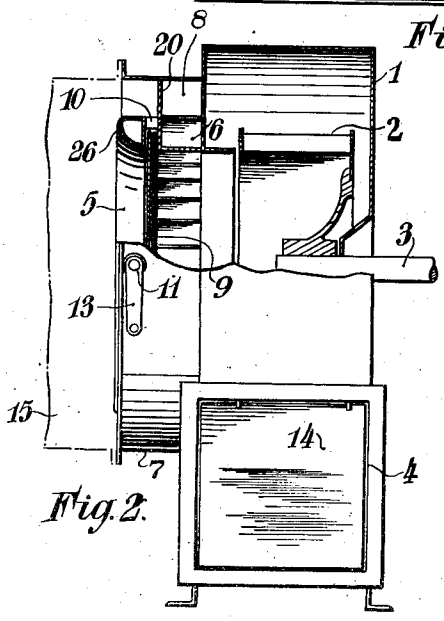


Fig. 2.

Fig. 4.

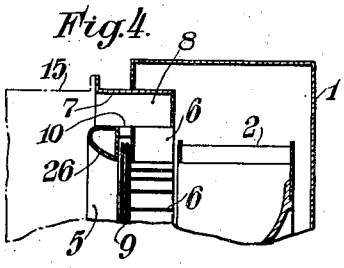
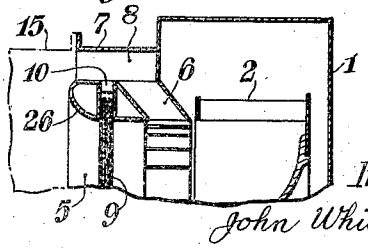


Fig. 5.



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CONTROL OF CENTRIFUGAL FANS, PUMPS, AND THE LIKE

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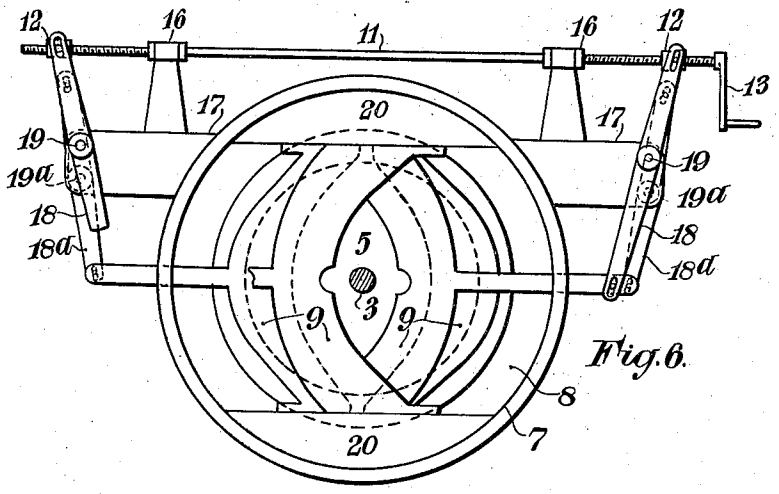


Fig. 6.

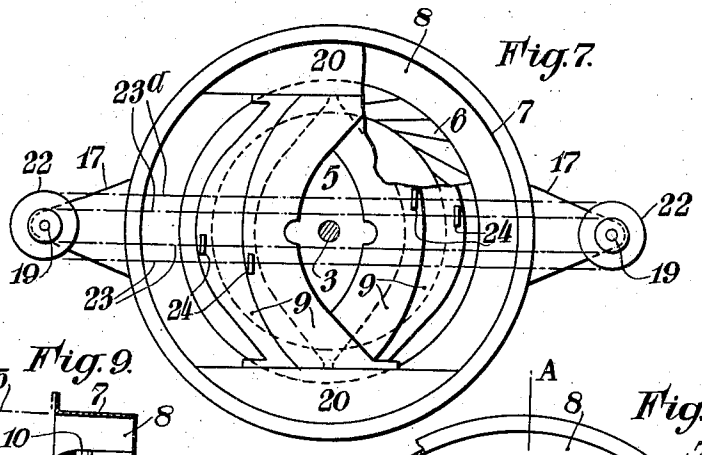


Fig. 7.

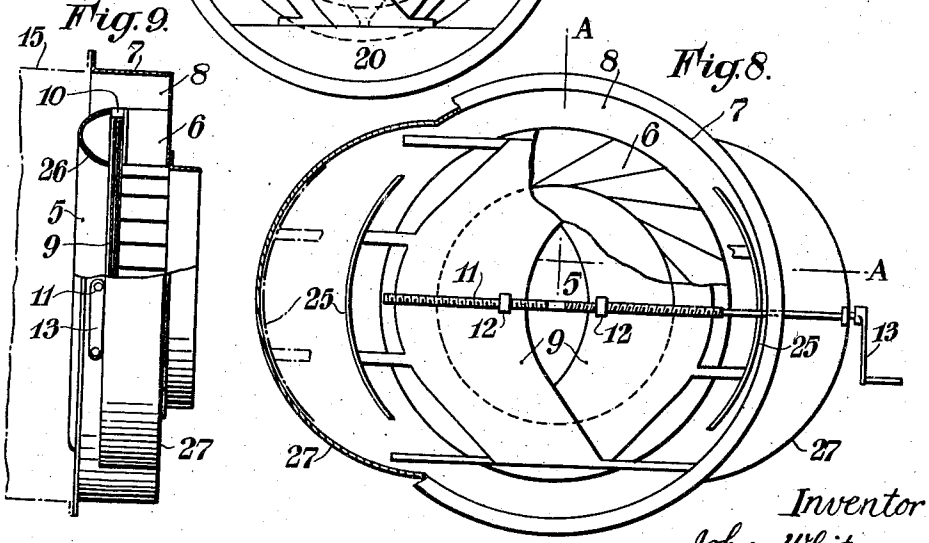


Fig. 9.

Fig. 8.

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Fig.11.

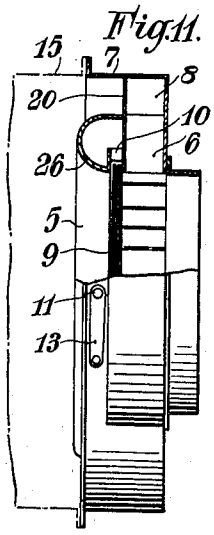


Fig.10.

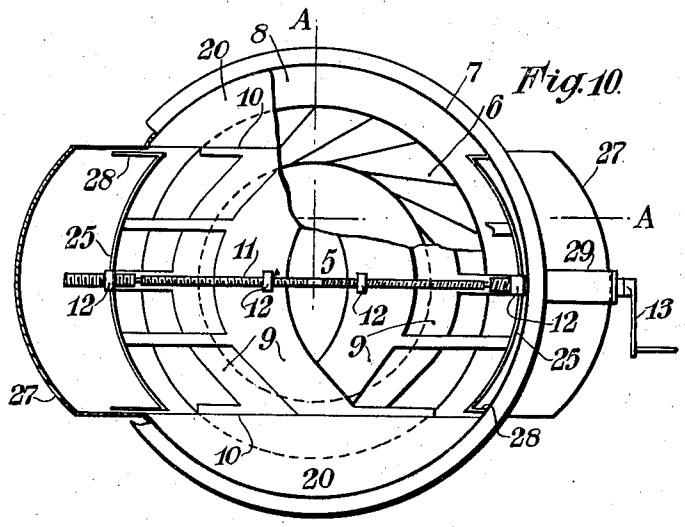


Fig.13.

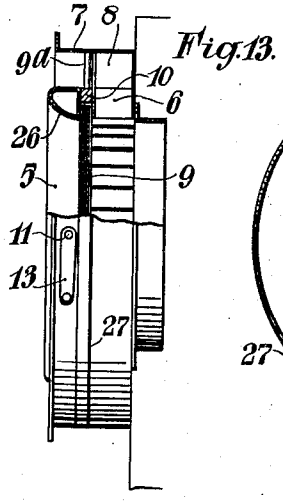


Fig.12.

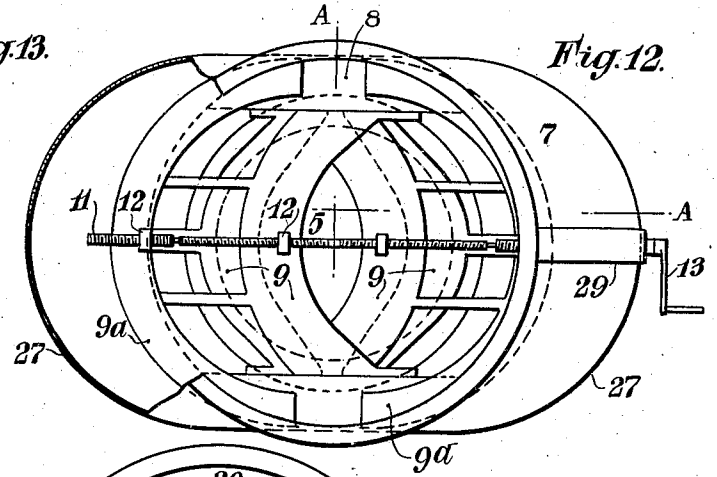
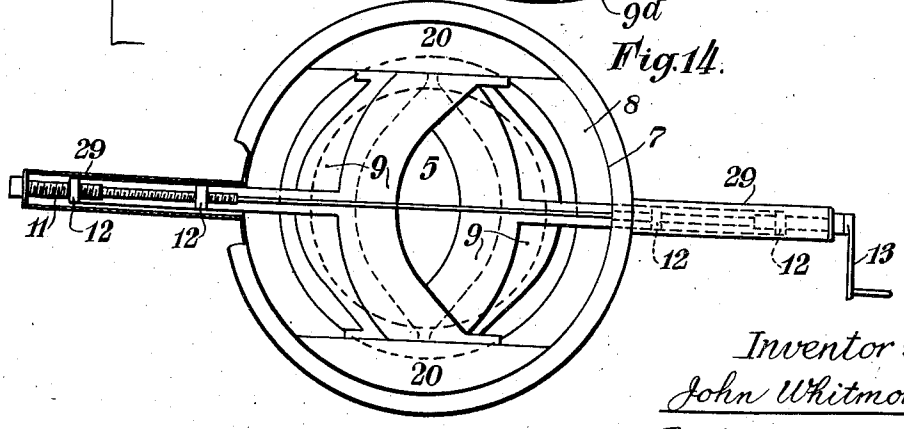


Fig.14.



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Patented Dec. 13, 1938

2,140,148

UNITED STATES PATENT OFFICE

2,140,148

CONTROL OF CENTRIFUGAL FANS, PUMPS, AND THE LIKE

John Whitmore, Belfast, Ireland, assignor to Davidson & Company, Limited, Belfast, Ireland

Application October 14, 1936, Serial No. 105,484
In Great Britain October 30, 1935

20 Claims. (Cl. 230—114)

This invention relates to the control of the performance of centrifugal fans, pumps and the like (hereinafter referred to as a "centrifugal fan") and is more particularly applicable, but not limited to such units when arranged to operate at constant speed.

The object of the invention is to maintain the efficiency of the apparatus when running for example at constant speed on partial loads, by a saving of the power required to operate the impeller of the fan at such decreased loads.

Hitherto in centrifugal fans in which the entering air is given a vortical motion at entry for the purpose of obtaining economy in operation, the volume of air corresponding to the full load on the fan flows over movable or stationary guide vanes, or their equivalent. Such vanes are usually placed in or near the fan inlet or within the fan casing, in such position that the air has to pass over such vanes to produce the desired vortical movement and are, consequently, more or less of an obstruction under all operating conditions. This is particularly undesirable when the fan is operating on full load, as it frequently results that to meet a stated performance, it is found necessary to resort to an increase in the fan size, compared with the size of fan having an inlet free of vanes or obstructions of any kind.

The object of the invention is to provide a centrifugal fan, capable of being operated with efficiency at loads less than maximum, and at the same time to provide a fan in which the eye or axial inlet thereof is unrestricted when the fan is operating at full load, that is to say, a fan wherein the whole of the entering air under maximum load passes directly to the impeller without the impediment of vanes or other devices for creating a vortical movement in the entering air.

According to the invention a method of regulating a centrifugal fan at all loads less than the maximum consists in causing the volume of air axially approaching the fan to flow into the fan in at least two controllable portions one of which passes through the eye of the fan and constitutes a main or axial inlet (hereinafter termed the "main inlet") and the other through a secondary inlet, which latter, when open, gives the air passing therethrough a flow in the direction of rotation of the impeller and is adapted to impart a similar flow to the air stream flowing through the main inlet when the latter is open.

Preferably the flow of air through both inlets is controlled simultaneously, in some cases a damper being disposed in the fan discharge, whereby additional control may be effected for example when the secondary air inlet alone is open.

Further, according to the invention there is provided a centrifugal fan having associated therewith mechanism which at all loads less than the maximum causes the volume of air axially approaching the fan to flow thereinto in at least two controllable portions one of which constitutes a main air supply (hereinafter termed the "main air") and the other a secondary air supply (hereinafter termed the "secondary air") which latter, when admitted, flows over vanes which give such secondary air a flow in the direction of rotation of the impeller and thereby imparting a similar flow to the main air stream when the latter is admitted.

The admission of main and secondary air streams is preferably controlled simultaneously by dampers or their equivalent (hereinafter referred to as "dampers") and the air flowing through the fan discharge may be controlled by a damper for example when the secondary air only is admitted.

In a suitable construction according to the invention a centrifugal fan is provided with dampers which are used to control the supply of air through the main inlet of the fan, the dampers being capable of simultaneously opening a secondary inlet to the fan through which air may enter and flow over vanes, blades or the like (hereinafter termed "vanes") which give said entering air a directional movement corresponding to the line of rotation of the impeller. The arrangement is such that when the main inlet of the fan is partially closed by the dampers air is permitted to enter the secondary inlet, flow over the vanes and impinge upon or contact with the in-flowing stream of air passing through the main inlet, whereby a similar motion is imparted to such stream in a direction corresponding to the line of rotation of the impeller. The dampers are operated by mechanism which enables them to be used to close or partially close the main inlet and simultaneously open fully or in part the secondary air inlet. The dampers may, however, be so formed that when the main inlet of the fan is totally closed the secondary air inlets may also be completely closed.

Preferably in one embodiment of the invention the outlet of the fan is provided with the usual form of damper which is operated to still further control the output of the fan especially

when the main inlet of the fan is totally closed and air to the impeller is flowing through the secondary inlet only.

In order that the invention may be clearly understood reference is directed to the accompanying drawings wherein:

Figure 1 shows a side elevation of the fan casing with the dampers and control gear therefor in part section.

Figure 2 is a front elevation of Figure 1 looking towards the fan outlet, the upper portion being a section on lines A—A Figure 1.

Figure 3 illustrates in detail and to a larger scale part of a damper actuating screw rod having two different pitches of thread.

Figures 4 and 5 show sectional elevations of alternative arrangement of vanes.

Figures 6, 7 and 14 illustrate further alternative methods of operating the dampers.

Figures 8, 9, 10 and 11 and 12 and 13, illustrate respectively in front and side elevation dampers of modified form.

The same distinguishing numbers are used for the same parts throughout the drawings.

In carrying the invention into effect in one convenient manner, and with particular reference to Figures 1 and 2, 1 indicates a fan casing, 2 an impeller within said casing and carried by a rotary shaft 3, 4 is a tangential outlet from the casing, and 5 is the main inlet thereto, which may be fitted with a flaring 26. A system of stationary vanes 6 is arranged around the main inlet 5 of the fan which is surrounded by a cylindrical casing 7 and forms an annular chamber 8 external to the system of vanes 6 which connect such chamber to the main inlet 5.

The stationary vanes 6 are so disposed that air passing through them from the annular chamber 8 and forming a secondary air inlet to the impeller 2 enters the impeller in a tangential direction (i. e. with a vortical flow), a whirling or secondary motion or movement being thereby set up in the air entering the impeller through the main inlet of the fan i. e., the eye of the fan, the direction of whirl being the same as the direction of rotation of the impeller.

Two pairs of oppositely moving dampers 9 slidably carried in guides 10, and operated by a right and left hand screw threaded rod 11, carried in bearings 11*a* are arranged to vary the effective area of the main inlet 5 to the fan.

Each damper 9 in this construction comprises two plates, preferably having concave inner edges and being of substantially crescent shape thus forming a compound damper, one plate of each pair of which moves relatively faster than the other. To produce such relative travel right and left hand threads of different pitches are formed on the rod 11 which has a screw engagement with nuts 12 attached to each damper plate, one end of the screwed rod 11 extends outside the casing and carries a crank 13 by which the rod is turned to operate the dampers. Oppositely moving dampers each comprising a single plate will be described later, but the arrangement now indicated possesses the great advantage that the casing 7 can be made neat and compact, and therefore occupies a relatively small space.

When the fan or pump is operating at its full capacity, it is usually advisable to close off the annular chamber 8 (formed by the interior of the casing 7 and the exterior of the vane system 6) to the passage of air. This may be effected by shaping the outer ends of the dampers 9, Figure 1, to fit (i. e. to the same curvature as) the interior of the casing 7 and by covering the diametrically opposite segmental openings formed by the upper and lower edges of the damper slides 10, and the interior of the aforesaid casing, with correspondingly shaped shields 20 so that air may only enter the fan in an axial direction. When composite dampers are fitted, that is where each damper blade comprises two or more plates, it is advisable to make the outer edges of the oppositely situated and quicker moving damper blades, that is, those which are actuated by the coarsest pitch, or quickest moving gear, if some other form of actuating gear is employed of the same shape as the interior of the casing 7, in order that the closure of the annular chamber 8 may be effected by this portion of the dampers.

One of the guide vanes 6 (indicated by the reference 21) at diametrically opposite positions, Fig. 1, behind the shield 20, may be extended if desired across the annular chamber 8 to the interior face of the cylindrical casing 7, in order to prevent eddying in the air current passing behind the said shields when annular passage 8 is open, which eddying might take place if air were to flow in opposite directions.

Under certain circumstances it may be considered necessary to carry each vane in the system of vanes 6 across the annular chamber 8. In this case, however, neither the segmental pieces 20 nor the curved shields 25 (hereinafter mentioned) would be used.

Figure 3 shows on a larger scale one side of the right and left hand screw threaded rod 11, one part of which is provided with a thread of different pitch to the other (in this case the right hand thread is about half the pitch of the other portion). The nuts 12 may be attached to the dampers 9 in any approved manner. In the illustration each nut consists of a non-rotatable central portion of anti-friction or other suitable metal screwed to suit the threads on the rod 11 and carried between two brackets or snugs 12*a* welded or otherwise secured to the dampers, or where necessary to extended portions of said dampers. This construction is simple and effective, but may be varied to suit circumstances. Housings 29 are shown in Figure 1 to accommodate such extensions and nuts, and also bearings 11*a* for the screwed rod 11.

In Figure 4 the system of stationary vanes 6 is shown mounted in the interior of fan casing 1 communicating respectively with the annular chamber 8 and the main inlet 5 to the impeller 2. A flange is formed on the circular casing 7 in order that such casing may be conveniently connected to a duct or trunk 15 as shown in dotted lines.

Figure 5 illustrates another arrangement or modification in which the system of stationary vanes 6 projects at an angle into the fan casing 1, while the inlet side of the vanes is external to the fan casing, and, as in Figure 4 communication is established between the annular space or chamber 8 and main inlet 5 by means of the vanes 6.

Figure 6 shows an alternative method for operating the dampers, the mechanism being entirely external and consisting of a screwed rod 11 carried in bearings 16 and provided with right and left hand threads operating in nuts 12 which engage with levers 18 and 18A pivoted at 19 and 19A on brackets 17 situated on each side of cylindrical casing 7. The ends of the levers re-

mote from the nuts are coupled to extensions from the composite dampers and actuate same as already described. It will be observed that the double armed lever 18A derives its motion from double armed lever 18 whereby one damper of each set travels faster than the other.

In this particular construction the fan shaft 3 projects through the vane and damper system without fouling the operating ear. The brackets 17 may be attached to the circular casing 7, or to any other part of the fan as found most convenient.

Figure 7 shows another form of damper actuating mechanism which comprises two pulleys, one of which may be operated by worm gear (not shown) or in any other manner, and mounted diametrically opposite each other on brackets 17 attached to the casing 7 or other convenient part of the fan. The pulleys carry endless ropes or chains 23, 23A or the like which are attached to the dampers at 24. The method is shown applied to composite or compound dampers and in this case each of the pulleys 22 consists of a double stepped cone, the larger step actuating the faster moving parts of each composite damper plate, and the smaller one the slower moving parts. It will be readily understood that as the right hand pulley, for example, is rotated by hand or power in a clockwise direction, the ropes or the like 23A in each case will not only drag the dampers 9 to which they are attached, with them, but the pulley on the opposite side will also be rotated, and in the same manner will traverse the dampers to which the ropes 23 are attached. Thus the ratio of the diameters of the pulleys determines the relative speed for each plate of the composite dampers. This particular arrangement has the further important advantage that each damper plate may be balanced by its oppositely moving counterpart if the dampers are arranged to slide vertically. This condition can be visualized by turning Fig. 7 through 90°.

Under normal conditions of working, it is not necessary to entirely prevent flow of air through the vanes when the main inlet is fully closed (that is when all main air flow is stopped) as the maximum flow of air which can flow freely through the vane system is small compared with the normal volume passing. Nevertheless, such secondary air flow may be completely prevented if desired, by the adoption of the following alternative means:—

A damper 14 may be provided in the fan outlet 4, Figure 1, to give a small additional degree of volume regulation with economy, and will also serve to isolate the fan if required. Further, dampers of suitable shape may be provided to control the passage of air into the annular chamber 8, and may consist of semi-circular shields adapted to fit over the outer surface of the ring of vanes, or the flow of secondary air into the annular chamber may be controlled by semi-circular shields adapted to cover this space. For convenience of working the dampers controlling the flow of air in the vane system, or into the annular chamber may be mounted on the sliding dampers controlling the flow into the axial inlet 5. Such means as are now described in relation to Figures 8 and 9 will thereby enable the fan to deal with volumes of air approaching zero.

In this construction each damper 9 consists of a single plate only and in order to reduce the volume of air at low duties curved shields 25 are carried on extensions from the outer ends of the dampers. These shields may partially or wholly close the outer periphery of the vane system when main air flow is stopped (as shown the shields 25 partially enclose the vanes) that is, when the dampers 9 are closed and thus allow only a volume approaching zero to enter the fan. When the dampers 9 are in the full open position, that is, when maximum flow is taking place, the shields 25 are accommodated in recesses 27 as shown dotted at the left hand side of Figure 8.

Figures 10 and 11 are similar to Figures 8 and 9 and show an alternative form of shield 25, in combination with the segmental covers 20 by means of which it is possible to entirely close off all ingress of air through the system of vanes by means of extensions or ears 28, attached to or forming part of the ends of the curved shields 25. These extensions, when the dampers 9 are in the closed position to prevent flow of air through the main inlet, close the secondary inlet to the space behind the segments 20 so that there is no flow of air whatever through the annular chamber 8. It will be understood that a similar form of shield provided with ears 28, may be fitted to a plain single type of damper, as illustrated in Figures 8 and 9, together with the segmental portions 20 referred to.

Figures 12 and 13 illustrate another method by which ingress to the annular chamber 8 may be entirely closed off when main air flow to the inlet 5 is stopped, thus also bringing the performance of the fan down to zero, or at least to the irreducible minimum. This is achieved by attaching to each damper 9, if only two are employed, or to one pair of oppositely moving dampers if multiple damper plates are used, curved shields 9A. These are accommodated in recesses 27 as before described when the fan is working at maximum output. It will be understood that any of the forms or arrangements of dampers may be fitted with the several forms of shields referred to or the methods of operating same may be varied as required, for instance the dampers shown in Figures 8 and 9 could be fitted to the construction of fan shown in Figures 1 and 2 and operated in accordance with the method described in connection with the construction shown in Figure 7.

The method of actuating the dampers by means of a right and left hand threaded rod having screws of different pitch is also illustrated in Figure 14 in which instance the threaded portion is shown external to the cylindrical casing 7, so that the nuts 12, and the screwed portion of the rod, are not exposed to the action of gases, should the fan be dealing therewith, particularly if the temperature is considerable, or if the ingoing air carries dust in suspension which would cause the screws and threads to wear.

In cases where it is desired to employ screws for operating the dampers when the driving shaft 3 passes through the axial inlet 5, two screwed rods (not shown) one on each side of the shaft may be employed, the one being actuated manually or otherwise and the other being driven from the first by a chain or sprocket gear or in any other approved manner.

It will be appreciated that the several methods described for operating the dampers are only representative of some mechanical devices which may be used for this purpose, and it is not thought necessary to illustrate further examples as the gear in question is only a matter of ordinary engineering expedience and to some extent dependent upon existing conditions.

The apparatus operates in the following manner:—

When the fan is operating under full load, the dampers 9, (Figure 1) will be open to their fullest extent, closing off all flow through the annular chamber 8, and the vane system 6, and the whole of the air or gas will then flow directly to the impeller through the main inlet 5. When, however, the fan is required to operate on a reduced or partial load the dampers 9 are moved towards each other, by means of the threaded rod 11 or other form of gear, consequently leaving a space between the outer ends of the said dampers and the casing 7 for air to enter the secondary inlet and vane system 6, which after passing therethrough joins the main air flowing through the fan, imparting thereto a motion in the direction of rotation of the impeller with the result that a reduction in power expenditure is effected.

It will be understood that as the proportion of air flowing through the vane system 6 increases, the volume of main air will decrease and if the dampers 9 are entirely closed, the whole of the air passing through the fan will in this case enter through the vane system, unless the vane system is entirely closed off as provided for.

But as already explained the quantity of air dealt with in comparison with the volume under normal conditions is small and may be reduced to zero in the manner and by the means already described and illustrated.

Various types of dampers may be employed for controlling the passage of air through the fan inlets. Furthermore, the damper employed for said purpose may be either a single-piece damper or a damper consisting of several co-acting damper elements. The term "damper" is, therefore, employed in the appended claims to cover various types of dampers and also to cover a damper consisting of a single damper element or a plurality of co-acting damper elements, except as otherwise specifically set forth.

The term "air" is employed in this specification and in the accompanying claims as referring to any matter which may be conveyed or otherwise handled through the medium of fans or the like.

It will also be understood that the fan may be connected through the casing 7 to a flue or the like, and discharge freely to the atmosphere, or the outlet may be connected to a system of trunking or the like, whilst the inlets draw freely from the atmosphere. In other cases both the inlets and the outlet of the fan may be connected to flues or ducts.

What I claim and desire to secure by Letters Patent is:—

1. A centrifugal fan or the like comprising an impeller, a main air inlet adapted to pass a main air supply axially toward the impeller, a secondary inlet adapted to pass a secondary air supply substantially tangentially into a peripheral area within said main air inlet at a point removed from the impeller whereby to impart vortical movement to the said main air supply in a desired direction prior to said main air supply's entry into the impeller.

2. A centrifugal fan or the like according to claim 1, said inlets having co-related means for varying the relative passage of air therethrough.

3. A centrifugal fan or the like according to claim 1, said inlets having co-related means for simultaneously varying the relative passage of air therethrough.

4. A centrifugal fan or the like according to claim 1, said inlets having co-related means for inversely modifying the passage of air therethrough.

5. A centrifugal fan or the like according to claim 1, further characterized in having a single exhaust duct, said duct and said inlets having means for regulating the passage of air therethrough, said means, with respect to the inlets, being co-related and adapted to permit variation of the relative passage of air through said inlets.

6. A centrifugal fan or the like according to claim 1, the secondary inlet being disposed about the main inlet and adapted to pass a vortical air current tangentially into the main air supply whereby to impart vortical movement thereto in a desired direction.

7. A centrifugal fan or the like according to claim 1, the secondary inlet comprising an annular chamber disposed about the main inlet and a plurality of passages extending inwardly therefrom tangentially into the main inlet.

8. A centrifugal fan or the like according to claim 1, the secondary inlet comprising an annular chamber having an opening extending about the main inlet, a passage extending inwardly from the said chamber into the main inlet, and vanes in said passage arranged substantially tangentially relatively to the main inlet, said vanes being adapted to cause the secondary air supply to vortically flow into the main air supply.

9. A centrifugal fan or the like according to claim 1, said inlets having adjacent openings, in a substantially common plane, for admitting air thereinto, and a movable damper having portions adapted to be moved across said openings and to vary the passage of air into said inlets.

10. A centrifugal fan or the like comprising an impeller, a compound inlet for passing air thereto, a main inlet opening, a secondary inlet opening disposed about said former opening, and means for regulating the passage of air through said openings, the said means comprising movable damper elements adapted to be simultaneously moved, in opposite directions, across said openings whereby to vary the effective areas thereof.

11. A centrifugal fan or the like according to claim 10, the said regulating means comprising simultaneously movable pairs of damper elements, one element of each pair being movable relatively faster than the other element thereof, the several elements of each of said pairs being adapted at outer positions to substantially overlap and form a restriction upon opposite portions of the secondary inlet opening and at inner positions to collectively form a substantial restriction upon the main inlet opening.

12. A centrifugal fan or the like according to claim 10, the said damper elements having portions which extend over and substantially close both said openings when said portions are at an inner position.

13. A centrifugal fan or the like according to claim 10, further having a mechanism for actuating said damper elements.

14. A centrifugal fan or the like according to claim 10, further having a mechanism for actuating said damper elements, comprising a rotatable rod, oppositely threaded toward opposite ends thereof, and adapted to co-act with threaded portions on opposed damper elements whereby to simultaneously move the latter towards or away from each other.

15. A centrifugal fan or the like according to claim 10, further having a mechanism for actuating said damper elements, comprising an endless pulley line having oppositely movable portions connected to opposed damper elements.

16. A centrifugal fan or the like according to claim 10, further characterized in having pairs of damper elements adapted to be simultaneously moved in opposite directions, one element of each pair being movable relatively faster than the other element thereof, and also in having a mechanism, for actuating said damper elements, comprising a rotatable rod having portions toward each end thereof with threads of different pitch, each of said portions being adapted to co-act with different damper elements whereby to impart different speeds of movement thereto.

17. A centrifugal fan or the like according to claim 10, further characterized in having pairs of damper elements adapted to be simultaneously moved in opposite directions, one element of each pair being movable relatively faster than the other element thereof, and also in having a mechanism, for actuating said damper elements, comprising a rotatable rod having oppositely threaded portions toward each end thereof, and levers, coacting with said threaded portions and with different damper elements and adapted to impart different speeds of movement thereto.

18. A centrifugal fan or the like according to claim 10, further characterized in having pairs of damper elements adapted to be simultaneously moved in opposite directions, one element of each pair being movable relatively faster than the other element thereof, and also in having a mechanism, for actuating said damper elements, comprising two endless pulley lines, movable at different lineal speeds, each line having oppositely movable portions connected to opposed damper elements.

19. A centrifugal fan or the like comprising an impeller, an axial inlet adapted to pass air substantially axially toward said impeller, an annular chamber substantially surrounding said axial inlet and adapted to receive an air supply, an annular passage between said chamber and the axial inlet, one or more vanes in said passage adapted to form one or more nozzles to guide air from said chamber tangentially into the axial inlet whereby to establish a vortical movement, in a desired direction, in the axially flowing air passing therethrough, and a damper comprising oppositely movable damper elements, adapted to vary the passage of air through said annular passage and said axial inlet, the damper having portions adapted to substantially close the said annular passage and the said axial inlet when the damper elements are in an inner position.

20. A centrifugal fan or the like comprising an impeller, an axial inlet adapted to pass air substantially axially toward said impeller, an annular chamber substantially surrounding said axial inlet and adapted to receive an air supply, an annular passage between said chamber and the axial inlet, one or more vanes in said passage adapted to form one or more nozzles to guide air from said chamber tangentially into the axial inlet whereby to establish a vortical movement, in a desired direction, in the air passing therethrough, and one or more of said vanes extending into the annular chamber whereby to minimize eddy currents therein.

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