Jan. 15, 1946.

H. F. HAGEN

2,393,042

AXIAL FLOW FAN

Filed Jan. 16, 1943

4 Sheets-Sheet 1

Fig. 1.

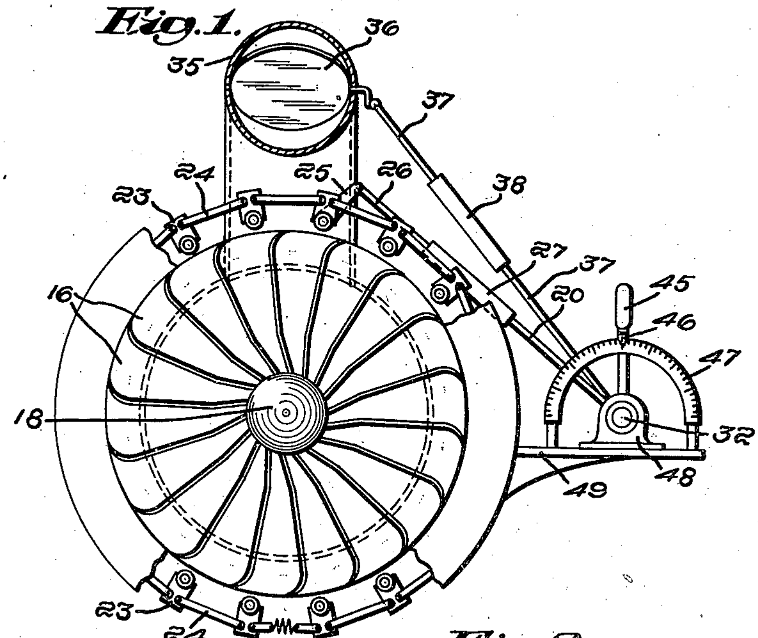
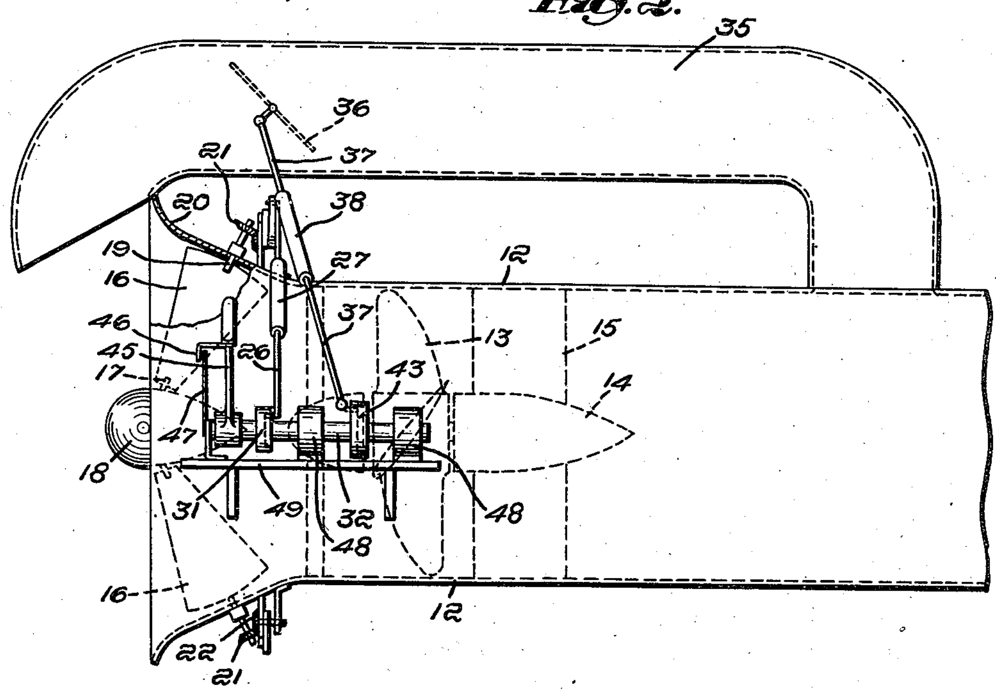


Fig. 2.



Inventor:
Harold F. Hagen,
by Robert T. Palmer
Attorney

Jan. 15, 1946. H. F. HAGEN 2,393,042
AXIAL FLOW FAN
Filed Jan. 16, 1943 4 Sheets-Sheet 2

Fig. 3.

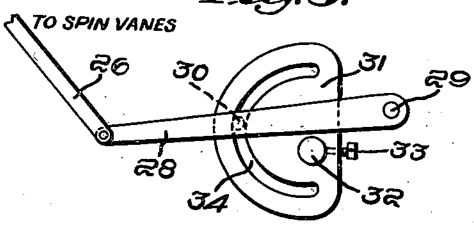


Fig. 4.

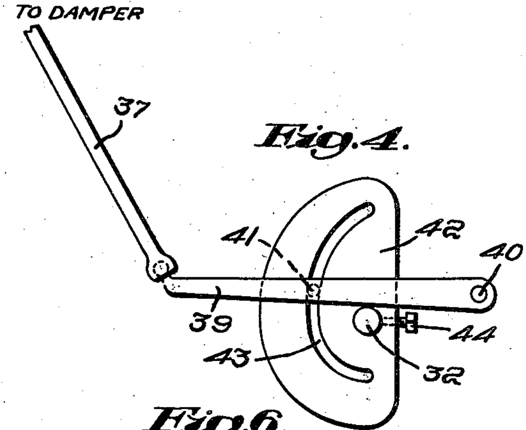


Fig. 5.

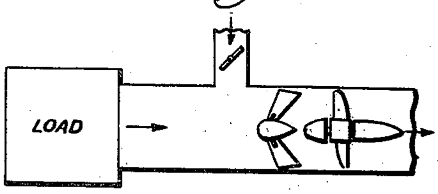


Fig. 6.

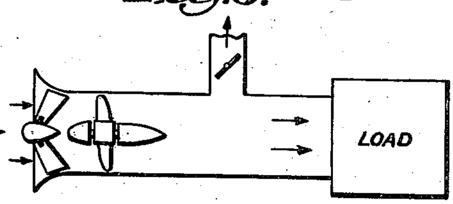


Fig. 7.

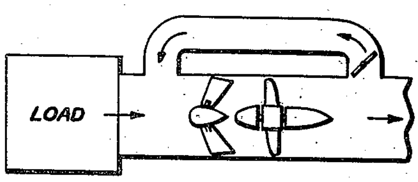


Fig. 8.

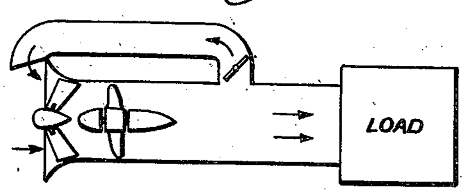
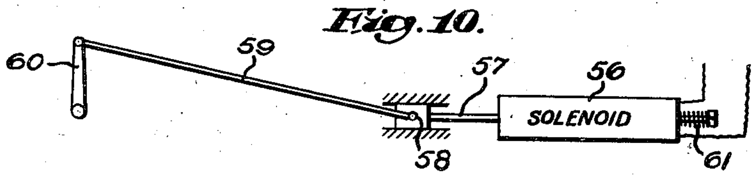


Fig. 10.



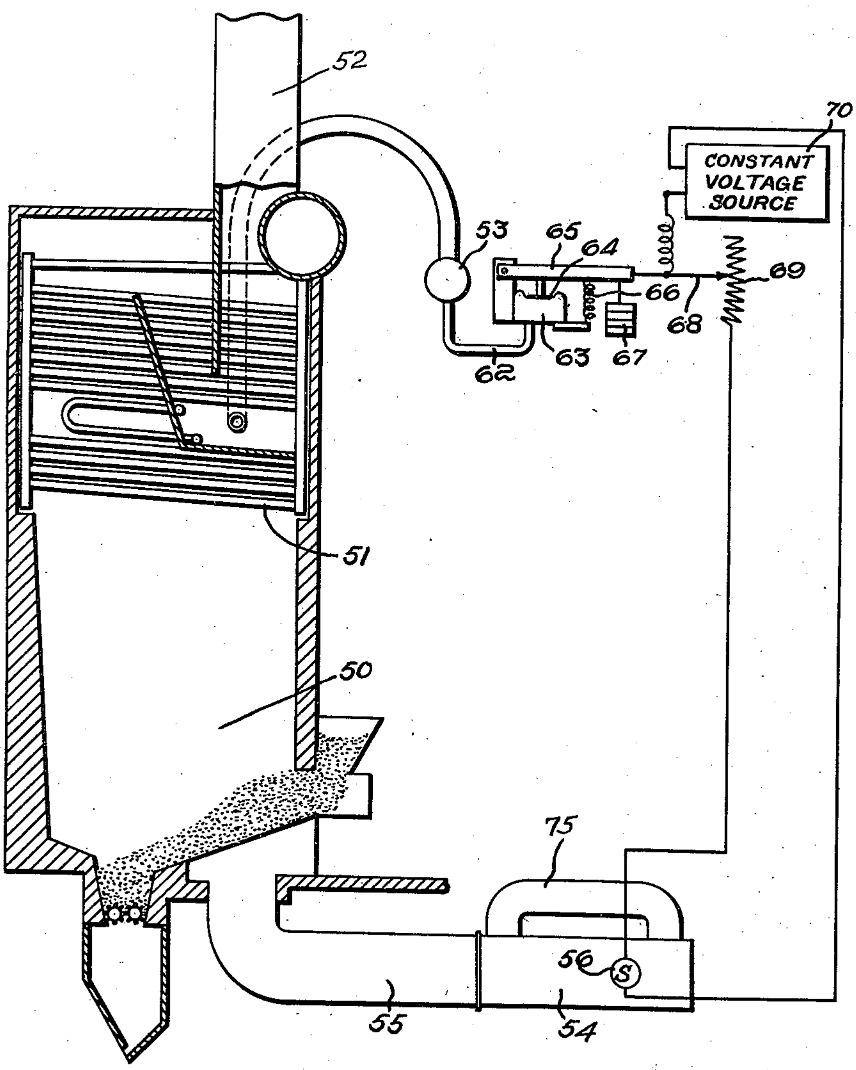
Inventor:
Harold F. Hagen,
by Robert T. Palmer
Attorney

Jan. 15, 1946. H. F. HAGEN 2,393,042

AXIAL FLOW FAN

Filed Jan. 16, 1943 4 Sheets-Sheet 3

Fig. 9.



Inventor:
Harold F. Hagen,
by Robert T. Palmer
Attorney

Jan. 15, 1946. H. F. HAGEN 2,393,042

AXIAL FLOW FAN

Filed Jan. 16, 1943 4 Sheets-Sheet 4

Fig. 11.

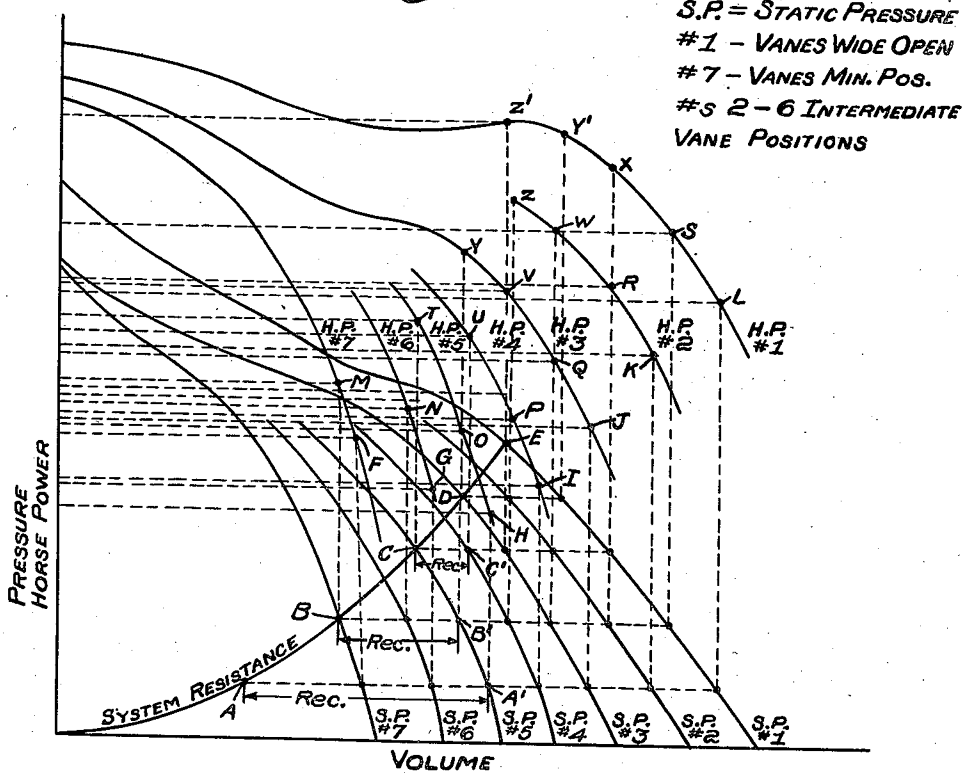


Fig. 12.

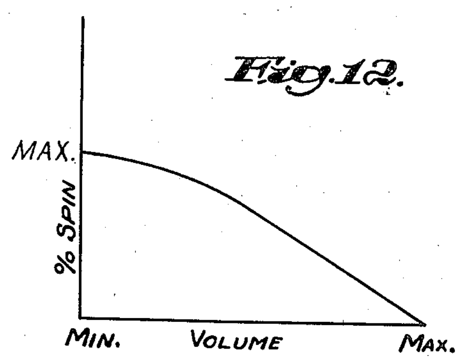
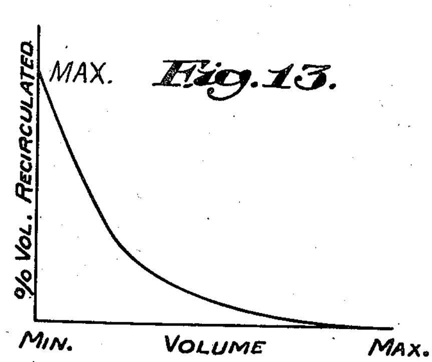


Fig. 13.



Inventor:
Harold F. Hagen,
by Robert J. Palmer
Attorney

UNITED STATES PATENT OFFICE

2,393,042

AXIAL FLOW FAN

Harold F. Hagen, Wellesley, Mass., assignor to B. F. Sturtevant Company, Boston, Mass.

Application January 16, 1943, Serial No. 472,543

17 Claims. (Cl. 230—114)

This invention relates to axial flow fans, and relates more particularly to means for operating axial flow fans connected to loads requiring reduced air gas volumes, at high efficiencies at the reduced volumes.

This application is a continuation-in-part of my copending applications, Serial No. 340,126, filed June 12, 1940, and Serial No. 456,635, filed August 29, 1942.

In many systems utilizing fans, such for example, as steam power plant systems, it is desirable to vary the air quantities of the fans. For example, in a steam power plant, it is usual to vary the volume of air supplied by a forced draft fan conformably with changes in the load upon the plant. It is also usual to drive the fans by constant speed induction motors. Heretofore it has been customary to utilize centrifugal fans for such duties for one reason that when an axial flow fan in the usual system, is driven at constant speed, it requires more power at the greatly reduced outputs required at times in power plant operation, than is required by centrifugal fans, with the result that the cost of operation of axial flow fans at reduced loads has been considered to be too great for efficient operation.

According to this invention, I provide for efficient operation of a constant speed axial flow fan at reduced loads by by-passing a portion of the output of the fan around the load and by spinning the air entering the fan, the volume of the by-passed air and the degree of spin depending upon the reduction in output which is desired. For varying the volume of by-pass air, dampers in the by-pass air passage are used, and for spinning the air, spin vanes of the type disclosed in my U. S. Patent No. 1,989,413 are used.

As fully explained in said patent and in my earlier U. S. Patent No. 1,846,863, spinning the air entering a fan causes a reduction in air pressure from the fan and a corresponding reduction in the volume of air delivered thereby. In a centrifugal fan, reduced air volumes thus obtained result in conformably reduced horsepowers over the entire operating range. Prior to the inventions disclosed in said patents, reduction in the output volumes from constant speed centrifugal fans were obtained by dampers in the fan outlets with inefficient operation due to the pressure loss through damper resistance.

Merely spinning the air entering axial flow fans does not provide the savings in power at reduced outputs that spinning the air entering centrifugal fans, does. In fact spinning the air entering axial flow fans for providing greatly reduced outputs, results in higher power requirements than for substantially higher outputs. Thus the spinning alone of the air entering axial flow fans for output volume control purposes is known to have no worthwhile advantages.

I have found that constant speed, axial flow fans may be operated to provide reduced outputs with high efficiencies over the entire range of adjustment which may be desired, by both spinning the air entering the fans and passing larger volumes of air through the fans than are required by the loads, the excess volumes of air being by-passed around the loads.

In one embodiment of this invention in which the fan has a load connected to its inlet, air from the atmosphere is drawn into the fan at reduced loads together with the air or other gas from the load for making up the volume at which the fan is most efficient.

In another embodiment of this invention in which the fan has a load connected to its outlet, the excess air or other gas required for efficient operation of the fan at reduced loads, is spilled off into the atmosphere at a point between the fan outlet and the load.

In another and preferred embodiment of the invention, a recirculation duct connects the outlet and the inlet of the fan, and the excess volumes at reduced loads, required for efficient operation, are recirculated through the fan.

A feature of this invention resides in coordinating the spin vane adjustment mechanism, and the damper adjustment mechanism for varying the volume of air by-passing the load, so that they can be varied simultaneously for most efficient operation, by a single calibrated control. This control may be adjusted manually for load changes or may be adjusted automatically by mechanism responding to load changes as will be described.

An object of this invention is to reduce the load volumes of a constant speed axial flow fan connected to a load requiring reduced air volumes below capacity, with corresponding reductions in the power required, by spinning the air entering the fan for providing reduced pressures, by passing larger volumes of air through the fan than are required by the load, and by by-passing the load with the differences between the desired volumes and the volumes provided by the fan.

Another object of the invention is to provide coordinated controls for variably spinning the air entering an axial flow fan and for simultaneously varying the volume of air by-passing the load connected to the fan, at reduced loads, whereby the fan operates at high efficiencies at the reduced loads.

The invention will now be described with reference to the drawings of which:

Fig. 1 is a front elevation with a portion in section and with a portion broken away, of an axial flow fan embodying this invention;

Fig. 2 is a side elevation partially in section of the fan of Fig. 1;

Fig. 3 is an enlarged view of the cam for adjusting the spin vanes, of Figs. 1 and 2;

Fig. 4 is an enlarged view of the cam for adjusting the damper, of Figs. 1 and 2;

Fig. 5 is a diagrammatic view illustrating how a fan embodying this invention may have a load connected to its inlet with a by-pass passage between the fan and the load for supplying into the fan, volumes of air in addition to those drawn from the load;

Fig. 6 is a diagrammatic view illustrating how a fan embodying this invention may have a load connected to its outlet with a spill passage between the fan and the load for spilling off air in excess of that required by the load;

Fig. 7 is a diagrammatic view illustrating how a fan embodying this invention may have a load connected to its inlet and may have a recirculation passage connecting its inlet and outlet for by-passing the load with the excess air moved by the fan;

Fig. 8 is a diagrammatic view illustrating how a fan embodying this invention may have a load connected to its outlet and may have a recirculation passage connecting its inlet and outlet for by-passing the load with the excess air moved by the fan;

Fig. 9 is a diagrammatic view illustrating the application of a fan embodying this invention, to a steam power plant with mechanism actuated by load changes for adjusting the spin vanes and the damper;

Fig. 10 is a view of the solenoid used with the mechanism of Fig. 9 for simultaneously adjusting the vane mechanism and the damper mechanism when load changes take place;

Fig. 11 is a curve chart illustrating the performance of an axial flow fan at different spin vane settings and at different loads;

Fig. 12 is a curve chart of axial flow fan performance illustrating typical vane settings for high efficiency at different load volumes, and

Fig. 13 is a curve chart of axial flow fan performance illustrating typical recirculation volumes for high efficiency.

The performance of a typical axial flow fan will first be described with reference to Figs. 11, 12, and 13.

Fig. 11 illustrates the performance of a typical axial flow fan at different spin vane settings and for different loads. The curve lettered "System resistance" shows the pressure required to overcome the system resistance of a load at different air or other gas volumes. The curve lettered "S. P. #1" illustrates the pressures at different volumes with the spin vanes wide open for providing no spin. The curve lettered "H. P. #1" illustrates the powers required for providing the pressures along the curve S. P. #1. The curve lettered S. P. #7 illustrates the pressures at different volumes with the spin vanes set at a minimum position which would not however, be a fully closed position. The curve lettered H. P. #7 illustrates the powers required for providing the pressures along the curve S. P. #7. The pressure curves lettered S. P. #2, #3, #4, #5, and #6 illustrate the pressures at intermediate vane settings and the power curves lettered H. P. #2, #3, #4, #5, and #6 illustrate the corresponding power required.

The points A, B, C, D, and E are selected along the system resistance curve for different loads ranging from a selected minimum to a maximum, respectively. A horizontal line is drawn from the point A through the pressure curves and where this line intersects the different pressure curves, vertical lines are drawn to intersect the corresponding power curves. These points of intersection of the power curves give the power required for the corresponding vane settings. The points F, G, H, I, J, K and L show the powers required at different vane settings for providing the desired pressure corresponding to the resistance point A. The point H is for the minimum horsepower and since the corresponding pressure provides a much larger volume than is required, the volume A—A' in excess of that required by the load, must be passed through the fan and by-passed around the load. The spin vanes are set at position #5.

A horizontal line is drawn from the resistance point B through the pressure curves and where this line intersects the different pressure curves, vertical lines are drawn to intersect the corresponding power curves. These points of intersection of the power curves give the powers required for the corresponding vane settings. The points M, N, O, P, Q, R and S show the powers required at different vane settings for providing the desired pressure corresponding to the resistance point B. The point O is for the minimum horsepower and since the corresponding pressure provides a larger volume than is required, the volume B—B' which is in excess of that required by the load, is by-passed around the load. The spin vanes are set in position #5.

A horizontal line is drawn from the resistance point C through the pressure curves and where this line intersects the different pressure curves, vertical lines are drawn to intersect the corresponding power curves. These points of intersection of the power curves give the powers required for the corresponding vane settings. The points T, U, V, W, and X show the powers required at different vane settings for providing the desired pressure corresponding to the resistance point C. The point U is for the minimum horsepower and since the corresponding pressure provides a larger volume than is required, the volume C—C' which is in excess of that required by the load, is by-passed around the load.

A horizontal line is drawn from the resistance point D through the pressure curves and where this line intersects the different pressure curves, vertical lines are drawn to intersect the corresponding power curves. These points of intersection of the power curves give the powers required for the corresponding vane settings. The points Y, Z and Y' show the powers required at different vane settings, for providing the desired pressure corresponding to the resistance point D. The point Y is the point of minimum horsepower. This point is vertically above the point of intersection of the curve S. P. #3 with the system resistance curve showing that minimum horsepower is required with the spin vanes at position #3 with no recirculation.

Since the resistance point E, the point of maximum load falls on the curve S. P. #1, with spin vanes wide open, the horsepower required is shown by the point Z' on the curve H. P. #1, there again being no recirculation.

It is seen that for small loads below maximum, most efficient operation may be obtained through spinning with no recirculation but as the loads are decreased, most efficient operation is obtained by combining spinning and recirculation. As the loads approach minimum, the percentage of recirculation increases and the percentage of spinning remains constant or may increase at a greatly reduced rate of increase.

Relatively few curves for spin vane positions have been plotted on Fig. 11 and relatively few load resistances have been selected. To show more curves and lines would result in unduly complicating the drawing. Figs. 12 and 13 illustrate however generally what may be expected as to the degree of spin and degree of recirculation required for different volumes.

Fig. 12 illustrates what may be expected as to the rate of change of spin for different volumes for most efficient operation. The rate of increase of spin will increase for volume decreases up to a certain minimum depending upon load resistance and fan characteristics and then remain constant or increase but slightly.

Fig. 13 illustrates what may be expected as to the rate of change of recirculation for different volumes for most efficient operation. It may be expected that there will be little or no recirculation for volumes slightly below maximum and that the rate of recirculation will increase as the volume decreases.

Figs. 11, 12 and 13 are illustrative only and since different fans may have different characteristics and since different loads may have different resistance characteristics, departures from the showings of the curves of Figs. 11, 12, and 13 may be expected. These curves however are believed to show generally the desirability of combining spinning and recirculation for reduced loads.

Referring now to Figs. 1 and 2, the casing 12 has mounted therein the axial flow fan 13 driven by a motor contained within the stream-lining fairing 14. The vanes 15 which support the fairing from the casing are the usual spin straightening vanes and may be four in number.

The spin vanes 16 which preferably are similar to those disclosed in my said Patent No. 1,989,413 are mounted in the inlet of the fan. The lower ends of the vanes 16 are attached to the rods 17 which are journaled in the streamlining fairing 18 for rotation therein. The vanes 16 are attached at their tips to the rods 19 which are pivoted in the diverging wall 20 forming the fan inlet.

The rods 19 have mounted thereon the bevel gears 21 which mesh with the bevel gears 22 mounted on the plates 23. The plates 23 are interconnected by the links 24. The lever 25 is attached to one of the gears 22 and is rotatable simultaneously through the gearing and linkage described to rotate the vanes 16 from full open position where they have no spin effect upon the air through an angle sufficient to place the vanes in the maximum spin position which may be desired. This mechanism and its principle of operation are described in detail in my said Patent No. 1,989,413.

The lever 25 is connected by the rods 26 and the take-up sleeve 27 to the outer end of the cam lever 28 (Fig. 3). The lever 28 is pivoted at 29 at its inner end and has the cam follower 30 between its ends. The cam 31 which is held on the cam adjusting shaft 32 for rotation therewith, by the screw 33 has the slot 34 formed thereon and on which the cam follower 30 is moved by motion of the cam as will be described.

The recirculation duct 35 interconnects the outlet and the inlet of the fan and contains the damper 36 for regulating the volume of air which is recirculated. The rods 37 and the take-up sleeve 38 connect the damper 36 with the outer end of the cam lever 39 (Fig. 4), the inner end of the lever 39 being pivoted at 40. The cam follower 41 is formed on the lever 39 between its ends and is moved within the slot 42 in the cam 43 by rotation of the cam by the shaft 32 to which it is attached by the screw 44.

The control lever 45 has the indicator 46 which moves along the calibrated segment 47 and is attached to the cam shaft 32 and when moved along the segment 47, rotates the cam shaft. Rotation of the cam shaft causes rotation of the cams 31 and 43 and simultaneous adjustments of the spin vanes and of the damper.

The slot 34 in the cam 31 is shaped to cause the spin vanes to be adjusted to provide spin as illustrated by Fig. 12, and the slot 42 in the cam 43 is shaped to cause the damper to be adjusted to provide recirculation volumes as illustrated by Fig. 13.

The cam shaft 32 is supported by the bearings 48 from the base 49 which in turn is attached to the inlet portion 20 of the casing. The calibrated segment 47 is supported by the brackets 50 from the base 49.

The segment 47 may be calibrated in terms of load or of the air volumes to be supplied at different loads. The control lever for adjusting the vanes and the damper may be adjusted manually as illustrated by Figs. 1 and 2 or automatically conformably with changes in load as illustrated by Figs. 9 and 10 as will now be explained.

Fig. 9 illustrates a typical steam power plant with combustion chamber 50, boiler tubes 51, stack 52 and steam header 53.

A casing 54 containing an axial flow fan embodying this invention is connected by the duct 55 to supply air for combustion, to the combustion chamber 50. The fan includes the recirculation duct 75. The solenoid 56 has its plunger 57 connected as shown by Fig. 10 through the crosshead 58 and connecting rod 59 to the vane and damper control lever 60 which corresponds to the control lever 45 of Figs. 1 and 2 and which is connected to cam adjusting mechanism such as is shown by Figs. 1 and 2.

The solenoid 56 is energized with electric currents which vary conformably with the loads on the boiler so that it retracts its plunger 57 distances which vary with the loads. For full load the plunger is fully retracted and the lever 60 then set for adjusting the damper in the recirculation duct 55 to fully closed position for no recirculation, and for adjusting the spin vanes for wide open position for no spin. For reduced loads the energizing current to the solenoid decreases and the spring 61 returns the plunger 57 to the proper position for the reduced load.

For regulating the energizing current to the solenoid conformably with boiler load changes, a standard Leeds & Northrup control which will now be described with reference to Fig. 9 may be used.

Steam from the header 53 passes through the pipe 62 into the chamber 63 sealed with the diaphragm 64. The diaphragm 64 exerts a force upon the pivoted lever 65 which is loaded by the spring 66 and the weights 67, so that the lever assumes different positions as the pressure drop in the header varies with the steam flow. The lever 65 is connected to the resistance arm 68 which moves along the resistor 69.

The contact arm 68, the resistor 69 and the solenoid 56 are in series with the constant voltage source 70. When the resistor arm 68 is at the position corresponding to the lowest boiler pressure, that is, to maximum steam flow, all of the resistance is cut out of the circuit and the energizing current of the solenoid 56 is therefore at the maximum. As the load reduces, the steam flow volume reduces, the boiler pressure increases and more of the resistor 69 is placed in the solenoid circuit for decreasing the solenoid energizing current. This causes, as the load decreases, the controls described in the foregoing, to adjust the spin vanes for increased spin, and the recirculation damper, for increased volumes of gas recirculated through the fan and by-passed around the combustion chamber.

Figs. 5, 6, 7 and 8 illustrate different ways this invention may be practiced.

In Fig. 5 the fan is an induced draft fan connected at its inlet to a load and having a by-pass passage between its inlet and the load whereby at reduced loads, volumes of gas in excess of those required from the load may be passed through the fan for maintaining high efficiencies at reduced loads.

In Fig. 6 the fan is a forced draft fan connected at its outlet to a load and having a spill passage for spilling off the excess volumes of gas not required by the load but which are required, at reduced loads, for high fan efficiencies.

In Fig. 7 the fan is an induced draft fan connected at its inlet to a load and having a recirculation passage for providing gas volumes in excess of those drawn from the load, through the fan for maintaining high efficiencies at reduced loads.

In Fig. 8 the fan is a forced draft fan connected at its outlet to a load and having a recirculation passage for recirculating gas volumes in excess of those supplied to the load, through the fan for maintaining high efficiencies at reduced loads.

The dampers and the spin vanes of the systems shown by Figs. 5–8 inclusive could be and preferably would be adjusted in step by mechanism utilizing the principles shown by the adjusting mechanism of Figs. 1 and 2.

In the practice of the invention illustrated by Figs. 1 and 2 and also Fig. 10, the manufacturer, it is expected, would supply the fan in its casing and including the spin vanes, a recirculation cr other form of by-pass duct with its damper and the mechanism for adjusting the spin vanes and the damper. The fan could be a stock fan for handling a given load or range of loads. The purchaser of the fan could supply data as to the resistance of the load to which the fan would be connected, such as the system resistance curve of Fig. 11 and the manufacturer from this and knowledge of the fan characteristics could provide cams which would adapt the fan and its adjusting machinery for use at high efficiency which means for minimum horsepower input to the fan at any point on a given system resistance.

While embodiments of the invention have been described for the purpose of illustration, it should be understood that the invention is not limited to the exact apparatus and arrangement of apparatus illustrated, as modifications thereof may be suggested by those skilled in the art without departure from the essence of the invention.

What is claimed is:

1. In a fan system having an axial flow fan driven by a constant speed motor, said fan having a conduit forming a passage for connecting said fan to apparatus forming a load upon said fan, the combination of means forming a bypass passage connected to said passage for bypassing said apparatus with a portion of the air volume handled by said fan, dampering means in said bypass passage for varying the volume of bypassed air, air spinning means in the inlet of said fan for varying the volume of air handled thereby, and means for adjusting said dampering means and said air spinning means for reducing the air volumes through said fan at reduced load requirements while maintaining larger volumes through said fan than are required by said apparatus and for bypassing said apparatus with the differences between the air volumes handled by said fan and those required by said apparatus.

2. In a fan system having a constant speed fan driving motor, the combination of an axial flow fan connected to said motor, said fan having a conduit forming a passage for connecting said fan to apparatus forming a load thereon, means forming a bypass passage connected to said passage for bypassing said apparatus with a portion of the air volume handled by said fan, dampering means in said bypass passage for varying the volume of bypassed air, air spinning means in the inlet of said fan for varying the volume of air handled thereby, and means for adjusting said dampering means and said spinning means for reducing the air volumes through said fan at reduced load requirements while maintaining larger volumes therethrough than are required by said apparatus and for bypassing said apparatus with the differences between the air volumes handled by said fan and those required by said apparatus.

3. In a fan system having an axial flow fan driven by a constant speed motor, the combination of a conduit forming a recirculation passage connected to the inlet and outlet of said fan for recirculating air through said fan in a path bypassing the apparatus to which the fan is to be connected, dampering means in said passage for varying the volume of air recirculated therethrough, air spinning means in said inlet for varying the volume of air handled by said fan, and means for adjusting said dampering means and said spinning means for reducing the air volumes through said fan at reduced apparatus requirements while maintaining larger volumes through the fan than are required from it by the apparatus and for bypassing the apparatus with the differences between the air volumes provided by the fan and those required by the apparatus.

4. In a fan system having a constant speed fan driving motor, the combination of an axial flow fan connected to said motor, means forming a recirculation passage connected to the inlet and outlet of said fan for recirculating air therethrough in a path bypassing the apparatus to which the fan is to be connected, dampering means in said passage for varying the volume of air recirculated therethrough, air spinning means in said inlet for varying the volume of air handled by said fan, and means for adjusting said dampering means and said spinning means for reducing the air volumes through said fan at reduced apparatus requirements while maintaining larger volumes through the fan than are required from it by the apparatus and for bypassing the apparatus with the differences between the air

volumes provided by the fan and those required by the apparatus.

5. An axial flow fan comprising a casing having an inlet and an outlet, axial flow fan blades supported for rotation in said casing, spin vanes in said inlet, said casing having an extension forming a passage for connecting said fan to apparatus forming a load thereon, means forming a bypass passage connected to said passage for bypassing the apparatus with a portion of the air volume handled by the fan, dampering means in said bypass passage, and interconnected control means having a common actuator for adjusting said vanes and said dampering means.

6. An axial flow fan comprising a casing having an inlet and an outlet, axial flow fan blades supported for rotation in said casing, spin vanes in said inlet, said casing having an extension forming a passage for connecting said inlet to apparatus forming a load upon said fan, means forming a bypass passage connected to said passage for bypassing said apparatus with a portion of the air volume drawn in by said fan, dampering means in said bypass passage, and interconnected control means having a common actuator for adjusting said vanes and said dampering means.

7. An axial flow fan comprising a casing having an inlet and an outlet, axial flow fan blades supported for rotation in said casing, spin vanes in said inlet, said casing having an extension forming a passage for connecting said outlet to apparatus forming a load upon said fan, means forming a bypass passage connected to said passage for bypassing said apparatus with a portion of the air volume supplied by said fan, dampering means in said bypass passage, and means including interconnected control means having a common actuator for adjusting said vanes and said dampering means.

8. An axial flow fan comprising a casing having an inlet and an outlet, axial flow fan blades mounted for rotation in said casing between said inlet and outlet, spin vanes in said inlet, said casing having an extension forming a passage connected to said inlet and outlet for recirculating through said fan a portion of the air volume handled thereby, dampering means in said passage, and interconnected control means having a common actuator for adjusting said vanes and said dampering means.

9. In a fan system having an axial flow fan connected to apparatus adapted to be operated under different loads and requiring air volumes varying with the loads, the combination of a conduit forming a bypass passage between said fan and apparatus for bypassing said apparatus at reduced loads with a portion of the air handled by said fan, dampering means in said passage, spin vanes in the inlet of said fan, and means including means responsive to changes in the load upon said apparatus for adjusting said vanes and said dampering means.

10. In a fan system having an axial flow fan connected to apparatus adapted to be operated under different loads and requiring air volumes varying with the loads, the combination of a conduit forming a recirculation passage between the inlet and the outlet of said fan for bypassing said apparatus at reduced loads with a portion of the air handled by said fan, dampering means in said passage, spin vanes in the inlet of said fan, and means including means responsive to changes in the load upon said apparatus for adjusting said vanes and said dampering means.

11. In a fan system having an axial flow fan connected at its inlet to apparatus adapted to be operated under different loads and requiring air volumes varying with the loads, the combination of a conduit forming a bypass passage at said inlet for bypassing said apparatus at reduced loads with a portion of the air drawn in by said fan, dampering means in said passage, spin vanes in said inlet, and means including means responsive to changes in the load upon said apparatus for adjusting said vanes and said dampering means.

12. In a fan system having an axial flow fan connected at its outlet to apparatus adapted to be operated under different loads and requiring air volumes varying with the loads, the combination of a conduit forming a bypass passage at said outlet for bypassing said apparatus with a portion of the air supplied by said fan at reduced loads, dampering means in said passage, spin vanes in the inlet of said fan, and means including means responsive to changes in the load upon said apparatus for adjusting said vanes and said dampering means.

13. An axial flow fan comprising a casing having an inlet and an outlet, axial flow fan blades mounted for rotation in said casing, spin vanes in said inlet, said casing having an extension forming a passage for connecting said fan to apparatus forming a load upon said fan, means forming a bypass passage connected to said passage for bypassing said apparatus with a portion of the air volume handled by said fan, dampering means in said bypass passage, means including a cam for adjusting said vanes, means including a cam for adjusting said dampering means, and means including means connected to said cams for adjusting said vanes and dampering means in step.

14. An axial flow fan comprising a casing having an inlet and an outlet, axial flow fan blades mounted for rotation in said casing between said inlet and outlet, spin vanes in said inlet, said casing having an extension forming a passage for connecting said inlet to apparatus forming a load upon said fan, means forming a bypass passage connected to said passage for bypassing said apparatus with a portion of the air volume drawn in by said fan, dampering means in said passage, means including a cam for adjusting said vanes, means including a cam for adjusting said dampering means, and means including means connected to said cams for adjusting said vanes and said dampering means in step.

15. An axial flow fan comprising a casing having an inlet and an outlet, axial flow fan blades mounted for rotation in said casing between said inlet and outlet, said casing having an extension forming a passage for connecting said outlet to apparatus forming a load upon said fan, means forming a bypass passage connected to said passage for bypassing said apparatus with a portion of the air volume supplied by said fan, dampering means in said bypass passage, spin vanes in said inlet, means including a cam for adjusting said dampering means, means including a cam for adjusting said vanes, and means including means connected to said cams for adjusting said dampering means and said vanes in step.

16. An axial flow fan comprising a casing having an inlet and an outlet, axial flow fan blades mounted for rotation in said casing between said inlet and outlet, said casing having an extension forming a passage for connecting said inlet with said outlet for recirculating a portion of the air volume handled by said fan therethrough, damp-

ering means in said passage, spin vanes in said inlet, means including a cam for adjusting said dampering means, means including a cam for adjusting said vanes, and means including means connected to said cams for adjusting said vanes and said dampering means in step.

17. An axial flow fan comprising a casing having an inlet and an outlet, axial flow fan blades mounted for rotation in said casing between said inlet and outlet, spin vanes in said inlet, said casing having an extension forming a passage for connecting said fan to apparatus forming a load upon said fan, means forming a bypass passage connected to said passage for bypassing said apparatus with a portion of the air volume handled by said fan, dampering means in said bypass passage, means for adjusting said vanes for reducing the air volumes through said fan at reduced apparatus requirements while maintaining larger volumes through the fan than are required by said apparatus, means for adjusting said dampering means for bypassing said apparatus with the differences between the air volumes provided by the fan and those required by said apparatus, and means including means connected to said vane adjusting means and said means for adjusting said dampering means for indicating the positions at which said vanes and said dampering means should be set at different apparatus requirements.

HAROLD F. HAGEN.