April 4, 1967 R. L. HULL ETAL 3,312,386

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Filed Dec. 21, 1964 6 Sheets-Sheet 1

FIG. 1

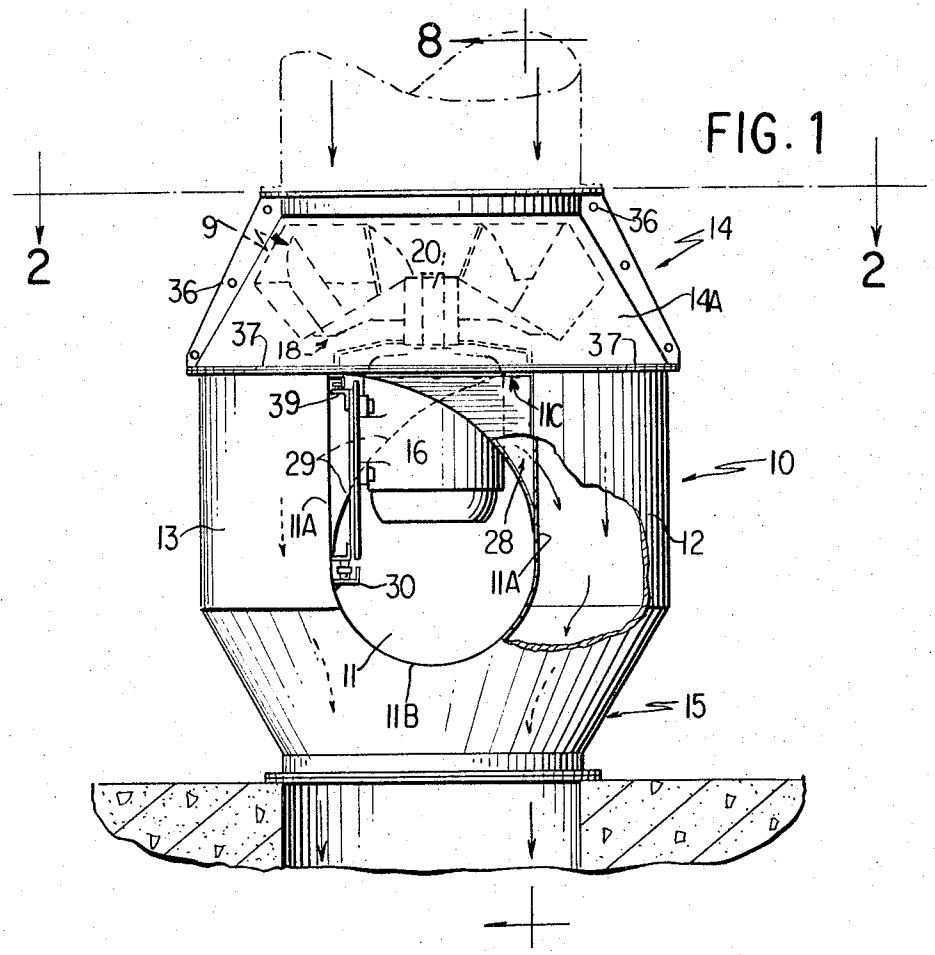
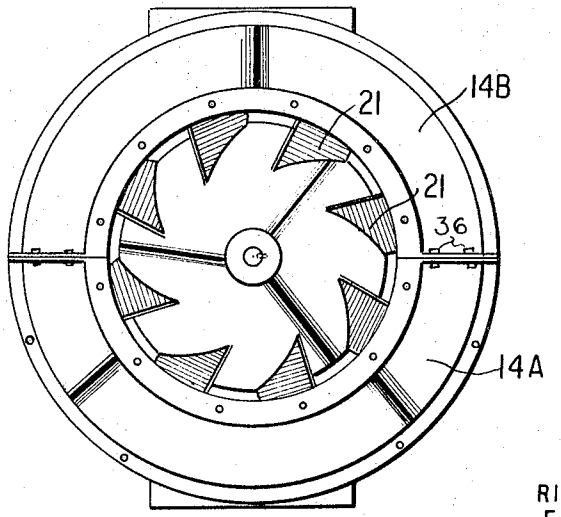


FIG. 2



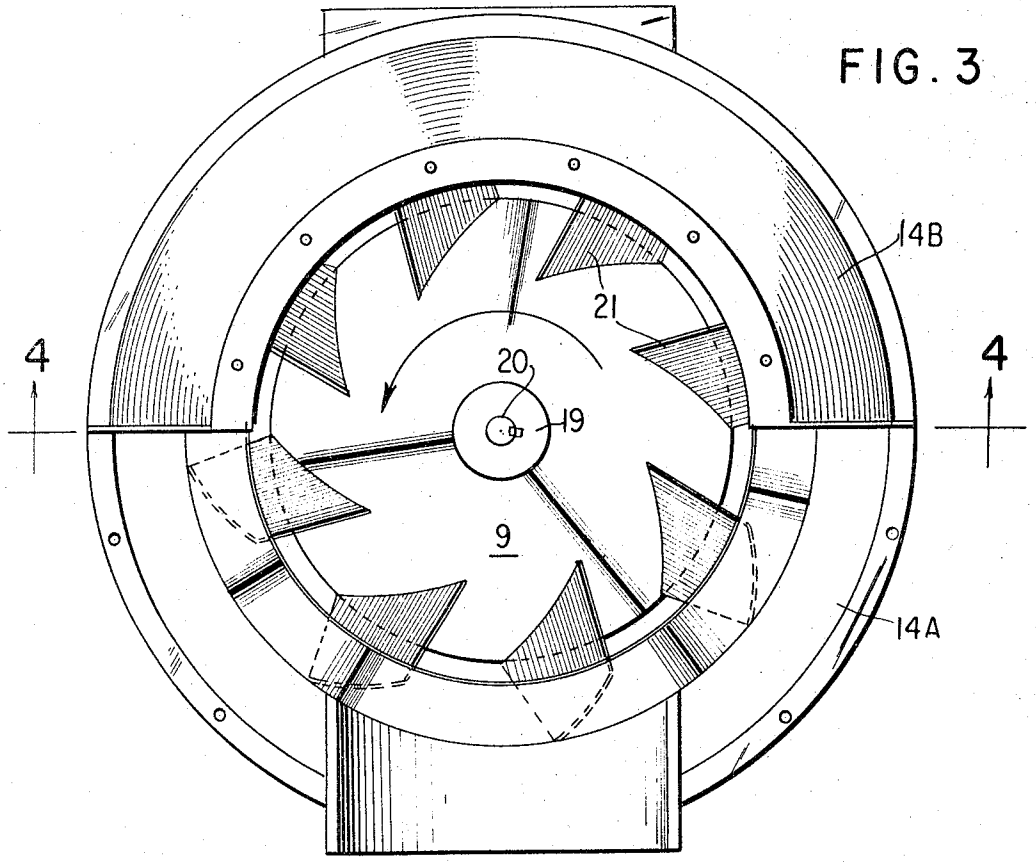
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FIG. 3



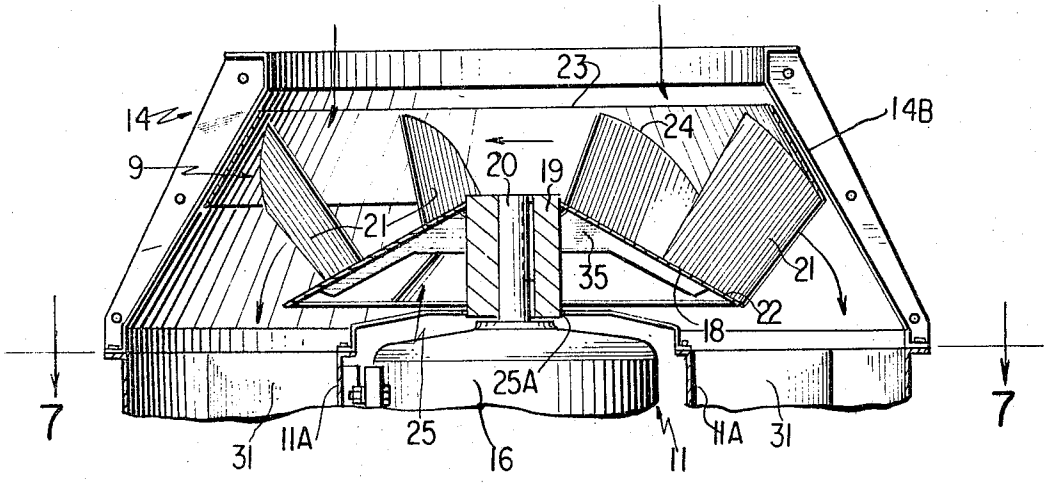


FIG. 4

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FIG. 6

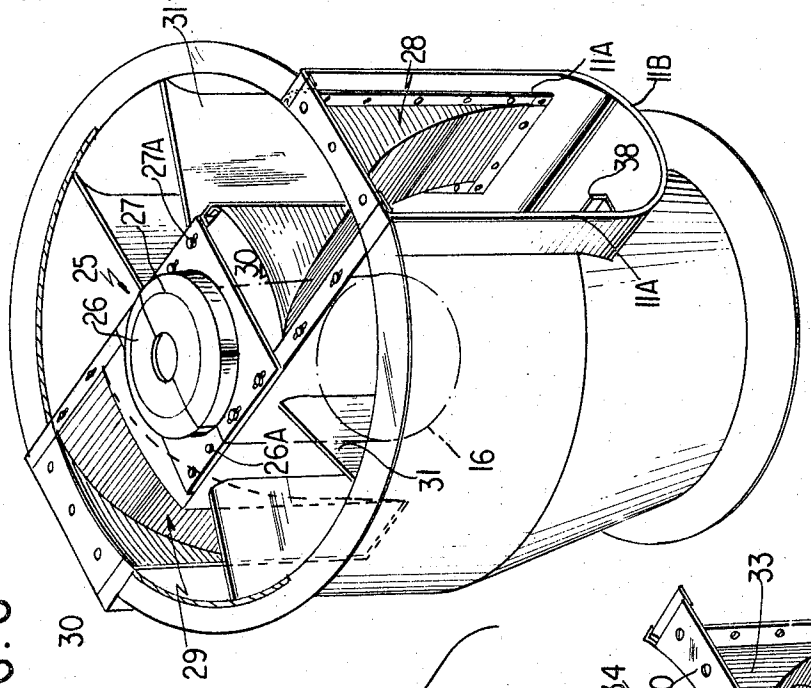
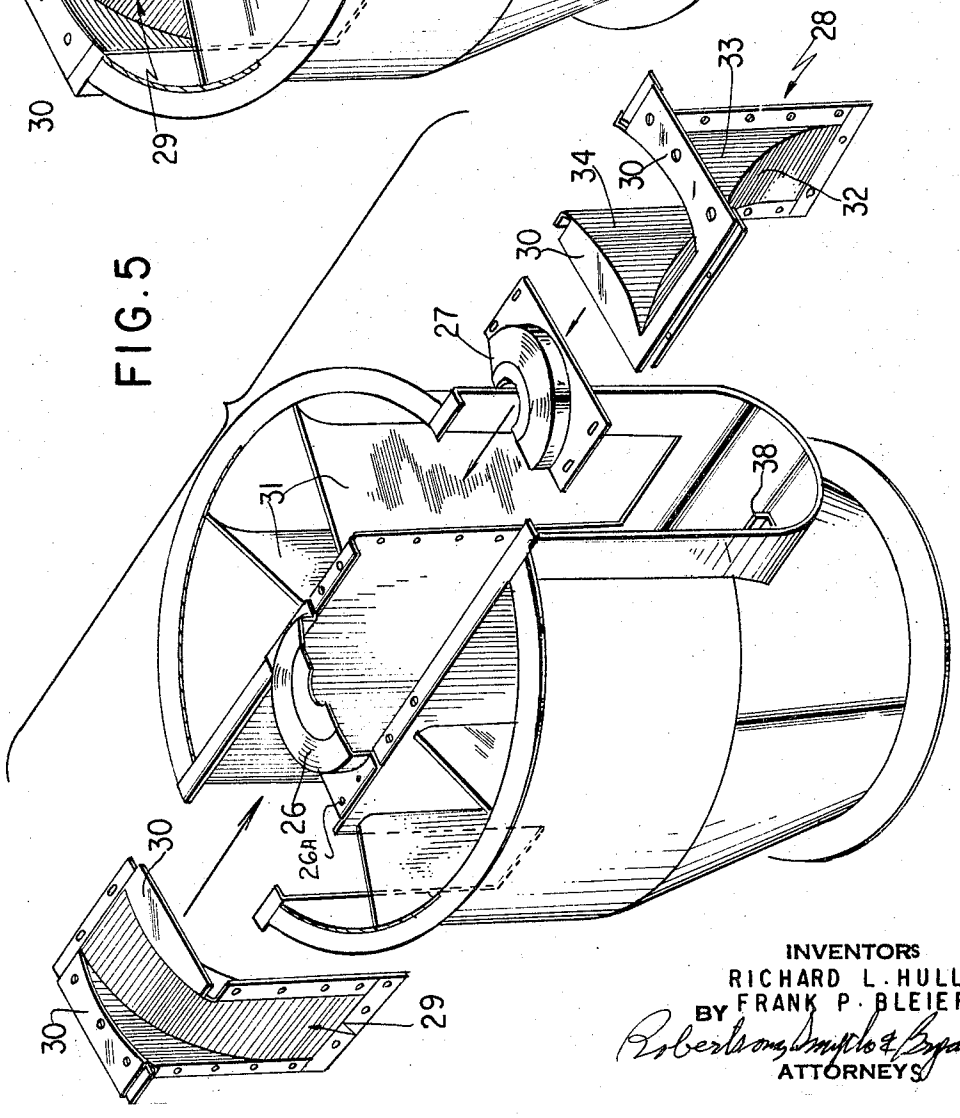


FIG. 5



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Filed Dec. 21, 1964 6 Sheets-Sheet 4

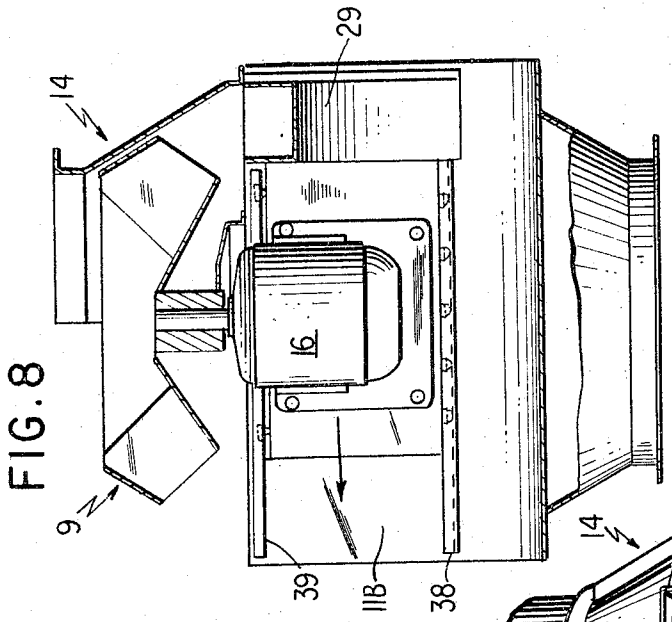


FIG. 8

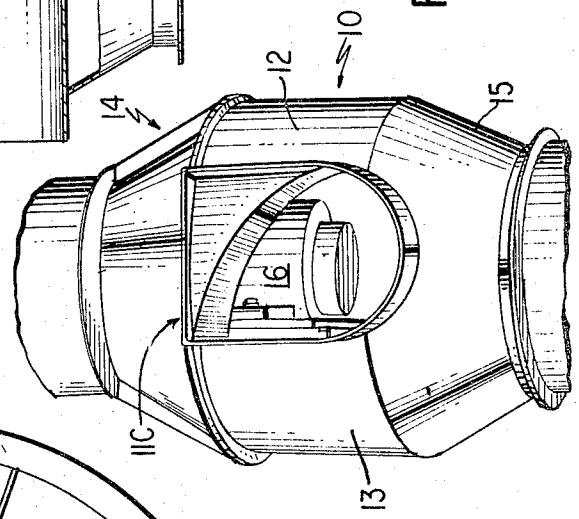


FIG. 9

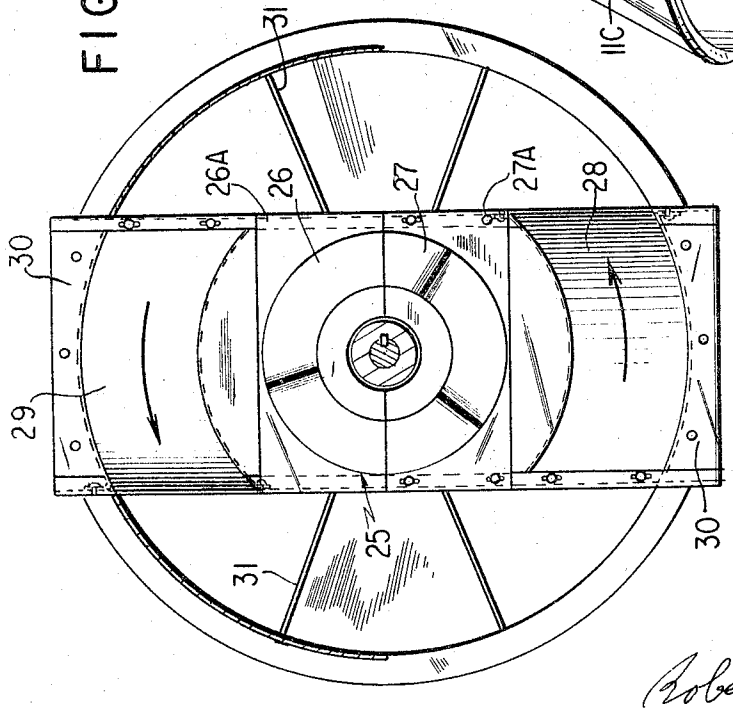
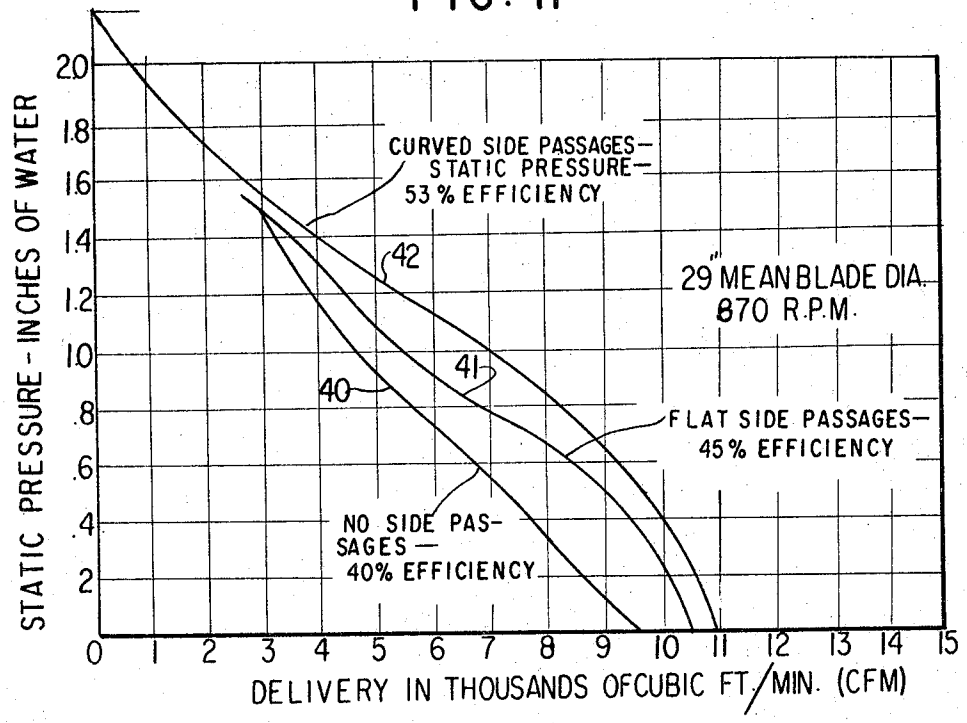


FIG. 7

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FIG. 11



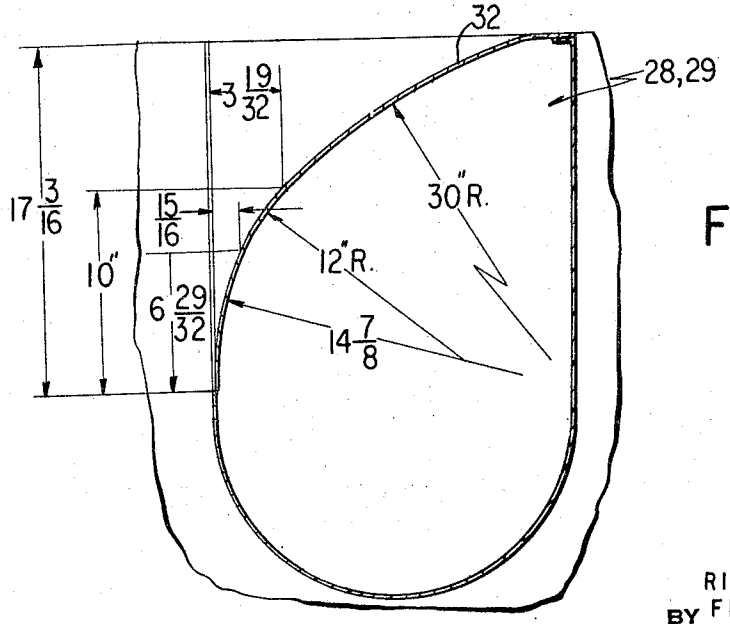


FIG. 10

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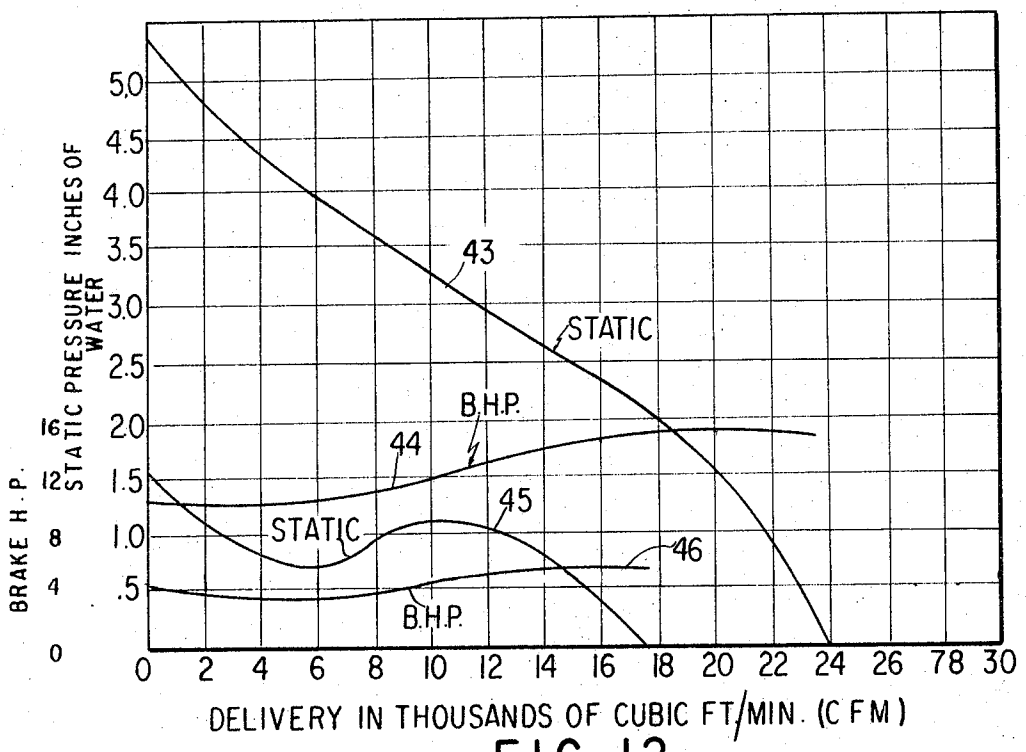


FIG. 12

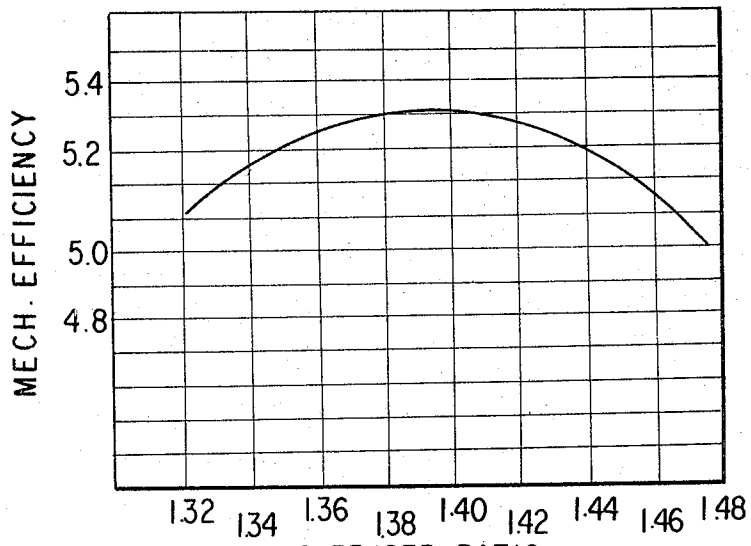


FIG. 13

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United States Patent Office 3,312,386 Patented Apr. 4, 1967

3,312,386

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Filed Dec. 21, 1964, Ser. No. 420,050
13 Claims. (Cl. 230—117)

This invention relates to fans and particularly to those of the divided or dual duct passage type.

Fans having divided passageways or double ducts and employing axial type impellers are well known in the art, such being especially useful for handling corrosive or hot gases, fumes, explosive mixtures, and similar materials. In the double duct or bifurcated fan, the fan motor is protected from destructive atmosphere, because it is in a separate motor chamber or pasage extending transversely through the body of the unit so that gases flow around the chamber. The motor chamber also may provide motor cooling by natural air circulation. In some installations, it has been found that higher pressure than hitherto available in dual duct or bifurcated axial fans is required.

One of the objects of the invention is to provide a dual duct fan construction for producing higher static pressures than in prior dual duct fans.

Another of the objects of the invention is to provide a fan assembly which is efficient and which is capable of high performance with low sound level.

A still further object of the invention is to provide a fan having a low tip speed for giving pressures.

Another object of the invention is to provide a fan which will give a higher rate of flow through a given duct system than those previously used.

Another object of the invention is to provide a fan unit which will give a greater output for a given duct size and speed.

A still further object of the invention is to combine the advantages of a centrifugal type fan with an axial dual duct fan.

In one aspect of the invention, a main housing is provided having an inlet and outlet with a driving means or motor chamber extending across or transversely through the main housing, the chamber being open to the atmosphere at both ends. This provided dual ducts or main passages through which gas can flow around each side of the chamber. The chamber has an upstream wall, downstream wall and side walls, the latter comprising one of the walls of each of said ducts. This permits the motor to be located outside of the gas stream in the housing. The inlet and outlet portions of the housing may be conical in form with a tubular central portion through which the chamber extends.

The motor or driving means is located in the chamber with its shaft extending through the upstream wall. A fan wheel or impeller is attached to the shaft adjacent the inlet of the main housing for moving gas from the inlet, through the dual ducts, to the outlet. The fan wheel or impeller includes blades and supports therefor arranged to move the gas both axially and outwardly or in a divergent pattern or path of flow. The wheel may include a substantially conical back plate with fan blades mounted thereon and with a substantially conical shroud or ring attached to the outer ends of the blades.

The term "conical" means a cone with straight surfaces or surfaces which can be curved.

As the fan draws gas from the inlet and moves it toward the outlet, gas will flow into and along the duct means from the fan wheel at the inlet of the housing. One or more trough-shaped side or supplementary passages are provided in the upstream wall portion of the chamber for guiding gas as it reaches the upstream wall or plane thereof through or into the side walls of the ducts on each side of

the fan axis, and thence into the gas flow through said duct means. Preferably, one side passage is located on each side of the axis of the fan. Thus, instead of hitting a closed surface and being carried to the dual duct openings in a possibly turbulent manner across the upstream wall, the gas is smoothly directed into the gas flow in the dual ducts. The bottom walls of the trough-shaped side passages preferably have a curved surface in order to provide smooth or laminar flow from the fan to the duct means. The curved surface may be one having a varying curvature composed of discrete arcs or a continuous curve, such being described in detail hereafter.

In order to assemble or remove the fan and motor, half of the inlet cone can be made removable and the upstream wall or bulkhead and side passages constructed such that they can be removed on one side of the fan axis so as to permit the motor or driving means and fan to be slid or moved outwardly from the housing and chamber.

The fan wheel can have ribs on the underside of the conical back plate for drawing air from the motor chamber around the motor hub and into the housing If desired, radiation shields could be provided between the fan motor and the chamber walls.

The side ducts have gas flow straightening vanes therein that start relatively close to the trailing edge of the fan blades.

These and other objects, advantages and features of the invention will become apparent from the following description and drawings which are merely exemplary.

In the drawings:

FIG. 1 is an elevation view partially in section of one form of the invention;

FIG. 2 is a section taken along the line 2—2 of FIG. 1;

FIG. 3 is an enlarged top view similar to FIG. 2 but showing one half of the inlet cone removed;

FIG. 4 is a sectional view along the line 4—4 of FIG. 3;

FIG. 5 is an exploded perspective view showing the manner in which the fan can be assembled, the inlet cones being omitted;

FIG. 6 is an assembled view of the parts in FIG. 5;

FIG. 7 is a top view of FIG. 6 showing the parts in assembled relation;

FIG. 8 is a fragmentary view, partially in section, taken in the direction and along line 8—8 of FIG. 1, the cone and one side passage being removed;

FIG. 9 is a perspective side view of the assembly;

FIG. 10 is an enlarged fragmentary side view showing one form of curvature of the bottom plate of the side passages;

FIG. 11 shows fan performance curves indicating the relation of static pressure to delivery of gas by a fan made without a side passage and with two types of side passages;

FIG. 12 shows fan performance curves of a fan made in accordance with the present invention as compared with an axial dual duct fan; and

FIG. 13 is a curve showing the effect on efficiency of varying the diffuser ratio.

Referring to FIG. 1, main housing **10** has a transverse motor chamber or passage **11** extending therethrough. Where appropriate, "motor chamber" includes "driving means chamber." Sector-shaped main passage means or dual ducts **12** and **13** guide gas or other material being handled from inlet cone **14** into outlet cone **15**. Motor **16** is located in motor chamber **11** out of the flow of gas or other material being handled by the fan. Motor chamber **11** has side walls **11A**, downstream wall **11B** and upstream wall shown generally at **11C**. The upstream wall is composed of several parts as will appear hereafter.

The fan wheel or impeller **9** is of the mixed flow type and has a conical back plate **18** on hub **19** (FIGS. 1, 4) which is mounted on shaft **20** of motor **16**. Fan blades

21 are fastened at their inner edges 22 to conical back plate 18 by welding or other similar manner. The outer edges 24 of the blades are similarly fastened to a shroud or ring 23. Preferably, shroud 23 should be the length of the blades, but the conical back plate need not be.

Conical inlet portion 14 is arranged so that the exterior of shroud 23 is closely adjacent to the interior surface thereof. The reason for this is that excessive clearance might permit undesirable recirculation of the gas in this zone.

Bulkhead cap 25, part of the upstream wall 11C, is in two parts 26, 27 (FIG. 7), so as to permit removal of the fan as in the manner to be described hereafter. Cap 25 is arranged so that there is a clearance 25A between the cap 25 and hub 19, which clearance should be relatively small.

Supplementary or side passages 28, 29 lead from the plane of the bulkhead or upstream wall 11C adjacent to the region of the impeller 9 to the sector-shaped passages or dual ducts 12, 13. Bulkhead cap portions 26, 27 can be removably fastened to the housing by any suitable means such as bolts 26A, 27A (FIGS. 6, 7).

In the form shown, the fan blades are of the backwardly inclined type, but other types can be employed. As the fan wheel or impeller rotates, gas will be directed in both an outward and axial direction, which can be termed a "divergent direction" of flow, the movement including a circumferential component of flow in the axial direction at the outlet. Some of the gas is directed into side passages 28, 29, the remainder of the gas being directed toward the dual ducts which have flow straightening vanes 31 therein.

The trough-shaped side passages extending through bulkhead 11C preferably should have a convex curved bottom surface 32 (FIG. 5), and, as an example, the curved bottom surface of a side passage as seen in FIG. 10 can be employed. Said surface is composed of a plurality of arcs of varying curvature without abrupt changes and blending tangentially with each other and tangentially with the duct wall. A curved surface of varying curvature herein means a plurality of discrete arcs or a continuous mathematical curve. The curved surface also could be an arc of single curvature blending substantially tangentially into the duct side wall. The arcuately shaped side walls 33, 34 of the trough-shaped side passages are curved to follow the curvature of the exterior of the housing 10. The trough preferably is of the shape shown, but also could be triangular or other suitable trough-like shapes.

If desired, the underside of the conical back plate 18 may have radial ribs 35 (FIG. 4) to act as a secondary fan to produce a small airflow over the motor and through the shaft hole 25A into the main gas flow. The secondary airflow will be particularly effective in cooling the front bearing of the motor and at the same time will prevent leakage of destructive fumes back into the motor chamber. Further, the radial ribs will increase rigidity of the impeller or wheel assembly.

Inlet cone 14 is made in two parts 14A, 14B (FIG. 2) which are bolted or fastened to each other by fastening means 36 and to the main housing by fastening means 37. In order to disassemble the fan, removably held inlet cone 14A is first removed as seen in FIG. 3. Side passage 28 then is removed, said side passage being attached to bulkhead plates 30 of upstream wall 11C. The removable cap 27 then is removed. The motor and fan can then be slid out of the motor chamber 11 as a unit on tracks 38, 39 (FIG. 8). An example of suitable tracks and motor mounting is found in Patent No. 3,159,335. When tracks are used upon which the motor can be slid, the side passages are arranged in conjunction with motor chamber side plates, as seen in FIG. 8, so that there will not be an opening on the side wall 11B of motor chamber 11 upon which the tracks are located. It is to be understood that tracks need not necessarily be used, in which event, bolts holding the motor onto a suitable plate (not shown) are unloosened and the motor and fan removed from motor chamber 11.

FIG. 11 shows a comparison of fan performances of three fan configurations. These were determined in accordance with standard fan test procedures, such as National Association of Fan Manufacturers, Inc., Test Plate VIII, Bulletin No. 110, Second edition 1952. Curve 40 is for a divergent wheel fan in accordance with the present invention but without side passages. Curve 41 is for a fan having straight bottom wall side passages, and curve 42 is for a fan with curved bottom wall side passages in accordance with the present invention. It can be seen that the air output (c.f.m. and static pressure) and the efficiency increase considerably when side passages are employed and when they are improved in shape, the maximum efficiency improving from 40% to 53% or a net increase of 36%.

In FIG. 12 curve 43 shows static pressure for a fan made in accordance with the present invention and curve 44 shows the brake horsepower thereof. Curve 45 shows the static pressure curve for a comparable axial flow dual duct fan and curve 46 shows the brake horsepower. It can be seen that the maximum static pressure of a fan of the present invention is about 3½ times that of a comparable single stage axial flow fan. It also should be evident that for a given duct system, much higher air flow (c.f.m.) and static pressure requirements can be handled.

FIG. 13 depicts the result of a series of tests wherein the mean wheel diameter was varied and the housing diameter of the present invention kept constant at 40½ inches. Mean wheel diameter is defined as the average outside diameter of the trailing edge of the blades. For these tests, the wheel was operated at 870 r.p.m. As can be seen, maximum efficiency was obtained with a diffuser ratio of 1.40. Diffuser ratio is the ratio of housing inside diameter to the mean blade outside diameter and is an indication of the space available into which the flow of gas can diffuse. The efficiency significantly dropped off as the diffuser ratio was increased or decreased from 1.40. The diffuser ratio is a dimensionless ratio.

The fan also could be driven by a motor outside (not shown) of the motor chamber 11, it being connected thereto by a belt to a pulley on the fan shaft, the pulley being located in the motor chamber.

It should be evident that variations can be made in the details of construction without departing from the spirit of the invention except as defined in the appended claims.

We claim:

1. A fan comprising a main housing member having an inlet and outlet; a motor chamber extending transversely therethrough and having an upstream wall, downstream wall and side walls, said chamber separating the main housing member into two duct means, one on each side of said chamber and communicating with said inlet and outlet; motor means mounted in said chamber having output shaft means extending through said upstream wall of said chamber; fan wheel means connected to said shaft means adjacent to the inlet of said housing member and said upstream wall, said wheel means having a conically-shaped back plate, fan blades on said plate, said plate and blades moving gas in a divergent path from said inlet to said duct means; and trough-shaped generally arcuate side passage means having a generally curved bottom wall extending from said upstream wall to the side walls of said motor chamber on at least one side of the axis of said fan wheel and into said duct means for guiding gas from said fan wheel means to gas flowing in said duct means.

2. A fan comprising a main housing member having an inlet and outlet; a motor chamber extending transversely therethrough and having an upstream wall, downstream wall and side walls, said chamber separating the

main housing member into two duct means, one on each side of said chamber and communicating with said inlet and outlet; motor means mounted in said chamber having output shaft means extending through said upstream wall of said chamber; fan wheel means connected to said shaft means adjacent to the inlet of said housing member and said upstream wall, said wheel means having a conically-shaped back plate, fan blades on said plate, said plate and blades moving gas in a divergent path from said inlet to said duct means; and trough-shaped generally arcuate side passage means having a curved bottom surface and extending from said upstream wall in the direction of rotation to the side walls of said motor chamber on both sides of the axis of said fan wheel and into said duct means for guiding gas from said fan wheel to gas flowing in said duct means.

3. A fan comprising a main housing member having an inlet and outlet; a motor chamber extending transversely therethrough and having an upstream wall, downstream wall and side walls, said chamber separating the main housing member into two duct means, one on each side of said chamber and communicating with said inlet and outlet; motor means mounted in said chamber having output shaft means extending through said upstream wall of said chamber; fan wheel means connected to said shaft means adjacent to the inlet of said housing member and said upstream wall, said wheel means having a conically-shaped back plate, fan blades on said plate, said plate and blades moving gas in a divergent path from said inlet to said means; and trough-shaped generally arcuate side passage means each having a curved bottom surface and extending from said upstream wall in the direction of rotation to the side walls of said motor chamber and into said duct means for guiding gas from said fan wheel to gas flowing in said duct means.

4. A fan comprising a main housing member having an inlet and outlet; a motor chamber extending transversely therethrough and having an upstream wall, downstream wall and side walls, said chamber separating the main housing member into two duct means, one on each side of said chamber and communicating with said inlet and outlet; motor means mounted in said chamber having output shaft means extending through said upstream wall of said chamber; fan wheel means connected to said shaft means adjacent to the inlet of said housing member and said upstream wall, said wheel means having a conically-shaped back plate, fan blades on said plate, said plate and blades moving gas in a divergent path from said inlet to said duct means; and trough-shaped generally arcuate side passage means each having a curved bottom surface of varying curvature blending tangentially with its respective side wall and extending from said upstream wall to the side walls of said motor chamber on both sides of the axis of said fan wheel and into said duct means for guiding gas from said fan wheel to gas flowing in said duct means.

5. A fan comprising a main housing member having an inlet and outlet; a motor chamber extending transversely therethrough and having an upstream wall, downstream wall and side walls, said chamber separating the main housing member into two duct means, one on each side of said chamber and communicating with said inlet and outlet; motor means mounted in said chamber having output shaft means extending through said upstream wall of said chamber; fan wheel means connected to said shaft means adjacent to the inlet of said housing member and said upstream wall, said wheel means having a conically-shaped back plate, fan blades on said plate, said plate and blades moving gas in a divergent path from said inlet to said duct means; and trough-shaped generally arcuate side passage means having a curved bottom composed of a plurality of arcs of varying curvature without abrupt changes blending tangentially with each other and tangentially with its respective side wall and extending from said upstream wall to the side walls of said motor chamber on both sides of the axis of said fan wheel and into said duct means for guiding gas from said fan wheel to gas flowing in said duct means.

6. A fan comprising a main housing member having an inlet and outlet; a motor chamber extending transversely therethrough and having an upstream wall, downstream wall and side walls, said chamber separating the main housing member into two duct means, one on each side of said chamber and communicating with said inlet and outlet; motor means mounted in said chamber having output shaft means extending through said upstream wall of said chamber; fan wheel means connected to said shaft means adjacent to the inlet of said housing member and said upstream wall, said wheel means having a conically-shaped back plate, fan blades on said plate, said plate and blades moving gas in a divergent path from said inlet to said duct means; and trough-shaped generally arcuate side passage means having a generally curved bottom extending from said upstream wall to the side walls of said motor chamber on both sides of the axis of said fan wheel and into said duct means for guiding gas from said fan wheel means to gas flowing in said duct means, and at least one of said side passages being removably mounted in said motor chamber.

7. A fan comprising a main housing member having a conically-shaped inlet portion, a conically-shaped outlet portion and a tubular portion joining said inlet and outlet portions; a motor chamber extending transversely through said tubular portion, said motor chamber having an upstream wall, downstream wall and side walls, said chamber separating the main housing member into two duct means, one on each side of said chamber; motor means mounted in said chamber having output shaft means extending through the upstream wall of said chamber; fan wheel means connected to said shaft means and located in said conically-shaped inlet portion, said fan wheel means having a conically-shaped back plate and fan blades on said plate, said fan blades terminating adjacent said conically-shaped inlet for moving gas in a divergent path from said inlet to said duct means; and trough-shaped generally arcuate side passage means having a generally curved bottom extending from said upstream wall to the side wall of said duct means in the direction of rotation of said fan wheel means, so as to guide gas from said fan wheel means to gas flowing in said duct means.

8. A fan comprising a main housing member having a conically-shaped inlet portion, a conically-shaped outlet portion and a tubular portion joining said inlet and outlet portions; a motor chamber extending transversely through said tubular portion, said motor chamber having an upstream wall, downstream wall and side walls, said chamber separating the main housing member into two duct means, one on each side of said chamber; motor means mounted in said chamber having output shaft means extending through the upstream wall of said chamber; fan wheel means connected to said shaft means and located in said conically-shaped inlet portion, said fan wheel means having a conically-shaped back plate, a conically-shaped shroud, and fan blades between said back plate and shroud, said fan blades terminating adjacent said conically-shaped inlet for moving gas in a divergent path from said inlet to said duct means; and trough-shaped generally arcuate side passage means having a generally curved bottom extending from said upstream wall to the side wall of said duct means in the direction of rotation of said fan wheel means, so as to guide gas from said fan wheel means to gas flowing in said duct means.

9. A fan comprising a main housing member having an inlet portion and an outlet portion, at least one part of said inlet portion being removable; a motor chamber extending transversely through said housing member separating said housing member into two duct means, one on each side of said chamber, said chamber having a down-

stream wall and side walls; motor means mounted in said chamber and having output shaft means extending into said inlet portion; fan wheel means in said inlet portion and connected to said shaft means, said fan wheel means having blades and supporting means for said blades arranged to move gas therethrough in a divergent path from said inlet to said duct means; plate means around said shaft means forming at least a part of the upstream wall of said motor chamber, at least one portion of said plate means being removable; trough-shaped side passage means having an inlet at said upstream wall and forming part thereof and an outlet into a side wall of said chamber and into said duct means for guiding gas from said fan wheel means to said duct means, at least one of said side passage means being removable so that upon removal of the removable inlet portion, the removable portion of said plate means and the removable side passage means, the motor means and fan can be removed from the housing and chamber.

10. A fan comprising a main housing member having a conical inlet portion and a conical outlet portion, at least one part of said conical inlet portion being removable in one direction; a motor chamber extending transversely through said housing member separating said housing member into two duct means, one on each side of said chamber, said chamber having a downstream wall and side walls; motor means mounted in said chamber and having output shaft means extending into said inlet portion; fan wheel means in said inlet portion and connected to said shaft means, said fan wheel means having a conically-shaped back plate and blades thereon in said conically-shaped inlet portion to move gas therethrough in a divergent path from said inlet to said duct means; plate means around said shaft means forming at least a part of the upstream wall of said motor chamber, at least one portion of said plate means being removable; trough-shaped side passage means on either side of said motor means having an inlet at said upstream wall and forming part thereof and an outlet in the direction of rotation into the side walls of said chamber and into said duct means for guiding gas from said fan wheel means to said duct means, at least one of said side passage means being removable so that upon removal of the removable inlet portion, the removable portion of said plate means and the removable side passage means, the motor means and fan can be removed from the housing and chamber.

11. A fan comprising a main housing member having a conical inlet portion and a conical outlet portion, at least one part of said conical inlet portion being removable in one direction; a motor chamber extending transversely through said housing member separating said housing member into two duct means, one on each side of said chamber, said chamber having a downstream wall and side walls; motor means mounted in said chamber and having output shaft means extending into said inlet portion; fan wheel means in said inlet portion and connected to said shaft means, said fan wheel means having a conically-shaped back plate and blades thereon in said conically-shaped inlet portion to move gas therethrough in a divergent path from said inlet to said duct means; plate means around said shaft means forming at least a part of the upstream wall of said motor chamber, at least one portion of said plate means being removable; trough-shaped side passage means on either side of said motor means with curved bottom surface means and having an inlet at said upstream wall and forming part thereof and an outlet in the direction of rotation into the side walls of said chamber and into said duct means for guiding gas from said fan wheel means to said duct means, at least one of said side passage means being removable so that upon removal of the removable inlet portion, the removable portion of said plate means and the removable side passage means, the motor means and fan can be removed from the housing and chamber.

12. A fan comprising a main housing member having an inlet portion and an outlet portion, at least one part of said inlet portion being removable; a motor chamber extending transversely through said housing member separating said housing member into two duct means, one on each side of said chamber, said chamber having a downstream wall and side walls; motor means mounted in said chamber and having output shaft means extending into said inlet portion; fan wheel means in said inlet portion and connected to said shaft means, said fan wheel means having blades and supporting means for said blades arranged to move gas therethrough in a divergent path from said inlet to said duct means; plate means around said shaft means forming at least a part of the upstream wall of said motor chamber, at least one portion of said plate means being removable; trough-shaped side passage means having an inlet at said upstream wall and forming part thereof and an outlet into a side wall of said chamber and into said duct means for guiding gas from said fan wheel means to said duct means, at least one of said side passage means being removable, track means in said chamber on the side wall thereof opposite to the outlet of the removable side passage means to its side wall, and means slidably mounting said motor means on said track means so that upon removal of the removable inlet portion, the removable portion of said plate means and the removable side passage means, the motor means and fan can be slidably removed from the housing and chamber.

13. A fan comprising a main housing member having an inlet and outlet; a motor chamber extending transversely therethrough and having an upstream wall, downstream wall and side walls, said chamber separating the main housing member into two duct means, one on each side of said chamber and communicating with said inlet and outlet; motor means mounted in said chamber having output shaft means extending through said upstream wall of said chamber; fan wheel means connected to said shaft means adjacent to the inlet of said housing member and said upstream wall, blades on said fan wheel means moving gas in a divergent path from said inlet to said duct means; and trough-shaped circumferential side passage means having a generally curved bottom wall extending from said upstream wall to the side walls of said motor chamber on at least one side of the axis of said fan wheel and into said duct means for guiding gas from said fan wheel means to gas flowing in said duct means.

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ROBERT M. WALKER, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,312,386 April 4, 1967

Richard L. Hull et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 30, after "said" insert -- duct --.

Signed and sealed this 7th day of November 1967.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents