Dec. 16, 1969 G. S. MITTELSTAEDT 3,484,039

FANS AND COMPRESSORS

Filed July 14, 1967 2 Sheets-Sheet 1

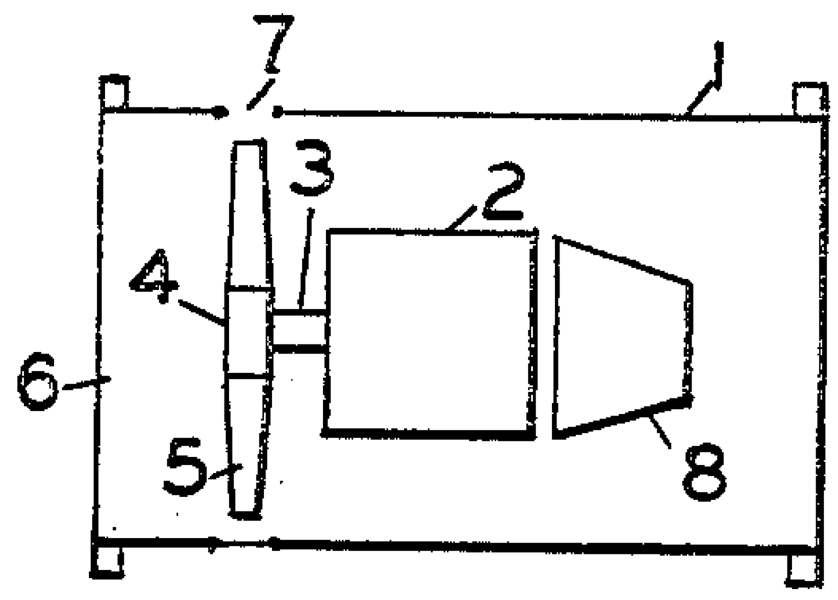


FIG. 1

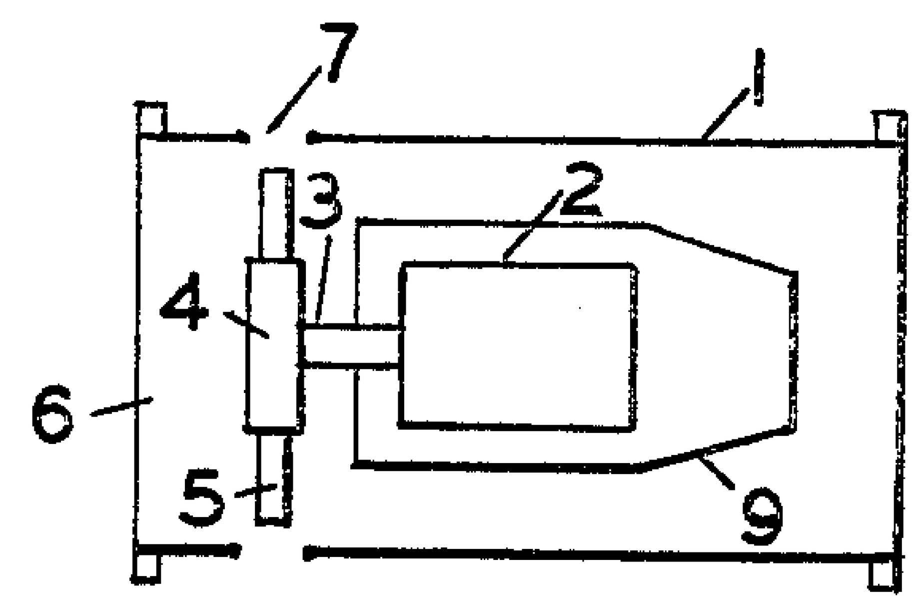


FIG. 2

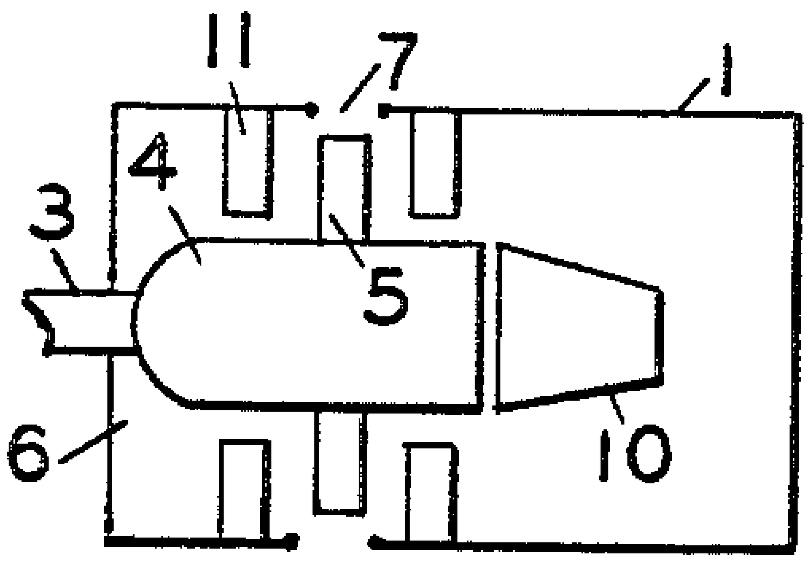


FIG. 3

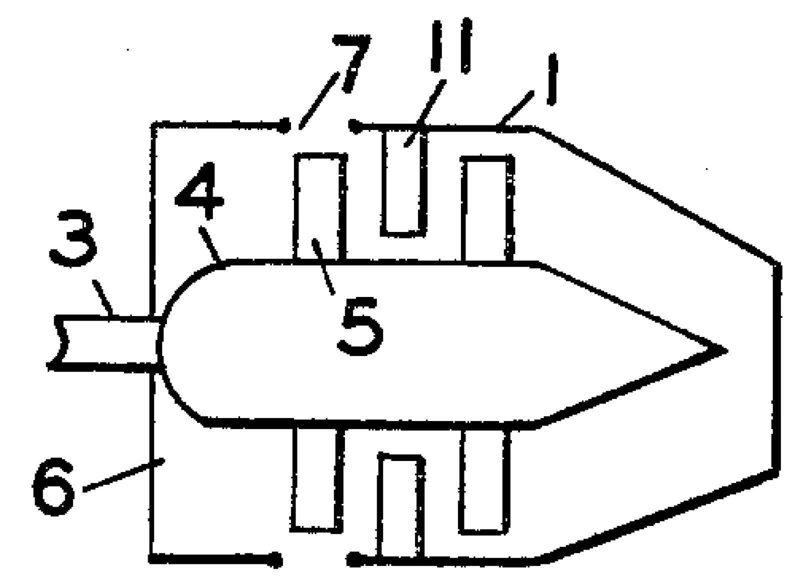


FIG. 4

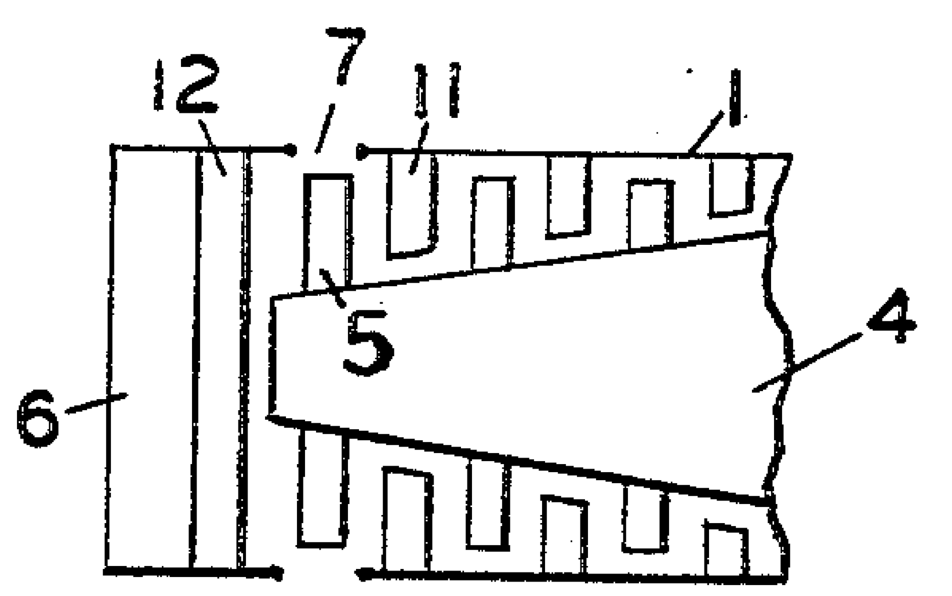


FIG. 5

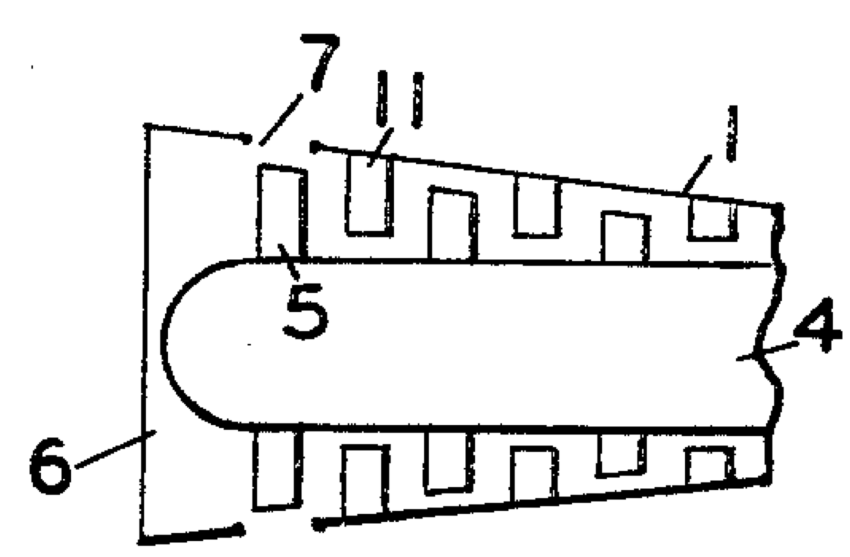


FIG. 6

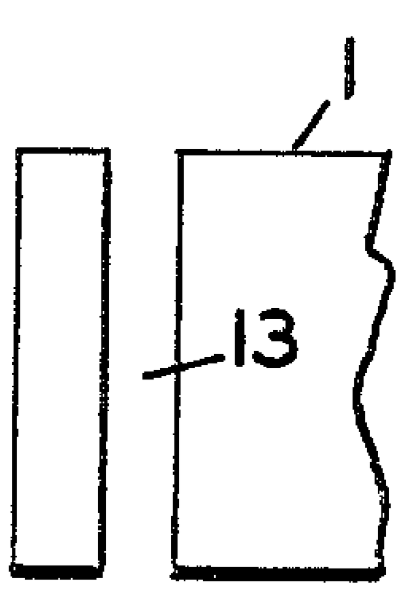


FIG. 7

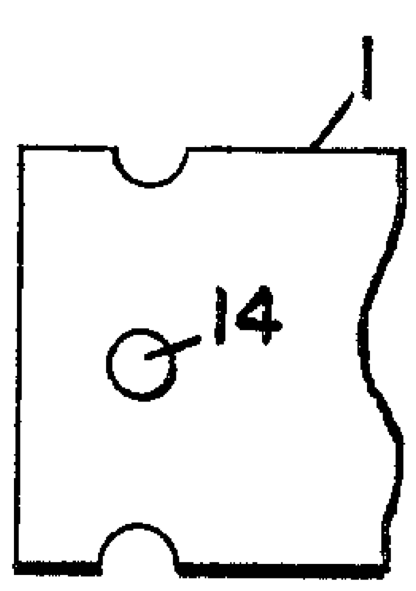


FIG. 8

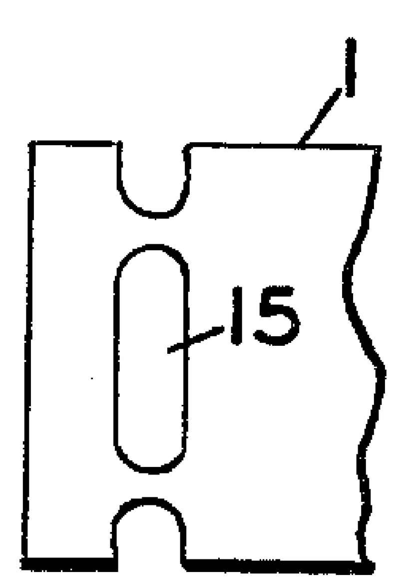


FIG. 9

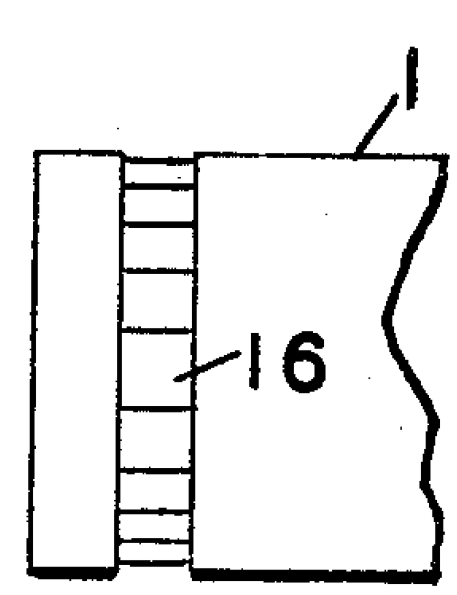


FIG. 10

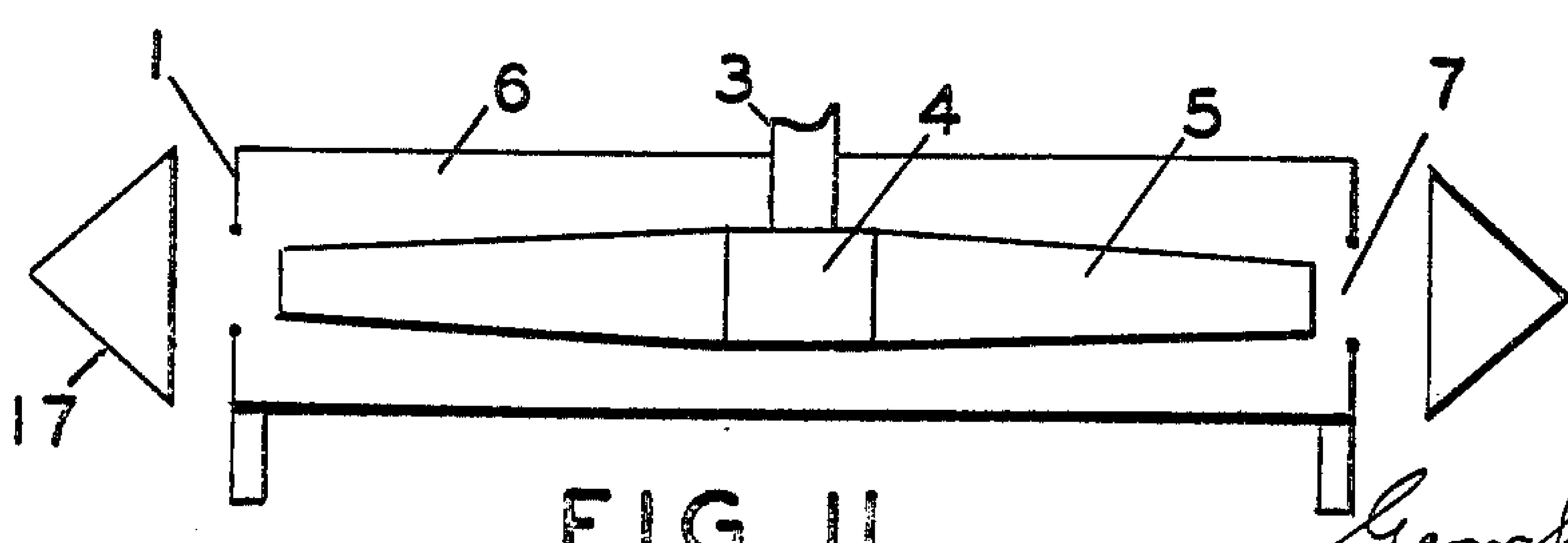


FIG. 11

INVENTOR.

Georg Mittelstaedt

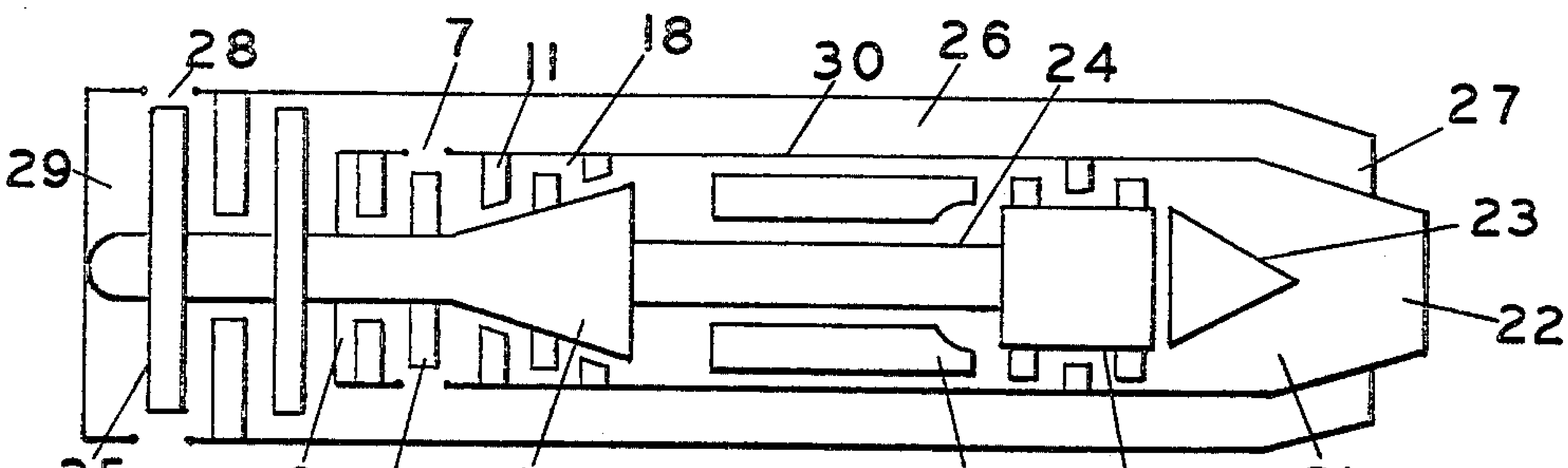


FIG. 12

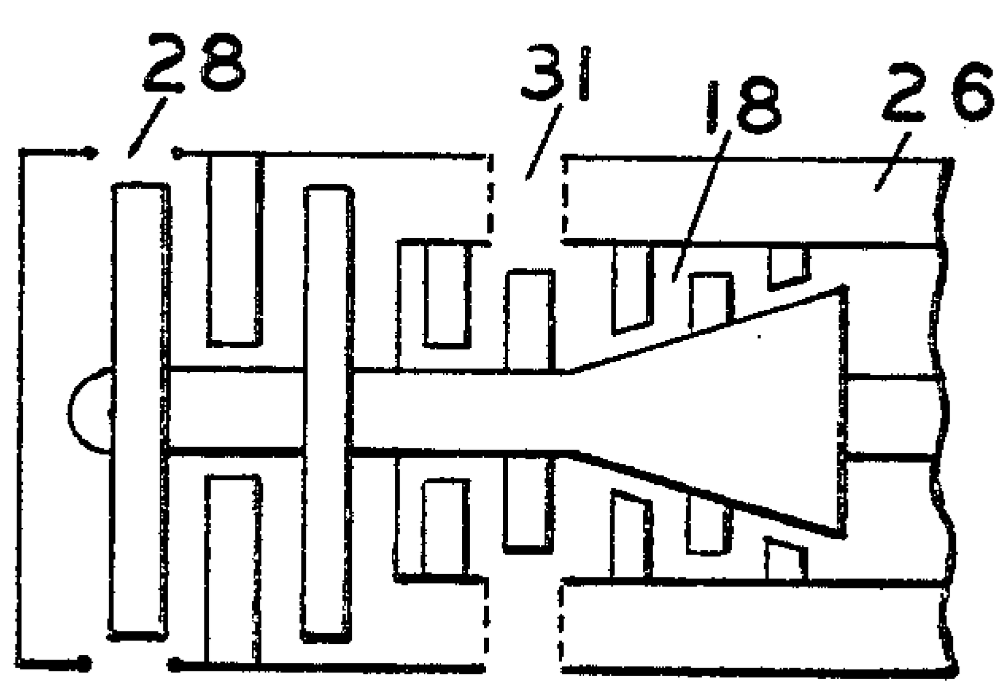


FIG. 13

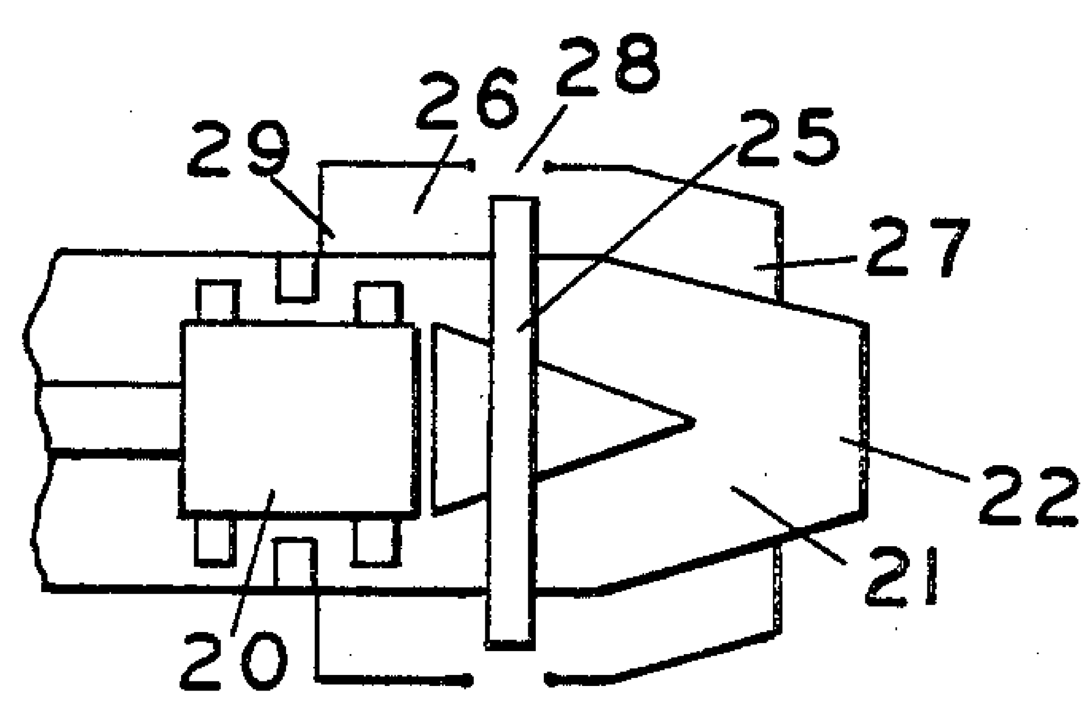


FIG. 14

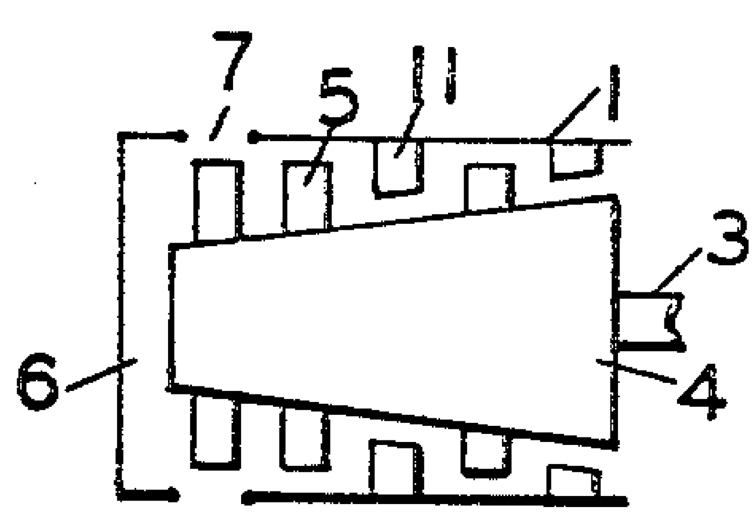


FIG. 15

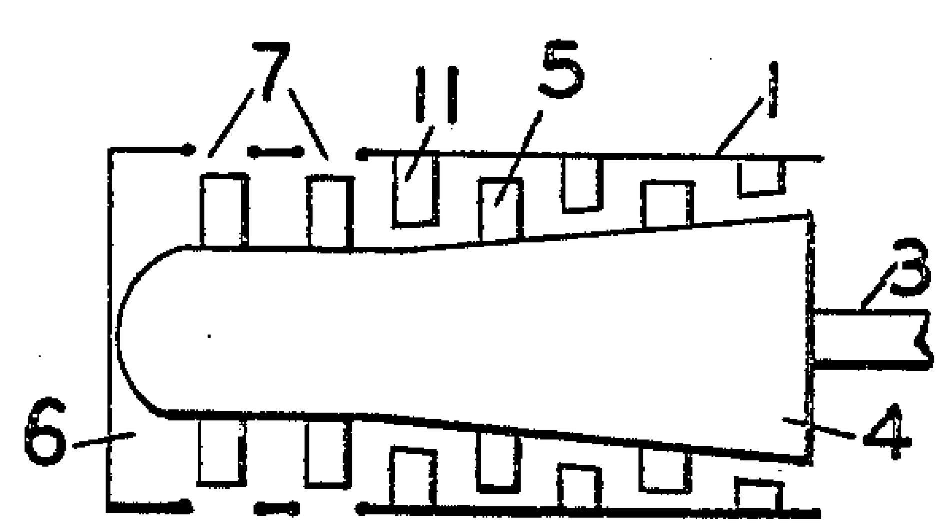


FIG. 16

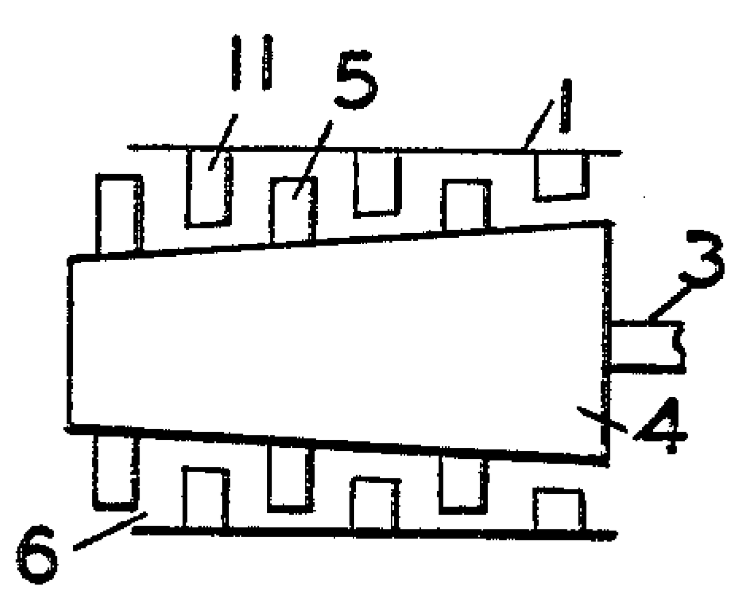


FIG. 17

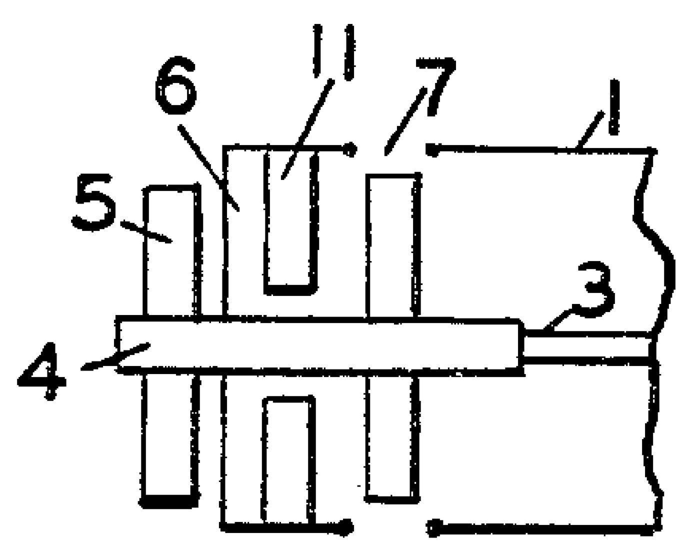


FIG. 18

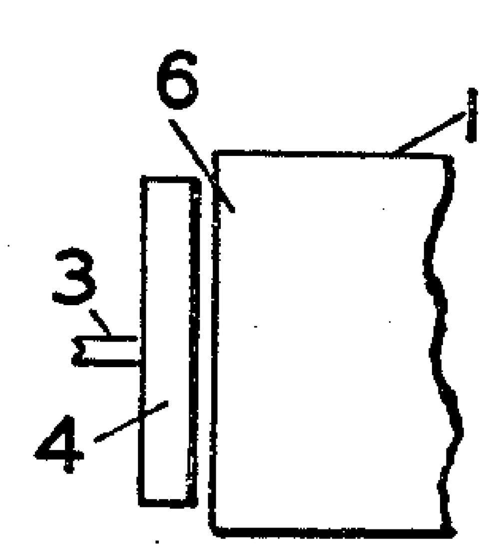


FIG. 19

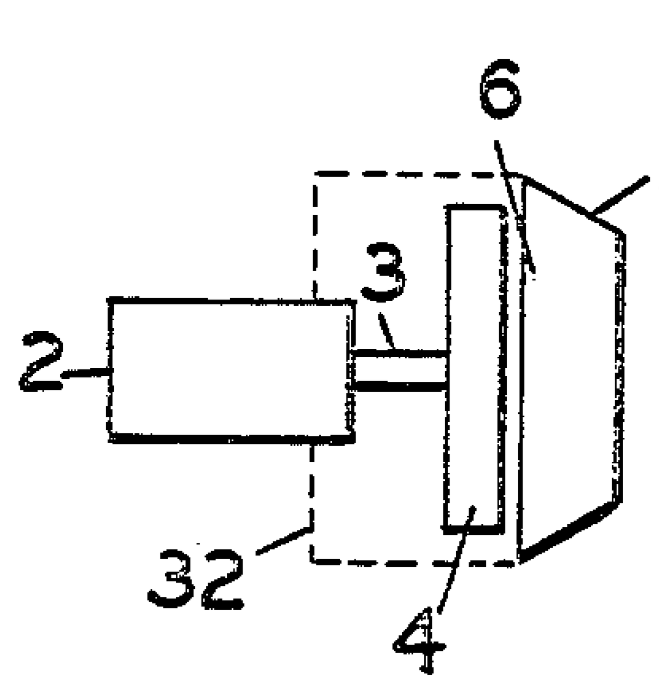
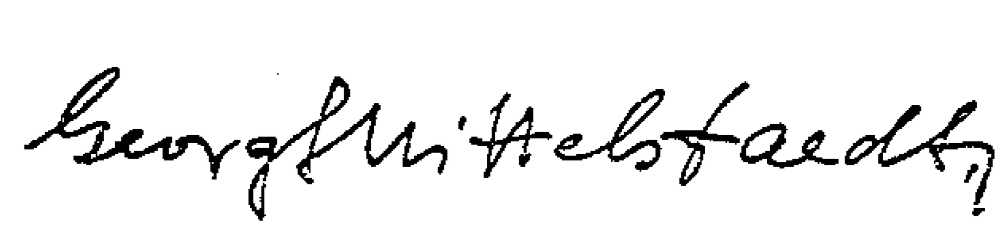


FIG. 20

INVENTOR.



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3,484,039
FANS AND COMPRESSORS
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U.S. Cl. 230—122 5 Claims

ABSTRACT OF THE DISCLOSURE

The conventional ducted axial flow fan or axial compressor essentially comprises a casing with a transversal front opening, a rotor or a stage of blades in the casing and means driving the rotor(s).

In this invention, I provide peripheral openings in the casing around the blades of the first rotor. During operation of the device, a low pressure area is produced around the tips of said first-rotor blades, and air is drawn into the casing through the peripheral openings. Therefore, in this invention air is taken in through the peripheral openings besides through the transversal front opening, resulting in improved efficiency.

This invention relates to ducted axial flow fans and to axial flow compressors.

The conventional ducted axial flow fan comprises an axial flow producing bladed rotor and perhaps fixed guide vanes in a cylindrical casing. The air passes through the rotor essentially without changing its distance from the axis of rotation. The rotor is often on the shaft end of the motor, and the motor is sometimes mounted in the casing, sometimes inside a diffuser casing, and sometimes outside the casing.

The term "tube axial fan" is used to designate a fan which has only a rotor in a cylindrical casing and no guide vanes. The term "vane axial fan" is used to designate a fan with a rotor and a set of fixed inlet and exit vanes in a cylindrical casing. Sometimes only one stator is used, either inlet, or exit, or between two rotors.

A conventional axial flow compressor usually comprises a drum or any other suitable rotor having many rows of compressor blades extending outward from it in a radial direction. This rotor is surrounded by a stationary casing, which also contains a similar number of rows of blades that extend inward and fit between the rows of blades on the rotor. When assembled, the two halves of the casing fit together around the rotor to form an annular passage into which the blades extend and through which the air or other medium flows as it is compressed.

There are many variations in the construction of axial flow compressors, and it is to be noted that any type of axial flow compressor may be used in connection with this invention.

In ducted axial flow fans and axial compressors, by "cylindrical" is often meant cylindro-frustoconical and similar variations.

I have found that in ducted axial flow fans more air is drawn in, and the efficiency is greatly improved, if in addition to the customary front opening a peripheral suction opening is provided in the casing, directly around the periphery of the rotor, or if a single or first rotor is projected from the casing.

In connection with axial flow compressors, a peripheral suction opening in the casing directly around the periphery of the first rotor, or a projected first rotor will draw in additional air, thereby improving compressor efficiency.

In this invention, I use peripheral air as well as frontal air. With the peripheral opening, peripheral air is drawn into the casing besides the usual frontal air, thereby improving efficiency. With the projected rotor, peripheral air as well as frontal air is drawn into the rotor blades, and both peripheral and frontal air are moved into the casing, thereby increasing efficiency.

In the text and claims, the term "ducted axial flow fan" includes axial flow fans and compressors with peripheral openings in the casing, and/or with a rotor projecting from the casing.

Objects of this invention are to draw air into a ducted axial flow fan of axial compressor through a peripheral opening in the casing, to improve the efficiency of ducted axial flow fans and axial compressors, to increase the intake area, to use both peripheral and frontal air, to augment suction air, to increase flow, to increase the mass of air passing through the ducted axial flow fan or axial compressor, to increase compression in an axial flow compressor, to reduce rotor speed, to reduce noise and high pitch, to reduce the number of stages, to increase thrust especially in connection with jet engines.

These and other objects will become apparent in the description below, in which characters of reference refer to like-named parts in the drawing.

In the text and claims, by "ducted axial fan" is also meant tube axial fan, vane axial fan, plural stage axial fan, or any axial flow fan, bladed rotor or propeller in a duct or casing; by "rotor" is also meant bladed rotor blades; by "first rotor" is also meant single rotor fan; by "casing" is also meant housing, fan duct, or row of rotating cylinder, ring, duct, peripheral shroud; by "opening" or "openings" is also meant inlet(s) gap or any other form of openings in the casing to admit peripheral air, any openwork to that effect e.g. framework or supports without covering, or any other means or form of ingress; by "air" is also meant gas, water, or any other medium; by "ducted axial flow fan" is also meant axial compressor and vice versa; by "drum" is also meant any suitable rotatable member supporting the radial blades; by "around the rotor" is also meant on a level with the rotor, radially in line with the rotor; by "in front of the transverse intake opening" is also meant sticking partly into the opening.

To repeat briefly, peripheral air is drawn into the ducted axial-flow fan or axial flow compressor, besides the usual front air. The peripheral air is drawn through a suction opening in the fan casing or compressor casing, directly around the periphery of the first rotor.

The peripheral opening increases the total mass of air taken in and moved through the fan or compressor, and increases flow, thereby improving the efficiency of the devices, and in connection with fan jets and other jet propulsion devices also increasing thrust. Since more air is taken in, compression is increased in compressors, and the number of stages can be reduced if so desired. Fan noise can also be reduced. At very high peripheral velocity of an axial fan rotor or axial compressor, the air velocity generates noise so high in pitch as to often prohibit such very high peripheral velocities under ordinary conditions. This is well known; but since my improved ducted axial fan or axial compressor takes in and moves a much greater mass of air, the rotor speed can be greatly reduced and still be very effective by present standards. The reduced rotor speed will result in reduced noise and lower pitch. Other objects will become apparent.

For highest efficiency, the peripheral opening in the casing must be unrestricted and unobstructed as is practicable, and must be at least as wide as the rotor wheel it exposes, and extend practicably all around the casing. Narrower or more restricted openings are less effective.

The opening in the casing may be in the form of a gap or any kind of holes around the periphery of the rotor it exposes, or may comprise any form of openwork or framework without covering, or any other means of ingress.

In this invention, the single rotor or first stage rotor, as the case may be, may also project or stick out from the front end of the casing, either partly or entirely, to move both frontal and peripheral air into the casing, to improve the efficiency of the ducted axial flow fan or axial compressor. Here, efficiency increases in proportion to increase of projection. Conversely, it can be said that in this variation the rotor is disposed outside the casing, or projects or sticks partly into it, and in the text and claims, one version is meant by the other.

In axial plural-stage fans and axial compressors, the change of pressure produced in the first stage is small, but there will be some pressure, and therefore some backpressure from the first stage.

To counteract this first stage backpressure, I use two rotors before the regularly slanted exit stator of the first stage. Then the backpressure produced in the first stage will be at least partly offset by the second rotor, the one nearest the slanted exit stator, thereby relieving the entering air of the adverse effects of backpressure and increasing suction flow.

It might be said that in this modification the first stage comprises two rotors followed by a regular slanted exit stator, the second rotor tending to offset backpressure against the intake air, thereby increasing intake suction flow and improving the efficiency of the first stage and of the rest of the device. Of course, there may be an entrance stator in the first stage.

In this modification, there may be peripheral openings in the casing around the first rotor or around both rotors of the first stage. In the latter case, the small pressure produced in the first stage will somewhat reduce the flow of suction air through the peripheral opening around the periphery of the second rotor, but since the second rotor counteracts the backpressure, the air passing through the peripheral opening around the first rotor and passing through the front opening in the casing will be greatly unimpeded.

As part of this invention, this feature may be applied to ordinary ducted axial flow fans and axial flow compressors having only the front intake opening. Here too, two rotors may be employed in the "first stage," that is, preceding the regular exit stator of the first stage. Then the second rotor will greatly absorb and counteract first stage backpressure, thereby relieving the entering air of the adverse effects of backpressure and increasing suction flow.

The invention may also be applied to lift devices using engine driven bladed lift rotors, such as helicopters, flying platforms, or any other lift devices of this type. Here, a casing, rim or shroud is disposed around the periphery of the horizontal lift rotor, and the described opening is provided in the shroud or casing, around the periphery of the lifting rotor.

Air is drawn into the lift-rotor blades through the peripheral opening in the casing besides being drawn in through the top opening, thereby augmenting the downwash, and thereby increasing upward thrust and lift.

Single or plural stages may be used.

An outer rim or shield may be placed around the peripheral opening in spaced relation to the casing or shroud, to prevent unwanted air from entering the peripheral opening, and said outer rim or shield may be streamlined, that is, faired outwardly and horizontally. In the text and claims, by "horizontal" is also meant slightly tilted.

In this type lifting device, e.g. helicopter, the "moments," that is, the difference of lift on the advancing and retreating side are greatly reduced or eliminated without the need of the usual lift compensating means e.g. the tilting blade mechanism.

If the lift rotors are of large diameter, gearing, perhaps beveled gears may have to be used to rotate such large rotors at the necessary slow speed.

The drawing illustrates the invention, but the invention is not limited to the particular example illustrated, nor to the particular construction shown.

Referring briefly to the drawing, FIGURE 1 illustrates an embodiment of the invention, showing a tube axial fan with a peripheral opening.

FIGURE 2 is a variation of FIGURE 1, also showing a peripheral suction opening.

FIGURE 3 shows a vane axial fan with a peripheral suction opening.

FIGURE 4 is a variation of FIGURE 3, also showing a peripheral suction opening.

FIGURE 5 shows an axial flow compressor with a peripheral suction opening.

FIGURE 6 is a variation of FIGURE 5, also showing a peripheral suction opening.

FIGURE 7 shows a gap-like suction opening in a fan or compressor casing.

FIGURE 8 shows round suction openings in the fan or compressor casing.

FIGURE 9 shows oblong suction openings in the fan or compressor casing.

FIGURE 10 shows openwork in the fan or compressor casing.

FIGURE 11 illustrates the invention as applied to a lift device, showing a horizontal tube-axial fan with a peripheral opening.

FIGURE 12 illustrates the invention as applied to a fan jet engine, showing a front fan with a peripheral suction opening, and an axial compressor with a peripheral opening.

FIGURE 13 shows peripheral suction tubes or ducts in the compressor of FIGURE 12.

FIGURE 14 shows an aft fan of a fan jet, having a peripheral suction opening.

FIGURE 15 shows two rotors in the first stage of an axial flow compressor and a peripheral suction opening in the casing around the first rotor.

FIGURE 16 is a variation of FIGURE 15, showing peripheral in the casing around the first and second rotors.

FIGURE 17 shows an axial flow compressor with the first rotor projecting from the casing.

FIGURE 18 shows a vane axial fan with the first rotor projecting from the casing.

FIGURE 19 shows a simple duct fan where the rotor is located in front of the duct or casing.

FIGURE 20 is similar to FIGURE 19, but the rotor is located in front of an abbreviated casing.

Referring in detail to the drawing, FIGURE 1 illustrates a tube axial fan. The numeral **1** indicates the casing, **2** indicates a motor in the casing, **3** the motor shaft, **4** a hub mounted on the shaft end of the motor, **5** indicates radial slanted blades rising from the hub **4**, and **6** indicates the front intake opening in the casing. The numeral **7** indicates a peripheral opening in the casing around the periphery of the rotor blades **5**, and **8** indicates a diffuser which may be used. During operation of the device, air is drawn in through the peripheral opening **7**, besides through the front opening **6**, thereby increasing the efficiency of the tube axial fan.

The basic parts and features will have the same numerals in all figures, as is practicable.

FIGURE 2 is similar to FIGURE 1. Again, the numeral **1** indicates the casing, **2** the motor, **3** the motor shaft, **4** the rotor hub mounted on the shaft end of the motor, **5** shows the slanted radial blades rising from the hub, 6 indicates the front intake opening in the casing, and 7 indicates the peripheral opening in casing around the tips of the rotor blades; however, in this figure the motor is mounted inside the diffuser casing **9**. During operation, air is drawn into this tube axial fan through the peripheral opening **7**, besides through the front opening **6**, thereby increasing the efficiency of the device.

FIGURE 3 shows a vane axial fan, in which the numeral **1** indicates the casing, **3** an engine shaft leading to an engine, not shown, **4** indicates a rotor drum mounted on the end of the engine shaft **3**, **5** shows a row of radial blades rising from the drum **4**, **6** indicates the front intake opening in the casing, and **7** indicates the peripheral opening in the casing around the periphery of the rotor-blades **5**. The numeral **10** indicates a diffuser behind the rotor drum. **11** indicates guide vanes or "stators." There are two rows of stators in this figure. The second row of guide vanes may be set at the usual angle, or may be axial to simply straighten the flow. During operation, air is drawn into this vane axial fan through the peripheral opening **7** in the casing, besides through the front opening **6**, thereby increasing the efficiency of the device.

FIGURE 4 also shows a vane axial fan. Again, the numeral **1** indicates the casing which here has a thrust nozzle, **3** indicates an engine shaft leading to an engine not shown, **4** shows a streamlined or diffusing drum mounted on the end of shaft **3**, and **5** shows radial blades rising from the drum **4**. There are two rows of radial blades in this figure. The numeral **6** indicates the front intake opening in the casing, and **7** indicates the peripheral opening in the casing around the tips of the first row of rotor blades. The numeral **11** indicates a row of guide vanes or a "stator." The guide vanes may be set at the customary angle, or may be axial, or they may be omitted. There also may be a peripheral opening around the periphery of the second rotor, not shown, in addition to or instead of the peripheral opening around the first rotor. During operation, air is drawn into this vane axial fan through the peripheral opening **7**, besides through the front opening **6** in the casing, thereby increasing the efficiency of the device.

FIGURE 5 shows the essential part of a form of axial flow compressor. The numeral **1** indicates a cylindrical casing, **4** indicates a frusto-cylindrical drum mounted on the end of an engine shaft, not shown, **5** shows radial blades rising from the drum, and there are 3 rows of radial blades in this figure. The numeral **6** indicates the front intake opening in the casing, and **7** indicates a peripheral opening in the casing around the periphery of the first row of rotor blades. The numeral **11** indicates guide vanes or "stators." There are 3 rows of stators around the drum **4**. The numeral **12** indicates a row of inlet guide vanes. During operation, air is drawn into this axial compressor through the peripheral opening **7**, besides through the front opening in the casing.

FIGURE 6 shows the essential part of a slightly different axial flow compressor. Here the numeral **1** indicates a frusto-cylindrical casing, **4** indicates a cylindrical drum mounted on an engine shaft not shown, and **5** shows radial blades rising from the drum. There are 3 rows of of radial blades in this figure. The numeral **6** indicates the inlet or front intake opening in the casing, and **7** indicates a peripheral opening in the casing around the tips of the first row of rotor blades. The numeral **11** indicates guide vanes or stators. There are 3 rows of stators in this figure. During operation, air is drawn into this axial compressor through the peripheral opening **7**, besides through the front opening **6** in the casing.

FIGURES 6–10 show different forms of openings in the casing.

FIGURE 7 shows a gap **13** in the casing **1**.

FIGURE 8 shows round openings **14** in the casing **1**.

FIGURE 9 shows ablong openings **15** in the casing **1**.

FIGURE 10 shows openwork **16** in the casing **1**.

Any other type of opening or form of ingress in the casing may be used in this invention.

FIGURE 11 illustrates the application of the invention to lifting devices e.g. helicopters, flying platforms etc. Illustrated here is a form of flying platform. This figure is basically the same as FIGURE 1 but is turned to point upward, and therefore the rotor is disposed in a horizontal position for producing lift. The basic numerals are the same as in FIGURE 1. The numeral **1** indicates the casing or shroud, **3** an engine shaft leading to an engine not shown, **4** a rotor hub, and **5** indicates horizontal radial blades extending from the rotor hub. The numeral **6** indicates the top opening in the shroud or casing, and **7** indicates a peripheral opening in the casing around the periphery of the rotor blades **5**. During the operation, air is drawn into this lifting device through the peripheral opening **7** besides through the top opening **6**, thereby augmenting the downwash, and thereby increasing the upward force or thrust and improving the efficiency of the device. Plural stages may be used, as shown in the vertical-rotor devices. The numeral **17** indicates a preferably streamlined outer rim or shield around the peripheral opening **7**, and spaced relation to the casing **1**, to increase the efficiency of the device in horizontal flight.

In the text and claims, by "horizontal" is also meant approximately horizontal or tilted.

Any other figures shown may be turned upward and used as lift devices, at least in part.

FIGURE 12 illustrates the essentials of a fan-jet engine. The numeral **30** indicates the casing of the primary engine, **18** indicates an axial flow compressor furnishing air at least partly for use in the combustors **19** in which air and fuel are burned. The combustion gases are passed through the turbine **20** and from there through an exhaust duct **21** and jet nozzle **22** to atmosphere. **23** indicates a tail cone. The turbine drives the compressor **18** through shaft **24**, and also drives the fan **25** which is located in front of the compressor. The numeral **26** indicates the fan air duct and **27** the fan nozzle. The fan **25** is similar to that of FIGURE 4 in that it comprises two rotors and a stator in between. More stages could be used, or only a single rotor. The numeral **28** indicates a peripheral suction opening in the outer wall of the fan air duct around the periphery of the first fan rotor to draw in air, besides the air drawn in through the usual front intake opening **29**. The main compressor **18** is located behind the fan **25**. In the main compressor, the numeral **4** indicates a partly cylindrical, partly frusto-conical drum and **5** shows radial blades rising from the drum. There are two rows of such radial blades in this figure. The numeral **6** indicates the front intake opening in the compressor **18**, and **7** indicates a peripheral opening in the compressor casing around the tips of the first row of rotor blades. The numeral **11** indicates guide vanes or stators. There are 3 rows of stators in this compressor. During operation of this fan jet engine, atmospheric air is drawn into the fan **25** through the front opening **29** and through peripheral opening **28**. As far as the main compressor **18** is concerned, air is drawn in through the front opening **6**, and fan air is taken in through the peripheral opening **7**.

FIGURE 13 generally shows the fan and compressor section of FIGURE 12, but here a tube or duct **31** leads from the peripheral opening in the compressor casing through the fan air duct to atmosphere, to draw in atmospheric air.

FIGURE 14 shows the rear section of a fan jet engine. It is similar to that of FIGURE 12, but has an aft fan. The parts and features will have the same numerals as in FIGURE 12. The numeral **20** indicates the turbine, **21** the exhaust duct, and **22** the jet nozzle of the primary engine. The numeral **26** indicates the fan air duct, **27** the fan nozzle, and **25** indicates a single fan rotor. The numeral **28** indicates the peripheral opening in the outer wall of the fan air duct around the blade tips of the rotor. During operation, air is drawn into this tube axial fan through the peripheral opening 28, besides through the front opening 29 of the fan, thereby increasing the efficiency of the device.

FIGURE 15 shows an axial compressor. The numeral 1 indicates the casing, 3 an engine shaft leading to an engine not shown, 4 a frustoconical rotor drum mounted on the end of engine shaft 3, 5 shows radial blades rising from the drum (there are 3 rows of rotating blades in this figure), 6 indicates the front intake opening, and 7 indicates the peripheral opening in the casing around the periphery of the first row of rotor blades. The numeral 11 indicates guide vanes or stators after the second and third rows of rotor blades, set at the usual angle. There is no stator shown between the first two rows of rotor blades, because the second row is chiefly to lessen or offset the backpressure produced in the first stage, to increase suction flow. However, there may be vanes, preferably axial vanes between the first two rotors, to straighten the flow. In operation, air is drawn into this axial compressor through the peripheral opening 7, besides through the front opening 6, and backpressure against the first rotor and intake air is lessened, thereby improving the efficiency of the device.

FIGURE 16 is similar to FIGURE 15 and also shows an axial flow compressor. The numeral 1 indicates the casing, 3 an engine shaft leading to an engine not shown, 4 a drum mounted on the end of the engine shaft 3, the drum beginning cylindrical and expanding conically, the numeral 5 shows radial blades rising from the drum. There are 4 rows of such radial blades in this Figure, the first two rows rising from the cylindrical drum section to better relieve first stage backpressure, the last two rows rising from the expanding conical drum section. The numeral 6 indicates the front intake opening in the casing, and 7 indicates peripheral openings in the casing around the blade tips of the first two rows of rotor blades. The numeral 11 indicates guide vanes or stators which are located after the second, third and fourth rows of rotor blades and are set at the usual stator angle. There is no stator shown between the first two rows of rotor blades, because the second rotor is chiefly to relieve the small backpressure produced in the first stage, to increase suction flow. However, there may be vanes preferably axial vanes, between the first two rotors, to straighten the flow. In operation, air is drawn into this axial compressor through both peripheral openings 7, besides through the front intake opening 6, and backpressure against intake air is lessened thereby improving the efficiency of the device.

FIGURE 17 indicates a compressor, in which the numeral 1 again indicates the casing, 3 an engine shaft leading to an engine, not shown, and 4 indicates a conical drum mounted on the end of the engine shaft 3. The numeral 5 shows radial blades rising from the rotor drum; there are 3 rows of radial blades rising from the drum. The numeral 6 indicates the intake opening in the casing, and 11 shows guide vanes or stators; there are 3 rows of stators in this figure. The feature in this FIGURE 17 is that the first row of rotor blades projects from the casing 1. It sticks out for the most part. This feature is, instead of the peripheral opening, shows in the previous figures. With this location, the first row of rotor blades will move peripheral air into the casing, besides frontal air, thereby improving the efficiency of this axial compressor.

FIGURE 18 illustrates a vane axial fan having the first rotor projecting from the casing, and also having a peripheral opening around the periphery of the second rotor. The numeral 1 again indicates the casing, 6 the front intake opening in the casing, 3 an engine shaft leading to an engine, not shown, 4 a drum, and 5 shows radial rotor blades rising from the drum. There are two rows of such rotor blades in this figure. The first row projects entirely from the front of the casing 1, and the second row is located inside the casing. The numeral 11 shows a row of stators, and 7 indicates a peripheral opening in the casing around the periphery of the second row of rotor blades. During operation, frontal and peripheral air is moved into the casing by the projecting first row of rotor blades, and extra peripheral air is drawn into the casing through the peripheral opening 7 in the casing.

FIGURE 19 shows a simple form of duct fan, in which a single rotor 4 is disposed directly in front of the intake opening 6 of the casing 1. The numeral 3 indicates the engine shaft leading to an engine, not shown. The engine shaft may also be on the other side of the rotor, in which case the external rotor 4 sticks out or projects entirely from the casing 1. I find that in this type fan peripheral air is drawn into the rotor and is moved into the casing, besides frontal air. The use of peripheral air as well as frontal air improves the efficiency of the device. The rotor 4 has slanted radial blades.

FIGURE 20 is similar to FIGURE 19, in that the bladed rotor 4 is located in front of the intake opening 6 of the abbreviated casing or ring 1, thereby moving peripheral air into and through the casing besides frontal air. The numeral 2 indicates a motor and 3 the motor shaft on which the rotor is mounted. The casing 1 diminishes rearwardly in diameter to form a nozzle, to increase flow and/or to increase thrust. There may be a guard around the rotor as indicated by the broken line 32, and the abbreviated casing 1 may be mounted on the guard. The motor may also be located on the other side of the motor. In that case the casing may be mounted on the motor. The casing 1 may also be mounted on the shaft 3 or rotor 4 and rotate therewith. During operation, frontal and peripheral air is moved through the abbreviated casing 1, thereby improving the efficiency of the device. The blades of rotor 4 are radial and set at an angle.

In this invention, the engines or motors driving the rotors may be disposed inside or outside the casing and may be located on either side of the rotor, as is practicable or desired.

The described and/or illustrated features are interchangeable, and all disclosed features form part of this invention. It is also to be noted that changes may be made without departing from the spirit or scope of the invention.

The principles involved in this invention may be applied to all pertinent fields, and the disclosed devices may be employed in any medium.

I claim:

1. In a multistage axial compressor comprising a casing, a transversal intake opening in the casing, rotors and stators in the casing forming plural stages and means driving the rotors, a peripheral opening in the casing around the first compressor rotor directed to the blade tips of the rotor; air being drawn through the peripheral opening to the blade tips of said first rotor besides transversal air being taken in.

2. In a device according to claim 1, the peripheral opening being at least as wide as the blade tips of the first rotor and radially in line with the blades of the rotor.

3. In a device according to claim 1, the peripheral opening exposing the blade tips of the first rotor laterally.

4. In a device according to claim 1, the inner end of the peripheral opening exposing the blade tips of the first rotor laterally, the outer end opening to atmosphere.

5. In a device according to claim 1, said peripheral opening being around the first rotor in the casing.

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HENRY F. RADUAZO, Primary Examiner

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60—39.29; 230—120; 133

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

'atent No. 3,484,039 December 16, 1969

Georg S. Mittelstaedt

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 13, "of" should read -- or --l line 29, after rotor", second occurrence, insert -- or row of rotating --; line 0, "rotor", second occurrence, should read -- rotor, --; lines 1 and 32, cancel "or row of rotating"; line 33, "inlet(s)" hould read -- inlet(s), --. Column 7, line 60, "is," should read - is --; line 61, "opening," should read -- opening --; same ine 61, "shows" should read -- shown --.

Signed and sealed this 8th day of September 1970.

;EAL)
ttest:

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