

March 7, 1950

H. F. HAGEN

2,500,070

MULTISTAGE, AXIAL FLOW, GAS COMPRESSOR

Original Filed June 15, 1945

3 Sheets-Sheet 1

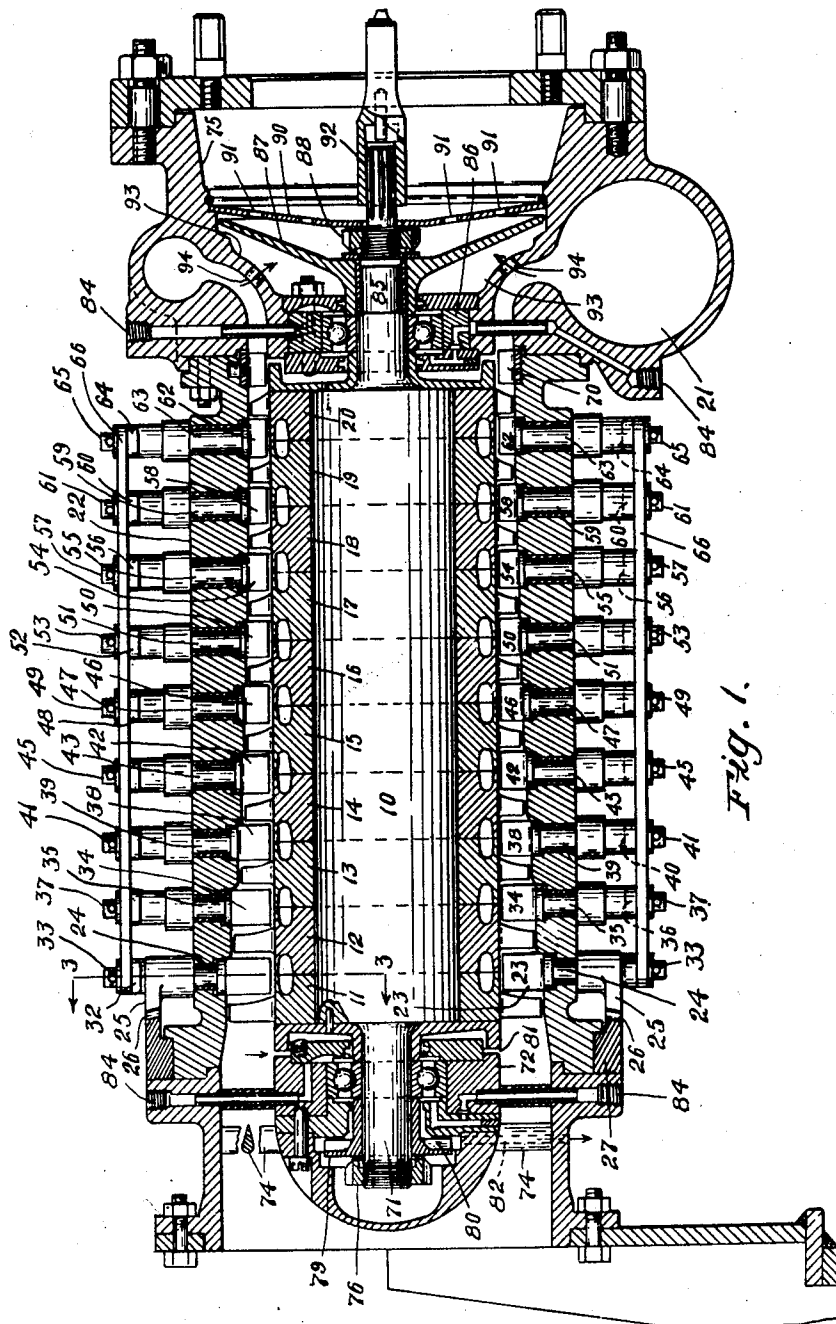


Fig. 1.

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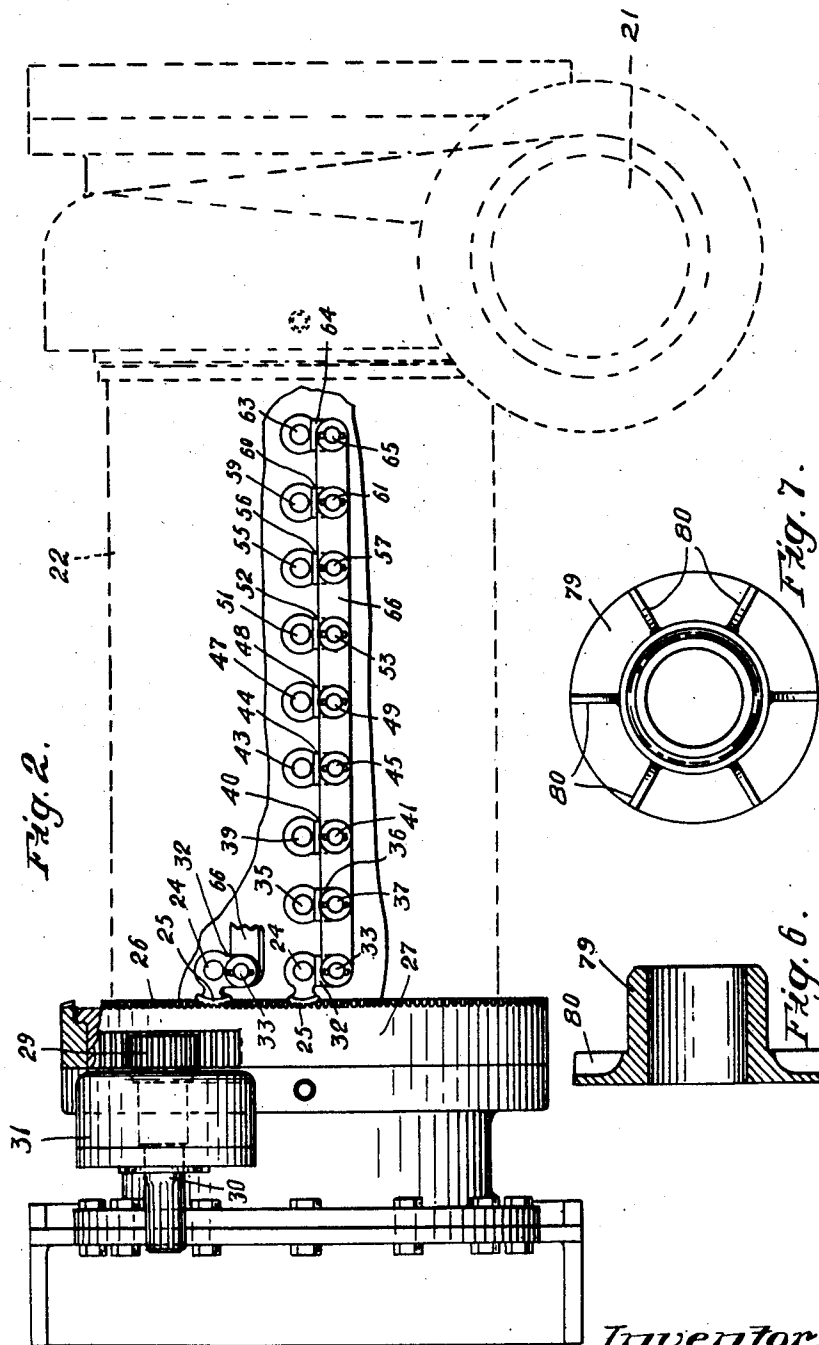
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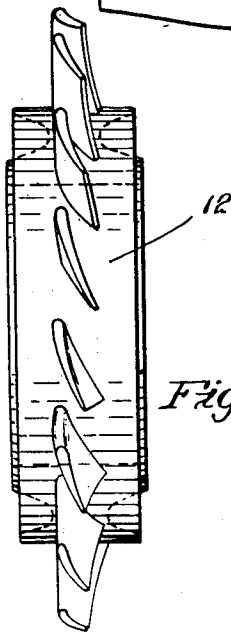
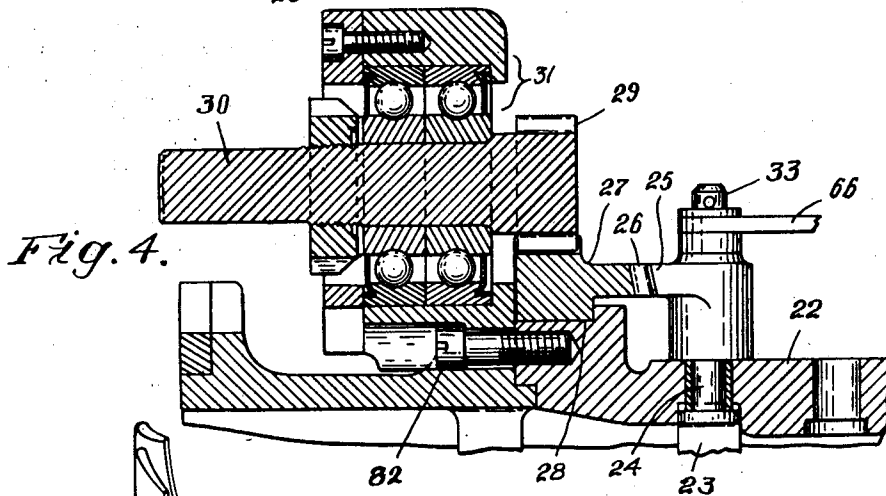
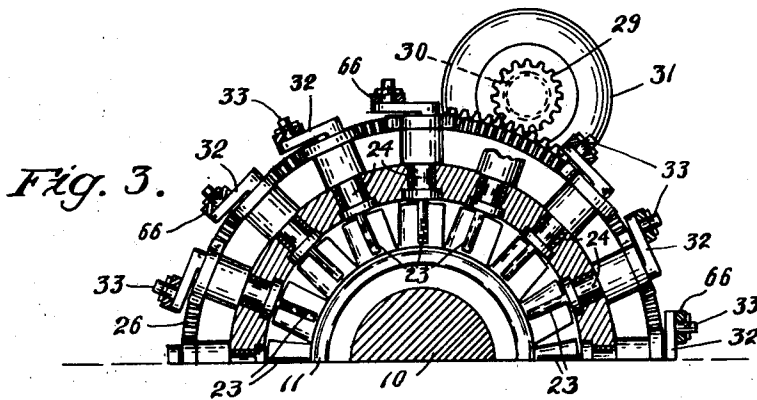
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,500,070

MULTISTAGE, AXIAL FLOW, GAS
COMPRESSOR

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mesne assignments, to Westinghouse Electric
Corporation, a corporation of Pennsylvania

Original application June 15, 1945, Serial No.
599,704. Divided and this application Novem-
ber 29, 1947, Serial No. 788,883

2 Claims. (Cl. 230-114)

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This invention relates to superchargers, and relates more particularly to superchargers for maintaining desired air pressures in the cabins of aircraft flying at high altitudes.

This application is a division of my co-pending application, Serial No. 599,704 filed June 15, 1945, now abandoned.

At an altitude of 40,000' above sea level, the atmosphere pressure is only about 2.8 pounds per square inch absolute. It is desired to increase this pressure to about 9.6 pounds per square inch within the cabin of an airplane flying at that altitude. The limitations of space and weight prevent the use of large size equipment so that it is necessary that a relatively small, high speed supercharger with a large number of blower stages be used. This invention provides such a supercharger.

In one embodiment of the invention, a ten stage supercharger has axial flow, blower wheels designed to revolve at 42,000 revolutions per minute.

Due to problems involving the drive, it is desired to operate the supercharger at constant speed at all altitudes although its full capacity is not needed below 40,000'. If the supercharger is operated at full capacity at sea level where the temperature of the outdoor air may be 100° F., the temperature of the air will rise in the supercharger to about 450° F., too hot to discharge into the cabin. Furthermore while the driving horsepower at 40,000' with the supercharger operated at full capacity will be about 25, the horsepower required at sea level with the supercharger operated at full capacity will be about 100.

It not being desired to increase the pressure in the cabin much above the atmospheric pressure at sea level, the pressure increase provided must be reduced to a fraction of a pound, just sufficient for providing ventilation, at sea level, and reduced in less degree at altitudes below 40,000'. The pressure provided could be reduced by damping, but this would not result in the desired reduction in air temperature, nor in the desired saving in power.

A feature of this invention resides in the use of spin vanes of the type disclosed generally in the H. F. Hagen, U. S. Patents Nos. 1,846,863 and 1,989,413, the vanes being provided in the inlets of all of the later-stage blower wheels. With the vanes adjusted to positions of maximum spin, there is substantially no air pressure rise. With the vanes adjusted to wide open positions, they straighten out the spinning air and the supercharger operates at full capacity. The vanes are

adjusted by a suitable barometric control to provide the desired air pressure at every altitude. Not only do the vanes provide power reductions which conform to the pressure reductions, but the temperatures of the delivered air are reduced as the air pressures are reduced. At 40,000' altitude, the outside temperature may be -60° F. so that the temperature of the delivered air will be about 190° F. which is not too hot to discharge into the cabin.

As is known, it is essential for continuity of flow, to have the same mass of air handled by every blower wheel of a multi-stage air compressor. The air density increases in the downstream stages due to temperature and pressure increases, and as the density increases, the volume decreases. It is the general practice to design the downstream blower wheels to handle less air volumes than the upstream wheels. In the past this has been accomplished by providing differently designed blower wheels for every stage, thus requiring a separate die for each wheel. Another feature of this invention resides in using similarly designed and constructed wheels for every stage, and by cutting off the outer ends of the blades of the downstream stages for progressively decreasing the downstream blade areas. Likewise all spin vanes are made the same way, the downstream vanes having their ends cut off for providing vane areas reduced conformably with the blade areas of the wheels, in the inlets of which they are placed. Not only is the cost reduced by using a single die for every wheel, and a single die for all spin vanes, but the wheel efficiencies are maintained uniform since the axial velocity through each wheel is uniform.

Due to the large pressure increase when the supercharger is operating at full capacity, there is considerable end thrust upon its bearings, in a direction opposite to that of the air flow through the supercharger. The bearings, considering the fact that the speed of rotation of the supercharger shaft is so high, could not be expected to stand up under this thrust. Another feature of this invention is that the end thrust is neutralized by applying air pressure at the output side of the supercharger to a member carried by the revolving shaft.

Due to the high rotative speed and the low pressure around the upstream bearing of the supercharger, lubricating oil tends to leak from the bearing into the air stream entering the supercharger and to be discharged into the cabin with the compressed air. Another feature of

this invention resides in the provision of a fan wheel on the upstream end of the supercharger shaft, the inlet of this wheel connecting with the interior of the upstream bearing, whereby upon rotation of the shaft, the fan wheel draws air through the bearing which air entrains the oil thrown out from the bearing and delivers the entrained oil to a point exterior the supercharger.

Objects of the invention are to provide an efficient, multi-stage supercharger having axial flow wheels, and to control the output of the supercharger with spin vanes in the inlets of blower wheels of same.

Another object of the invention is to oppose the end thrust in a supercharger caused by the movement of air therethrough, by the application of air pressure at the outlet of the supercharger.

Another object of the invention is to prevent oil leaking from an upstream bearing of a supercharger from entering the air compressed in the supercharger.

Another object of the invention is to decrease the cost of manufacture of supercharger blower wheels.

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

Fig. 1 is a side elevation, in section, of a supercharger embodying this invention;

Fig. 2 is a side elevation, with a portion broken away, and a portion in dotted outline, of the supercharger of Fig. 1;

Fig. 3 is a sectional view along the lines 3-3 of Fig. 1;

Fig. 4 is an enlarged view, in section, of the spin vane adjusting gears of Figs. 1, 2, and 3;

Fig. 5 is a side elevation of one of the blower wheels;

Fig. 6 is a side elevation, in section, of the centrifugal fan used to remove the oil leaking from the upstream bearing of the supercharger, and

Fig. 7 is an end elevation of the fan of Fig. 6.

The supercharger has the shaft 10 to which are keyed the blower wheels 11, 12, 13, 14, 15, 16, 17, 18, 19, and 20, arranged in the order named with respect to air flow through the supercharger. As illustrated by Fig. 1, the downstream wheels have blades, the radial lengths of which decrease progressively towards the outlet 21, whereby continuity of flow is maintained. The blades are all similar except that the downstream blades have portions removed at their tips for providing the desired reduced blade areas. The wheels all have the same number of blades.

The casing 22 around the wheels has, as illustrated by Fig. 1, inner diameters which decrease downstream to correspond with the reduced wheel diameters.

The spin vanes 23 between the wheels 11 and 12, have the shafts 24 journaled in the casing 22, and have the gear segments 25 keyed to the shafts 24. The gear teeth in the segments 25 mesh with the gear teeth 26 of the annular gear 27 which is supported to rotate in a vertical plane around the casing 22 at 28 (Fig. 4). The pinion gear 29 is attached to the shaft 30 which rotates in the bearing 31 attached by the cap screw 32 to the upper portion of the casing 22. The shaft 30 is adapted to be rotated by a barometric or other suitable control which is not illustrated, as will be described in the following.

The shafts 24 also have attached thereto, the arms 32 with the pivot pins 33 thereon.

The spin vanes 34 between the blower wheels 12 and 13, have the shafts 35 journaled in the cas-

ing 22, and have the arms 36 with the pivot pins 37 thereon, attached to the shafts 35.

The spin vanes 38 between the blower wheels 13 and 14, have the shafts 39 journaled in the casing 22, and have the arms 40 with the pivot pins 41 thereon, attached to the shafts 39.

The spin vanes 42 between the blower wheels 14 and 15, have the shafts 43 journaled in the casing 22, and have the arms 44 with the pivot pins 45 thereon, attached to the shafts 43.

The spin vanes 46 between the wheels 15 and 16, have the shafts 47 journaled in the casing 22, and have the arms 48 with the pivot pins 49 thereon, attached to the shafts 47.

The spin vanes 50 between the wheels 16 and 17, have the shafts 51 journaled in the casing 22, and have the arms 52 with the pivot pins 53 thereon, attached to the shafts 51.

The spin vanes 54 between the wheels 17 and 18, have the shafts 55 journaled in the casing 22, and have the arms 56 with the pivot pins 57 thereon, attached to the shafts 55.

The spin vanes 58 between the wheels 18 and 19, have the shafts 59 journaled in the casing 22, and have the arms 60 with the pivot pins 61 thereon, attached to the shafts 59.

The spin vanes 62 between the wheels 19 and 20, have the shafts 63 journaled in the casing 22, and have the arms 64 with the pivot pins 65 thereon, attached to the shafts 63.

The levers 66 have perforations therein which extend around the pivot pins 33, 37, 41, 45, 49, 53, 57, 61 and 65 described in the foregoing, whereby rotation of the shaft 30, the pinion gear 29, the annular gear 27 and the gear segments 25, affects rotation of all of the spin vanes.

As illustrated by Fig. 1, the downstream spin vanes have radial lengths which decrease progressively towards the supercharger outlet corresponding to the decrease in the radial lengths of the blades with which they cooperate. The spin vanes have contours at different radii similar to those of the blades of the blower wheels as illustrated by Fig. 5.

The blades and spin vanes of the supercharger are preferably designed as disclosed in the H. F. Hagen application Serial No. 357,767, filed September 21, 1940, now Patent No. 2,390,879, of December 11, 1945.

At sea level the spin vanes would be adjusted to provide maximum spin, all vanes being adjusted to corresponding positions. Up to 30,000' altitude, the vanes would automatically be adjusted to maintain an air pressure of 14.7 pounds per square inch in the cabin. From 30,000' to 40,000' the vanes would be adjusted, if necessary, to provide air pressures decreasing with altitude increases, from 14.7 pounds at 30,000' to 9.6 pounds at 40,000'. While the supercharger could be designed to provide an air pressure of 14.7 pounds per square inch at 40,000' or even higher, the performance described was decided to be satisfactory.

The blower wheel 20 discharges the compressed air past the diffusion vanes 70 and then into the scroll outlet 21 from which a duct which is not illustrated, conveys the air into the cabin.

The upstream end of the shaft 10 has the portion 71 of reduced diameter supported for rotation in the roller bearing 72 which is supported from the casing by the stream-lined struts 74. The lock-nut 76 on the upstream end of the shaft maintains same in position in the bearing 72.

The small centrifugal fan 79 having the blades 80, is attached to the shaft portion 71 adjacent

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the lock-nut 76 and acts to draw air through the passages 81 into the bearing 72, and then to move this air through the bearing and to discharge it through the opening 82 in the lower strut 74 to a point outside the supercharger. This air entrains the lubricating oil leaking from the bearing, and prevents it from entering the air stream passing through the supercharger.

Lubricating oil is supplied to the shaft bearings from oil cups which are not illustrated, and which would be threaded into the tapped openings 84 in the casing 22.

The downstream end of the shaft 10 has the portion 85 of reduced diameter around which the roller bearing 86 is fitted. The disc 87 is attached to the shaft portion 85 against the inner race of the bearing 86, and is held in position thereagainst by the lock-nut 88 threaded onto the shaft portion 85. The plate 90 having the perforations 91 therein extends around the shaft portion 85 between the lock-nut 88 and the shaft drive coupling 92, and is supported from the inner wall 75 of the casing.

The wall 93 of the scroll outlet 21, has the openings 94 therein which provide passages for air compressed by the supercharger against the inner side of the disc 87, providing a thrust thereagainst opposing the thrust caused by the reaction of the air passing through the supercharger. The openings 91 in the plate 90 provide an air pressure against the outer side of the disc 87 which is the same as that at the inlet of the supercharger. For example, at 40,000' altitude, the air pressure at the inlet of the supercharger and on the back side of the disc 87 will be 2.8 pounds per square inch absolute. The air pressure in the outlet of the supercharger and on the inner side of the disc will be 9.6 pounds per square inch absolute. The difference in pressure on the two sides of the disc, and its surface area, are suf-

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ficient to neutralize the thrust on the supercharger bearings caused by the reaction of the air passing through it.

While one embodiment of the invention has 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. A supercharger comprising a plurality of blower wheels, a plurality of spin vanes located between said wheels, a casing around said wheels and vanes, said vanes having rotary shafts journaled in said casing, arms attached to said shafts, a lever pivoted to said arms, an annular gear around one end of said casing, a gear segment on one of said shafts, said segment having teeth meshing with teeth of said gear, and means for rotating said annular gear whereby through said segment, said shafts, said arms and said lever, all of said vanes are adjusted simultaneously.

2. A supercharger comprising a plurality of blower wheels, a plurality of spin vanes located between said wheels, a casing around said wheels and vanes, said vanes having rotary shafts journaled in said casing, arms attached to said shafts, a lever pivoted to said arms, an annular gear around the upstream end of said casing, gear segments on the upstream ones of said shafts, said segments having teeth meshing with the teeth of said gear, and means for rotating said annular gear whereby through said segments, said shafts, said arms and said lever, all of said vanes are adjusted simultaneously.

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No references cited,