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A. BAJ
CENTRIFUGAL SUPERCHARGES FOR
INTERNAL COMBUSTION ENGINES
Filed July 5, 1940

Serial No.
344,165
2 Sheets-Sheet 1

FIG.1

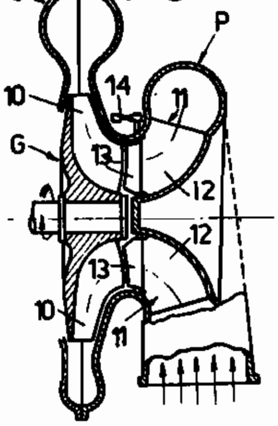


FIG.3

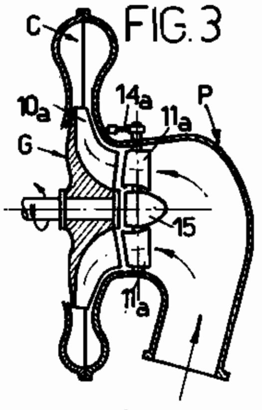


FIG 2

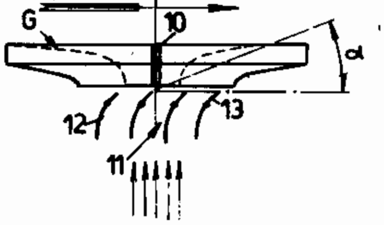


FIG.4

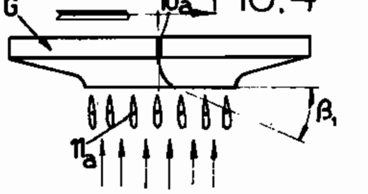


FIG.5

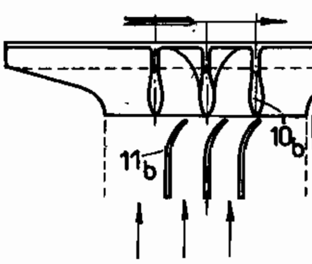
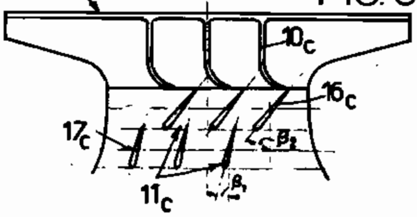


FIG.6



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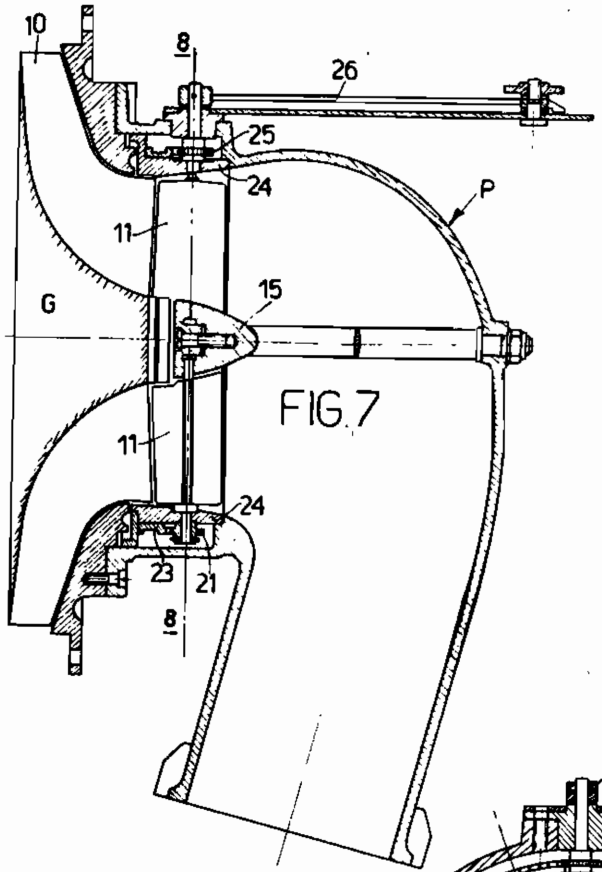


FIG. 7

FIG. 8

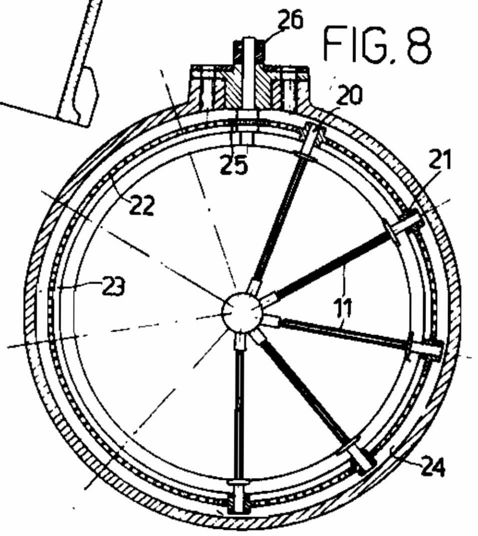
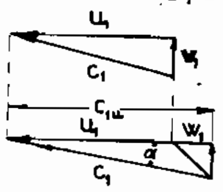


FIG. 9



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ALIEN PROPERTY CUSTODIAN

CENTRIFUGAL SUPERCHARGES FOR INTERNAL COMBUSTION ENGINES

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Application filed July 5, 1940

The objects of the present invention are some important improvements in centrifugal compressors for supercharging internal combustion engines.

It is known that in order to obtain the best adiabatic efficiencies and the highest compression ratios from centrifugal compressors, it should be carefully avoided that the flow of air accelerated by the compressor should strike anywhere in its passage through the intake channels leading to the fan and between the fan and the fixed diffusing blades.

Experiment has also shown that the changes in speed should be gradual and congruent.

The higher the pressure-ratio of a fan and therefore the higher the peripheral speed, the more important is a correct and regular flow of the air stream. In modern compressors for supercharging aircraft engines, in which the speed of flow of the fluid, both in the conduits as in the fan, have attained the highest values recorded in the art, it is of the utmost importance to prevent the fluid vein from striking on anything.

The present improvements have the object of impressing to the fluid vein a motion approaching very nearly the theoretical flow and such to avoid the fluid from striking against anything on entering the fan.

A first improvement consists in this, that the compressor is provided with means capable of securing to the fluid entering the fan, besides axial (longitudinal) flow also a rotational motion having linear speeds, along the radius, substantially equal to those of the fluid flowing the fan.

The means capable of securing a rotational motion to the fluid entering the fan consist in a number of fixed blades, separated from the fans-blades by a very short air gap and having the exit side conveniently curved.

Another improvement consists in this that said fixed directional blading is curved helicoidally and receives the air from an air transporter in form of an helix, capable of imparting to the fluid a rotational component corresponding very approximately to the mean average value of the rotational component in the fan.

In practice, it has also been found that the shockless intake conditions of inflow are obtained approximately as theory has them only for a given value of the volume of flow, of the delivery pressure and number of rev. per minute; when these quantities vary there should be a change in the inclination of the single points of the exit edge of the directional blading. This can be obtained by making the last portion of said blading more or less inclinable.

Another innovation consists in this, that the change of the directional blades incidence is brought about by a servo-motor controlled by the supercharging pressure feeding the engine.

In order to disclose the importance of the invention it should be noted that a device used in many compressors for radial engines consists in using an intake spiral in front of the fan, having a simple radial blading; this device has the drawback of causing a free vortex wherein the highest peripheral speeds are towards the centre (hyperbolic law) with flow conditions which are absolutely the reverse of the real variation of linear velocities along the radius of the fan: (linear law increasing with the radius).

These and other innovations will be disclosed in the following specification and attached drawings, showing different profiles directional-blade shapes and of the centrifugal compressors pertaining thereto.

Fig. 1 is a sectioned elevation of a compressor with directional blading having an end portion movable.

Fig. 2 shows diagrammatically a portion of directional blading and of the fans blades developed in a plane, according to Fig. 1.

Fig. 3 shows another sectioned elevation of a compressor with movable directional blading.

Fig. 4 shows a view similar to Fig. 2 of the compressor shown in Fig. 3.

Figs. 5 and 6 are other similar views of alternatives, with sectioned fans, also developed in a plane.

Fig. 7 shows a sectioned elevation of a preferred embodiment for a compressor with variable directional blading.

Fig. 8 is a section of the above along line 8—8 of Fig. 7.

Fig. 9 shows velocity diagrams referring to a particular case.

With a particular reference to Figs. 1 and 2 the fan G is of the straight radial type and its vanes (see Fig. 2) are straight.

A shroud of convenient shape, forms the spiral delivery chamber C and the intake P or cowl, also in spiral form, the latter having directional blades **11** for the fluid, having a helical shape. Said blading is formed by a rear part **12** fixed to the cowl and by a front part **13** movable and controlled simultaneously by a lever **14**. In such a manner the fluid stream lines in motion assume a motion approaching very nearly to the motion of a fluid in theoretical conditions and such as to avoid striking at the entrance of the fan and forming vortices.

It happens also that the fluid stream-lines along the fans radius are directed along the resultant of the peripheral speed and of the longitudinal (intake) speed, i. e. the fluid at the entrance (of the fan) has, besides an axial (longitudinal) motion, also a rotational motion with linear velocities along the radius equal to those in the fan.

The helical shape of the blading **11**, due to the particular snail volute shape of the cowl, impart to the (incoming) fluid a rotational component corresponding very nearly to the mean average value of the rotational component in the fan.

The alternative shown in Figs. 3 and 4 obtains the same result, by bending forward in the direction of motion the vanes **10a** of the fan G at the entrance of the fluid in the latter. The directional blading **11a** for the (incoming) fluid is achieved in this case by having the blades movable, so that they may take the desired angle of entrance.

The cowl P in this alternative is not in form of a spiral, due to the mobility of the rear part also of the blades, the same being pivotally mounted at the bottom on an ogival hub **15** so that the fluid may pass around it without incurring in losses.

In Fig. 5 is shown another embodiment of a fan wherein the vanes **10b**, towards the fluid intake, bulge, in a bulb so as to achieve high adiabatic efficiencies. In fact from this profile applied to the vanes of the fan and to the directional blading depends the critical value of the angle of attack, beyond which the stream lines leave the surfaces of the channels wherein they flow, creating good or bad conditions of flow in dependance of the induced turbulence.

In the alternative shown in Fig. 6 which follows the same ideas, the fan C has vanes **10a** as in the case of Figs. 3 and 4, whilst the directional blading **11c** has a double order of blades **16** and **17** of which one has movable blades and, when both orders of blades are movable, their members will have different intake angles and such as to secure a gradual directional lead of the flux.

Said blading members may be controlled either by a single controlling member or by one member for each order of blades.

The inventive principles disclosed may be achieved by providing a fan of the pattern mentioned above in combination with any of the above directional blading types or with other types, according to the various requirements of the particular technical conditions.

Likewise the blades control may be achieved in various manners: Figs. 7 and 8 show a preferred embodiment of said control.

The blades carry in correspondence of the pivoting outer pin **20** a small pinion **21** fixed on it and meshing with a front teeth gear **22** cut into a crown **23** turning within a seat cutout in a ring **24** placed in the intake chamber P of the compressor.

The control of crown **23** is obtained by means of pinion **25** which can be rotated from the outside through a lever **26** properly connected or not to the controlling members of the running conditions of the supercharger (intake pressure or outlet pressure, speed, outer atmospheric pressure, functional characteristics of the engine etc.).

The compressors obtained by following the above principles, have very greatly improved operating features, due to the dynamic conditions in which the fluid operates.

In the particular case of air-craft superchargers, the volume of air per second is bound to the number of revolutions of the engine. With a compressor driven by the engine by means of a multiplying gear with a fixed ratio, when no reductions are made in the channels sections before or after the compressor, for each number of rev. per minute there corresponds a certain value of the feeding pressure. If we suppose to be working at the altitudes for which the normal operations of the engine is calculated the maximum engine output is obtained exactly in the above conditions and with the highest pressure of air-feed; if the output has to be varied without varying the rev. per min. the feed pressure should be reduced as stated above, by reducing the section of flow either before or after the fan. Concerning the compressor this means an increase in delivery and a reduction in the volume flow, which condition causes the operation of the compressor on another point of its characteristic curve with a change in adiabatic efficiency and in power input.

With a compressor provided with movable directional blading according to the present invention, it is possible to change the features of the theoretical water head pressure of the fan (always keeping constant the rev. per min.) so that the new pressure head and volume flow correspond to a lesser power input, obtaining by throttling.

On analysing Eulers formula giving the theoretical head H_t it is found that

$$H_t = \frac{U_2C_{2u} - U_1G_{1u}}{g}$$

If in first approximation we consider a radial outflow, we obtain

$$H_t = \frac{U^2{}_2 - U_1C_{1u}}{g}$$

where u = is the peripheral speed

C_{1u} = the peripheral component of absolute velocity. We can vary the term C_{1u} by varying the intensity of the direction of the absolute inlet velocity C_1 as shown in the diagram Fig. 9.

In such a case H_t will vary and namely will decrease for any increment of C_1 and for any increment in the inclination of the blades (reduction of angle α).

In our case these quantities are bound one to another by this that, on increasing the inclination of the blades, the free area of passage between the blades decreases.

These considerations on the triangles show also that the integral value of the changes in the momentum (quantity of motion) pressed on the fluid depends on the inclination of the directional blades; now the intake condition shows that a part of the energy of the fluid is returned to the fan precisely because it is found in this form. It will be therefore possible to obtain a decrease in the useful water head H_{ut} with a final energy balance-sheet better than when obtained by throttling.

In the case of a radial blading with intake edge bended forwards according to the direction of the theoretical triangles at the entrance, it is important for avoiding shocks to obtain an airflow with streamlines rigourously axial at inflow. In such a case the admission conduit has a blading in radial direction, and when the compressor will have to operate in conditions of utilization varying only slightly, the same blading may be fixed (non movable); otherwise, on reasoning as above, the blading will be made movable. In any case it will be convenient to design bladings which represent a compromise between the two fundamental bladings disclosed.

In practise, particulars of construction may vary in any way without thereby exceeding the limits of the invention and therefore the protection of the patent.

ALESSANDRO BAJ.