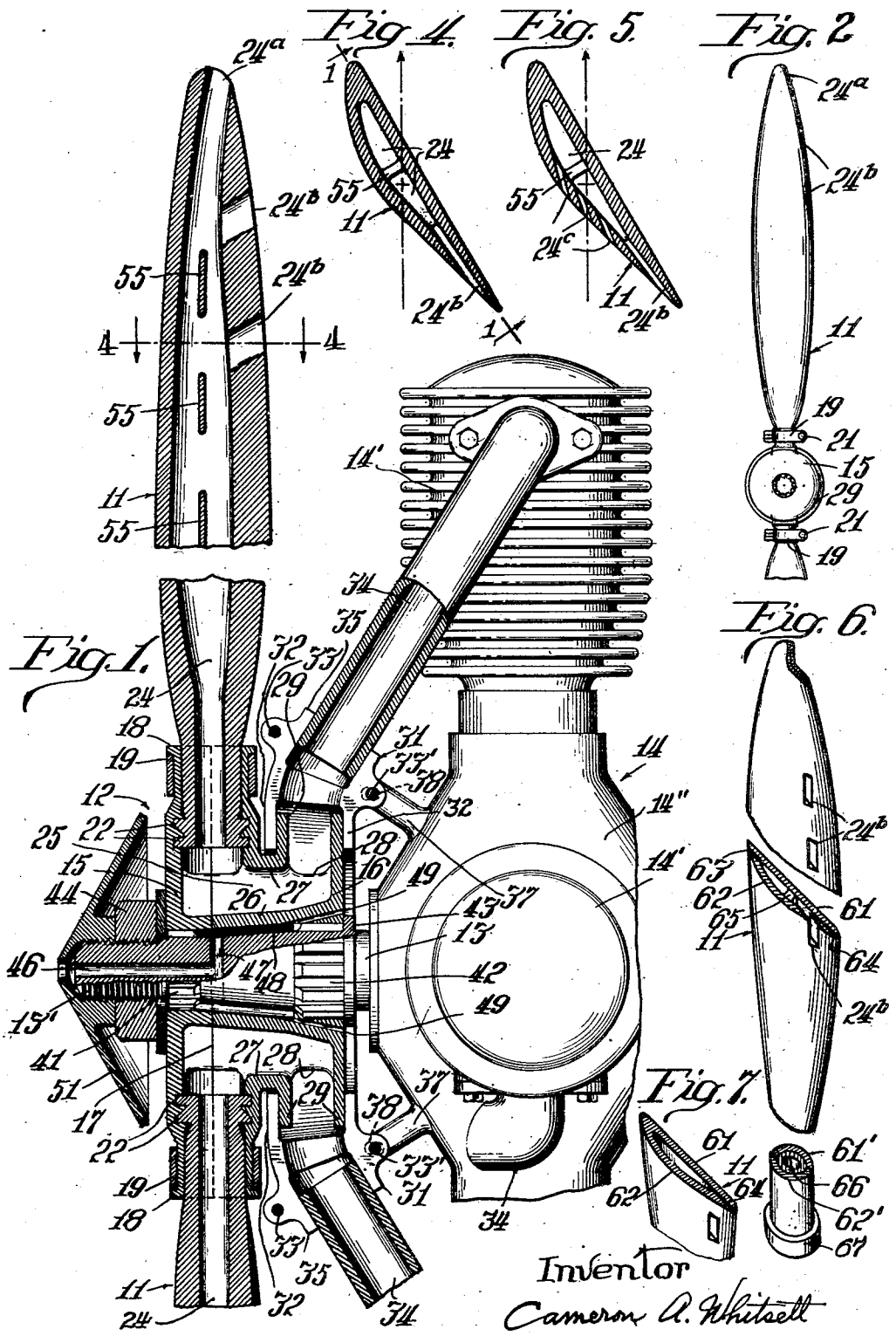
Jan. 9, 1934. C. A. WHITSETT 1,942,674

AEROPLANE POWER PLANT

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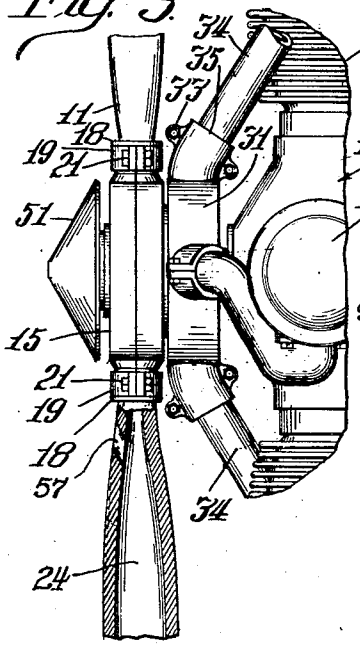


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Fig. 3.



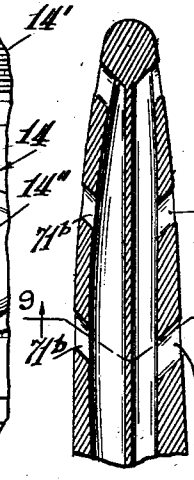
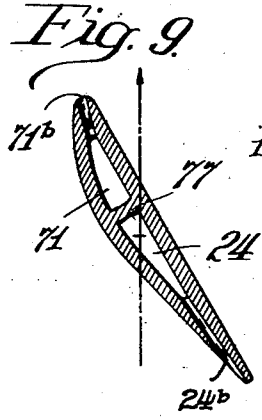


Fig. 8.

Fig. 9.



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1,942,674

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1,942,674

AEROPLANE POWER PLANT

Cameron A. Whitsett, Chicago, Ill.

Application July 15, 1929. Serial No. 378,207

12 Claims. (Cl. 170—172)

The present invention relates generally to aeroplane power plants.

One of the principal objects of the invention is to provide improved means for silencing the exhaust of the aeroplane motor, and also for so discharging this exhaust as to increase the efficiency of the motor and the efficiency of the propeller driven thereby. The use of a conventional type of automobile muffler on an aeroplane has generally been considered objectionable for numerous reasons, such as the weight of the relatively large muffler required, its head resistance to air flow, the back pressure which it exerts on the exhaust with consequent loss of engine power, etc. Because of these objections it has been generally considered that the noise of the motor exhaust was a necessary evil if the desired high efficiency of the aeroplane was to be retained.

I propose muffling the motor by discharging the exhaust through hollow blades of the propeller which drives or sustains the aircraft. The ordinary aeroplane propeller, when rotating at moderately high engine speeds, has a peripheral velocity closely approaching the velocity of sound, the average peripheral speeds ranging between 600 and 1000 feet per second. It will be apparent that by discharging the exhaust from the tips of the propeller blades, the air medium into which the discharge occurs will be receding from the blade and from the point of exhaust at a speed closely approaching the velocity of sound. Because of the extremely high speed of this recessional flow of air away from the point of discharge, the discharge does not have a medium in which the sound impulses of compression and rarefaction can be created with ordinary intensity and, hence, there is a pronounced muffling effect on the exhaust.

At these blade velocities, it will naturally follow that a high degree of suction or vacuum will exist directly along the entire trailing edge of each blade, and that this rarefied condition will closely approach an absolute vacuum adjacent to the outer end of the blade. My invention also contemplates discharging the exhaust from the propeller blades either through these trailing edges or at points in proximity thereto, so as to obtain the silencing benefit of discharging into these highly rarefied areas.

My invention can be made to increase the efficiency of the aeroplane motor by utilizing the aspirating or suction effect of these points of exhaust discharge to create a rarefied condition into which the discharge occurs. That is to say, because of the aspirating suction induced by discharging from the tips or trailing edges of the blades, the exhaust can be made to occur into a sub-atmospheric pressure considerably below the prevailing atmospheric pressure, and it will be noted that this will still be true irrespective of the altitude at which the aircraft is flying. The considerable centrifugal force set up in the flow of the exhaust gases outwardly toward the ends of the hollow propeller blades also aids materially in creating this aspirating action on the exhaust discharge.

The invention also increases propeller efficiency by virtue of the exhaust gases reducing the rarefaction prevailing at the trailing edges and on the back sides of the blades, thereby diminishing the suction effect or pressure differential between the front and back sides of the blades. In this regard, my invention also comprehends taking atmospheric air into passages in the propeller blades and exhausting such air at the trailing edges or at any other points of the blades where rarefaction, turbulence, eddy flow or the like represent parasitic losses in propeller efficiency.

Another feature within the purview of my invention is to utilize the aeroplane propeller as a supercharger for the engine.

The high velocity of the air impinging against the leading edges and front faces of the propeller blades creates an exceptionally high air pressure at these points, and my invention contemplates conducting this air pressure through passages in the hollow blades to the carburetor, or directly to the cylinders in the case of Diesel operation.

Other objects, features and advantages of the invention concerned with the manner in which the exhaust gases are conducted to the hollow propeller blades, the manner in which intake air may be conducted from the blades to the engine, the manner in which the propeller hub may be cooled, etc., will appear in the following detailed description of a preferred embodiment of my invention. In the accompanying drawings, illustrating such embodiment:

Fig. 1 is a sectional view illustrating an adaptation of my invention to a radial air cooled motor, the section plane through the propeller blade following the curvature of the blade as represented by the section plane 1—1 of Fig. 4;

Fig. 2 is a fragmentary front view of the propeller shown on a smaller scale and illustrating one arrangement of the exhaust ports in the blades;

Fig. 3 is a fragmentary side elevational view showing the stationary manifold ring in elevation,

this view showing one of the propeller blades in section for illustrating a modified construction designed to admit air to the blade passages;

Fig. 4 is a transverse section taken on the plane of the line 4—4 of Fig. 1 and illustrating one arrangement of the exhaust ports, the dash and dot arrow indicating the line of rotation of the blade;

Fig. 5 is a similar sectional view illustrating another arrangement of the exhaust ports;

Fig. 6 is a perspective view with parts broken away in section illustrating an improved method of constructing hollow propeller blades, such constituting another feature of my invention;

Fig. 7 is a fragmentary perspective view in section illustrating another method of forming hollow propeller blades;

Fig. 8 is a view similar to Fig. 1 illustrating a modified construction adapted to the taking of intake air through the propeller blades as well as for the discharging of exhaust gases therefrom; and

Fig. 9 is a transverse sectional view of this modified propeller blade, taken on the plane of the line 9—9 of Fig. 8.

In the construction shown, the propeller comprises two or more blades 11 mounted in a hollow hub structure 12 which is keyed to the drive shaft 13 of the motor 14. This hub structure is divided into front and rear sections 15 and 16, respectively, which are fastened together at the transverse split line indicated at 17. The propeller blades 11, which are constructed of metal, are each mounted in a tubular clamping boss 18 extending radially from the outer wall of the hollow hub. There may be two, three or more blades carried by the hub, each being mounted in one of these clamping bosses 18.

The front half of each boss is formed as an integral part of the front hub section 15, and the rear half of the boss is formed integral with the rear hub section 16. A clamping band 19 encircles each boss 18 and is provided with a suitable arrangement of clamping bolts 21 (Fig. 3) by which the two halves of the boss 18 can be rigidly clamped to the shank portion of the propeller blade. The inner end of this shank portion is preferably provided with one or more right angle shoulders 22 engaging in internal grooves in the boss 18 for locking the blade therein against centrifugal force. This clamped mounting of the blades in the bosses 18 permits the pitch angle of the blades to be adjusted if desired.

Extending outwardly through each blade is a passageway 24 which communicates at its inner end with a chamber area 25 formed in the hub structure between spaced inner and outer walls 26 and 27, both sections of the hub being formed with matching portions of these walls. Both sections of the hub are also provided with reenforcing webs 28 located at angularly spaced points in the hub and joining the outer and inner walls thereof. Extending outwardly from the rear section 16 are two annular flanges 29 defining therebetween a rotating manifold area which communicates with the space or spaces 25 within the hub. A stationary manifold ring 31 has two annular flanges 32 extending inwardly over the outer sides of the rotating flanges 29 and contacting therewith to provide substantially closed communication between the interior of the stationary manifold ring and the space between the flanges 29.

This outer manifold ring is split into two semicircular sections to permit assembly over the flanges 29, these two sections being clamped together by bolts 33 as illustrated in Fig. 3. The exhaust gases of the engine are conducted to the stationary manifold ring 31 through conduits 34 which connect with bosses 35 opening into the ring. I have illustrated a radial type of air cooled motor comprising cylinders 14' extending outwardly from a crank case 14'', and when adapting the invention to this type of motor, a separate conduit 34 will preferably be extended to the exhaust port of each cylinder 14'. When adapting the invention to a V-type motor or to a straight line motor, any desired number of conduits 34 may be extended to different cylinders or groups of cylinders, although most generally in such embodiment one or two manifolds will conduct all of the exhaust gases to the manifold ring 31.

The conduits 34 may be relied upon for holding the manifold ring against rotation, or such ring may have bolted connection with brackets or arms 37 extending from the crank case 14 or other stationary part of the motor. The bolts 33' which connect the manifold ring with these arms may be arranged for limited horizontal movement in slots 38 provided either in the manifold ring or in the arms 37, whereby the ring will be securely held against rotation but will be capable of shifting slightly so as to follow any slight shifting movement of the flanges 29 consequent upon thermal expansion or the like.

The front and rear sections 15 and 16 of the propeller hub are mounted on splines 41 and 42 extending from the propeller shaft 13, these hub sections having cooperating splines or keys interfitting therewith. The rear hub section 16 abuts against a radial flange 43 extending from the shaft 13, and the two hub sections are rigidly clamped together with this rear section abutting the flange 43 by a nut 44 screwing over the threaded front end 13' of the propeller shaft. The two sections of the hub may be held together solely by the clamping bands 19 and by the nut 44 compressing the hub against the flange 43, or these two sections may be provided with additional clamping lugs extending from their outer wall and receiving clamping bolts.

It will be evident from the foregoing that all of the exhaust gases of the engine will be conducted to the manifold ring 31, from whence they will travel inwardly between the flanges 29 and through the longitudinal chamber areas 25 to the passageways 24 extending outwardly through the propeller blades. It may be desirable to provide means for cooling the hub 12, in addition to the natural cooling function which will occur by radiation to the high velocity air stream, and particularly to minimize the transmission of heat from the hub to the shaft 13 so as to avoid the possibility of heating the shaft bearings.

As illustrating one such cooling arrangement, I have shown the front portion of the shaft as provided with a central bore 46 into which the high velocity air can enter. This bore opens through branch passageways 47 into an annular space 48 defined between the shaft 13 and the inner wall 26 of the hub and between the splines at the front and rear ends of the hub. A plurality of small ducts 49 extend outwardly from this annular space 48 through the rear section of the hub and discharge to the rear thereof. It will hence be seen that the air stream creates a constant circulation of air through the passages 46, 47 and through the annular space 48 for venting through the ducts 49, thereby cooling the hub and providing a thermally insulating medium between a considerable part of the hub and the

shaft. If desired, a conical wind deflector 51 may be screwed over the threaded end 13' of the shaft for reducing the head resistance of the propeller hub.

The passageway 24 conducting the exhaust gases outwardly through each propeller blade 11 may be extended out to the tip of the blade, or it may terminate at the trailing edge of the blade at a point intermediate the ends thereof. The section of the blade illustrated in Fig. 1 is taken along a varying plane following the pitch angle or twist of the blade. The passageway 24 is preferably substantially cylindrical in the inner shank portion of the blade, but as the thickness of the blade diminishes toward its tip end, this passageway assumes a flattened formation of diminishing depth transversely of the blade and of increasing width in the plane of the blade, substantially as shown in Figs. 1 and 4.

In Fig. 1, the port 24*a* at the trailing side of the blade tip illustrates one arrangement of outlet port. The other ports 24*b* in or adjacent to the trailing edge, illustrate other exhaust points; the passageway 24 terminating at either of these ports 24*b*, or such ports being employed in conjunction with the port 24*a* at the tip of the blade. As shown in Figs. 1 and 4, in the thin portion of the blade the front and back walls may be reenforced transversely of the passageway 24 by small spaced ribs 55 integrally joined with these front and back walls and extending across the passageway.

Based on air flow characteristics of similarly formed airfoils, there is apparently a considerable degree of rarefaction at the trailing edge of the blade and along the relatively flat rear portion of the camber on the rear face of the blade. By discharging the exhaust gases into this rarefied zone, the sound impulses have a very unstable, attenuated medium on which to react and, consequently, the exhaust is muffled to an efficient degree. Fig. 4 illustrates an arrangement of ports 24*b* wherein all of the ports are disposed in a line extending along the back side of the blade at the trailing edge thereof. Fig. 5 illustrates a modified construction wherein additional ports 24*c* are disposed at several different points along the reverse side of the blade, these ports discharging through the comparatively long, flat portion of the camber of the blade, into the zone of rarefaction referred to above. The ports 24*c* may be arranged in groups or singly located at different radial points along the length of the blade.

Because of the high peripheral speeds of all of these ports, an intense aspirating effect is exerted thereon by the slip stream and rarefaction in the wake of the propeller blade, and this aspirating effect, together with the appreciable centrifugal force set up in the gases within the passageway 24, causes an extremely high velocity of flow outwardly through the blade so that the passageway 24 need not be of very large size to handle a large volume of exhaust gases. By proper proportioning of the construction to provide sufficient flow areas, the aspirating suction and centrifugal force may be utilized to maintain a partially exhausted condition or sub-atmospheric pressure in the line of the exhaust flow, so that the discharge from the engine cylinders occurs into a pressure below that of atmosphere.

Whatever suction or rarefaction exists at the trailing edge and on the back side of the propeller blade increases the pressure differential between the front and rear sides of the blade and reduces the propeller efficiency by requiring that much more power to rotate it. It will be evident that, by discharging the exhaust gases into this rarefied area, the pressure differential or drag of the blade is materially reduced. In Fig. 3 I have illustrated a modified arrangement wherein atmospheric air is vented out through the ports 24*a*, 24*b* or 24*c* (shown in Figure 1) for reducing this suction drag on the blade. This atmospheric air may be introduced into the passageway 24 at any desired point, such as through the hollow propeller hub or through the front or leading face of the blade.

The port 57 illustrates this latter arrangement, representing an air inlet opening into the passageway 24 from the front side of the blade or from the front face thereof where it will be subject to the impinging velocities of the air stream.

The propeller blades may be constructed by casting, forging or in accordance with any of the practices now used. However, in Figure 6, I have illustrated an improved method of constructing an aeroplane propeller to have the aforementioned general arrangement of passageways and ports for discharging either exhaust gases, air, or both, adjacent to the trailing edge of each blade. Two metallic plates 61 and 62 are shaped to the proper formation and are given the proper twist corresponding to the pitch of the blade, and these two plates then have their tapered, longitudinal edges welded together along the leading and trailing edges of the blade, as indicated at 63 and 64. Interposed between the two plates is a series of spacing spools or a continuous rib, generally indicated at 65, which may be joined to both walls, as by spot welding, such spacing means maintaining the chamber of the back plate 62 and reenforcing the entire blade. The ports 24*b* leading from the intervening passageway 24 to the trailing edge of the blade are formed by notching out portions of the back plate along the trailing edge, as shown in Figure 6. The inner ends of the two plates 61 and 62 may be provided with a cylindrical shank portion for mounting in a propeller hub by shaping the inner ends of both of these plates into semi-cylindrical portions 61' and 62' and then welding these portions over a tubular shank 66. This tubular shank may be formed with an integral annular flange 67 projecting outwardly beyond the end portions 61' and 62' to form a locking shoulder similar to one of the shoulders 22.

Fig. 7 illustrates a further modification of this general construction, wherein the front and back walls 61 and 62 are both made from a single plate. This plate is folded along a line corresponding to the leading edge of the blade and the two tapered edges of the plate are then welded together along the trailing edge of the blade, as indicated at 64. A similar arrangement of spacing means 65 may be employed and the inner ends of the front and rear sides may be given a cylindrical shaping for welding over the outer side of a tubular shank, as shown in Fig. 6. In both of the constructions illustrated in Figs. 6 and 7, the front and rear walls 61 and 62 may be flattened and brought into direct contact with each other for welding together at the tip end of the blade, thereby forming a tip end of relatively thin section.

Figs. 8 and 9 illustrate a modified arrangement wherein the propeller is utilized as a supercharger for supplying air under pressure to the engine. In this arrangement, an air passageway 71 is extended out through each blade with one or more ports 71*b* extending therefrom to the leading

edge of the blade, substantially as illustrated in Fig. 8. The high velocity impingement of the air against this attacking edge of the blade establishes high air pressures along this edge, which are conducted inwardly through the passageway 71 to the engine. These passageways 71 of the two or more propeller blades open into a longitudinal passageway 72 in the hollow hub 12, such longitudinal passageway discharging between radial flanges 73 at the rear end of the hub into a stationary manifold ring 74.

One or more conduits 75 conduct this air from the manifold ring 74 to the carbureting apparatus of the engine, or directly to the engine cylinders in the case of Diesel operation. The intake manifold ring 74 may be constructed in the form of two halves for clamping together over the flanges 73, as described of the exhaust manifold ring 31. I have shown these air intake passages embodied in a propeller and hub designed also for discharging the exhaust gases through the propeller blades. In such arrangement, the air intake passage 71 in each blade will be separated from the exhaust passage 24 by a partition wall 77, and the longitudinal air passageway 72 in the propeller hub will be separated from the exhaust passageway 25 by an annular wall 78. The forward end of this annular wall joins with a radially extending wall 78' which engages with the inner end of the partition 77 in each blade, thereby maintaining the air and exhaust passageways separate in the blade and in the hub. The split line on which the two sections of the hub join extends through this radial wall 78'. The intake of air through the propeller and the discharge of the exhaust therefrom increases the efficiency of the engine by increasing the pressure of the air admitted to the engine and reducing the pressure into which the exhaust discharges. The close juxtaposition of the passageways 24 and 71 in the propeller blades and the close juxtaposition of the annular passageways 25 and 72 in the propeller hub result in a desirable transfer of heat from the exhaust gases to the incoming air so that the air supplied to the engine will not be excessively cold. It will be understood, however, that the propeller and hub of Fig. 8 can be constructed without the exhaust passageways so that air admission only will occur through the propeller and hub.

While I have shown and described my invention in what I consider to be the preferred embodiment thereof, it will be understood that such embodiment is merely exemplary and that various modifications and re-arrangements may be made without departing from the essence of the invention. For example, airfoils of different contours or at different angles of attack have their zones of rarefaction and zones of compression differently distributed and therefore in propellers of different sectional contour or at different angles of attack it may be desirable to have the exhaust ports 24b, 24c at different points other than at the trailing edge of the blade, and, likewise, it may be desirable to have the air admission ports 71b at different points other than at the leading edge of the blade, such being within the purview of my invention.

Furthermore, the adaptability of the invention is not limited to the conventional propeller which now propels the present day aeroplane. For example, the invention may be incorporated in a helicopter screw, or in the series of revolving sustaining surfaces characterizing that type of aircraft commonly known as the autogyro.

I claim:

1. In combination, an internal combustion aircraft engine, a propeller driven thereby, ports in the blades of said propeller, passageways communicating with certain of said ports, means for conducting intake air from said passageways to the cylinders of said engine, and passageways communicating with other of said ports for discharging the exhaust from said engine through said blades.

2. In combination, an internal combustion aircraft engine, a propeller driven thereby, a port in one of the blades of said propeller opening from said blade adjacent to a zone of compression created by the moving blade, means for conducting air from said port to the air intake of the engine to supply air under pressure to the engine, a second port in one of said propeller blades opening from said blade adjacent to a zone of rarefaction induced by the moving blade, and means for conducting the exhaust of the engine to said second port.

3. In combination, an internal combustion aircraft engine having an air intake communicating with its cylinders, a propeller driven thereby, said propeller comprising a hub, a port in one of the blades of said propeller located to have air impelled therein in the rotation of the propeller, said hub having a duct receiving the air from said port and a passageway connecting with said duct and conducting said impelled air from said hub to the air intake of said engine for supplying air under pressure to the engine.

4. In combination, an aircraft engine comprising a power shaft, a propeller driven thereby, said propeller comprising a hub mounted on said shaft and blades radiating from said hub, a passageway in said hub communicating with passageways extending outwardly through said blades, said latter passageways discharging through outlet ports in the propeller blades, means for conducting the exhaust of the engine to the passageway in said hub, and means for causing a cooling stream of air to flow between said power shaft and said hub.

5. The combination with an aircraft engine having a propeller shaft, of a propeller driven thereby, said propeller comprising a hub mounted on said shaft and divided into two sections, means for clamping the propeller blades between said sections, passageways extending outwardly through said blades and communicating with exhaust ports opening outwardly to atmosphere through said blades, a passageway in said hub surrounding said shaft and spaced therefrom and communicating with the passageways in said blades, and means for connecting said latter passageway with said engine.

6. The combination with an internal combustion aircraft engine, of a propeller driven thereby, said propeller comprising a hub having an exhaust passageway therein, propeller blades extending outwardly from said hub, one of said blades having a longitudinally extending passageway therein communicating at its inner end with the exhaust passageway in said hub and communicating at its outer end with an exhaust port discharging from said blade adjacent to an area of rarefaction, means for conducting the exhaust of the engine to the exhaust passageway in said hub, said hub also having an air passageway therein separate from said exhaust passageway, one of said blades having a longitudinally extending passageway therein communicating at its inner end with said air passageway and com-

municating at its outer end with an air intake port in said blade opening to atmosphere adjacent to an area of compression, and means for conducting air from said air passageway in the hub to the air intake of said engine for supplying air under pressure to said engine, said exhaust transferring heat to the incoming air in their passage through said hub.

7. The combination with an internal combustion aircraft engine, of a propeller driven thereby, said propeller comprising a hub having two substantially concentric passageways therein, propeller blades extending outwardly from said hub, said concentric passageways both extending from said propeller blades to the inner end of said hub, each of said blades having two longitudinally extending passageways therein terminating at their outer ends respectively with ports opening from said blades into rarefied zones adjacent to said blades and into compression zones adjacent to said blades, the inner ends of each pair of passageways in each blade communicating respectively with the concentric passageways in said hub, means for conducting the exhaust of the engine to one of the concentric passageways in said hub, and means for conducting air from the other concentric passageway in said hub to the air intake of said engine for supplying air under pressure to said engine, said exhaust transferring heat to the incoming air in their passage through said hub and blades.

8. The combination with an aircraft engine, of a propeller driven thereby, said propeller comprising a hub, propeller blades, and means connecting said blades with said hub providing for pitch adjustment of said blades relatively to said hub, a port in one of said blades opening from the blade adjacent to a zone of compression created by the moving blade, means for conducting air from said port to the air intake of the engine, a second port in one of said blades opening from the blade adjacent to a zone of rarefaction induced by the moving blade, and means for conducting the exhaust of the engine to said second port.

9. The combination with an aircraft engine having a propeller shaft, of a propeller driven thereby, said propeller comprising a hub mounted on said shaft and divided into two sections on a plane transverse of the hub axis and substantially coincident with the axes of the propeller blades, means for clamping the propeller blades between said sections, passageways extending outwardly through said blades and communicating with ports opening outwardly to atmosphere through said blades, and means for connecting said passageways with said engine comprising a connecting passageway in said hub surrounding said shaft and spaced therefrom.

10. The combination with an aircraft engine, of a propeller driven thereby, said propeller comprising a hub and propeller blades radiating therefrom, said hub being divided into two sections, means for clamping the propeller blades between said sections, a port in each of said blades adjacent to the leading edge thereof, means for conducting air from said port to the air intake of the engine, a second port in each of said blades adjacent to the trailing edge thereof, and means for conducting the exhaust of the engine to said second port.

11. The combination of an internal combustion aircraft engine comprising an exhaust conduit and an air supply conduit connecting with the cylinders of said engine, an aircraft propeller driven by said engine, said propeller comprising a hub and blades radiating therefrom, each of said blades having an exhaust duct extending outwardly through the blade and venting to atmosphere through an exhaust port opening into an area of rarefaction adjacent to said blade, each of said blades having an air supply duct extending outwardly through the blade and communicating with atmosphere at its outer end through an air intake port opening into an area of compression adjacent to said blade, an annular exhaust manifold and an annular air supply manifold, both of said manifolds being disposed at the inner end of said hub, said exhaust and air supply conduits communicating respectively with said exhaust manifold and with said air supply manifold, and passages in said hub connecting said exhaust manifold with said exhaust ducts and connecting said air supply manifold with said air supply duct, whereby the propeller serves as a muffler and as a supercharger by discharging the exhaust into rarefied areas adjacent to the revolving blades and by supplying air to the engine drawn from compression areas adjacent to the revolving blades, and whereby the exhaust gases heat the intake air in their passage through the hub and propeller blades.

12. In an aircraft, an internal combustion aircraft engine comprising an air supply conduit connecting with cylinders of said engine, an aircraft propeller driven by said engine, said propeller comprising a hub and blades radiating therefrom, ports in said blades opening from said blades into zones of pressure created by the moving blades, whereby air is forced under pressure into said ports in the rotation of said propeller, passageways in said blades for conducting said air under pressure from said ports inwardly to said propeller hub, and a manifold chamber in said propeller hub establishing communication between said passageways and said air supply conduit whereby said propeller functions as a supercharger for said engine by supplying air under pressure to the engine cylinders.

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