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[54] DRIVE ENGINE HAVING SHROUDED PROPELLER WITH A VARIABLE OUTLET CROSS SECTION

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[52] **U.S. Cl.** **60/230**, 60/231, 60/221, 60/226

[51] **Int. Cl.** **F02k 1/20**

[58] **Field of Search** 60/230, 231, 221, 226; 244/67; 114/150, 151; 115/42

[56] **References Cited**

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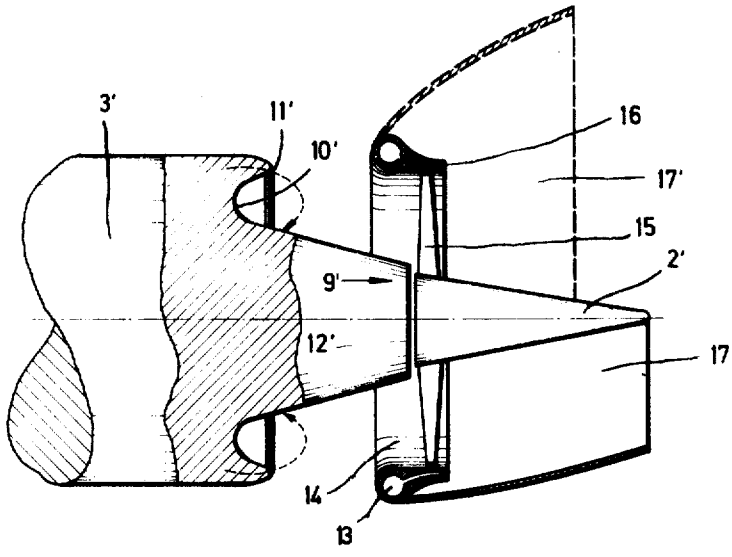
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[57] **ABSTRACT**

A drive engine includes a rotatable propeller with a shroud around the propeller which carries flaps which extend in the flow direction and which may be moved inwardly and outwardly for varying the shroud outlet cross section. A drive engine is operated to produce a high specific static thrust using the shrouded propeller, for example during take off, when it is in an outward position at which the discharge or outlet is expanded. For a high speed flight the outlet of the shroud is narrowed by moving the trailing ends of the flaps inwardly, for example; this accelerates the main air current inside the shroud for a great specific thrust with reduced shroud drag. In one embodiment, the mounting body for the propeller and the flaps is provided with an annular slot having an auxiliary air current feed for stabilizing potential vortices. Similar potential vortices adjacent the shroud are controlled either by the use of a separate auxiliary ring member associated with the shroud or by using a closed ring having means for discharging a fluid current in the vicinity of the vortex generation. The shroud itself may advantageously be either also provided with or alternatively provided with an annular groove for controlling any vortices in this location.

20 Claims, 3 Drawing Figures



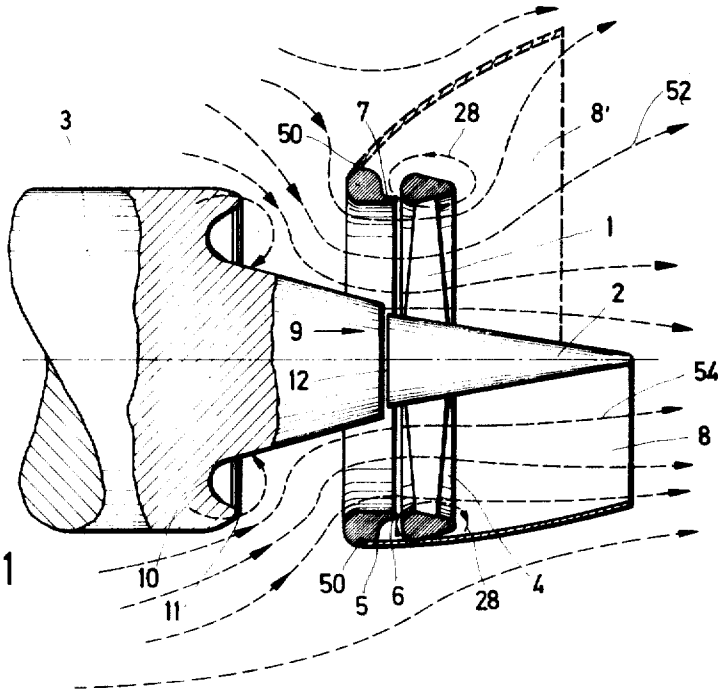
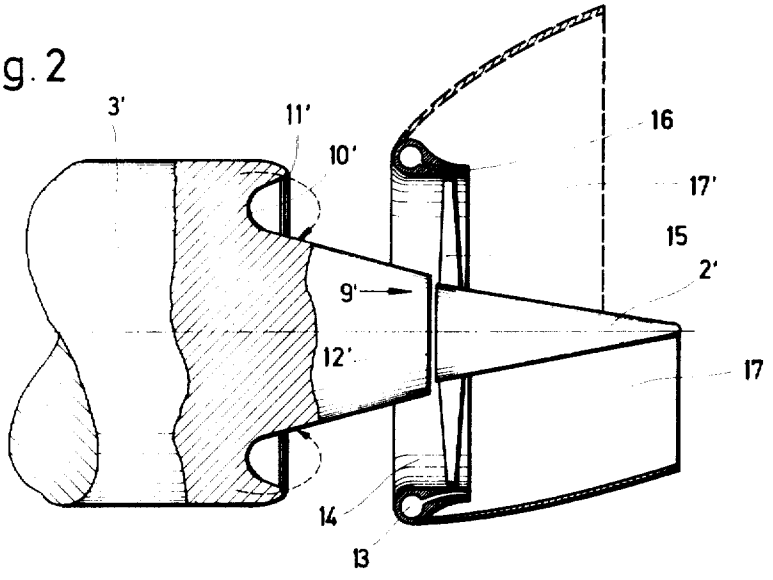


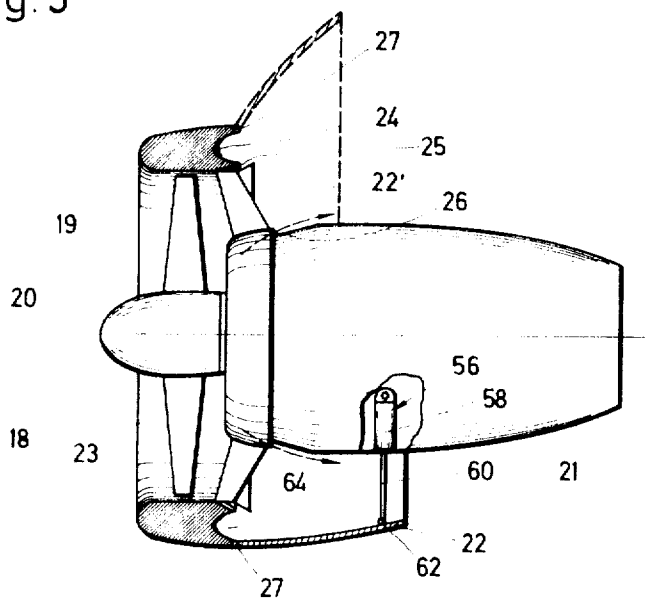
Fig. 1

Fig. 2



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Fig. 3



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DRIVE ENGINE HAVING SHROUDED PROPELLER WITH A VARIABLE OUTLET CROSS SECTION

SUMMARY OF THE INVENTION

This invention relates in general to the construction of driving engines having shrouded propellers, and in particular, to a new and useful drive engine having a shrouded propeller with a shroud having means for varying the outlet cross section thereof.

In order to increase the static thrust of a drive engine which is provided with a free flying propeller, it is known to provide the propeller with a ring-shaped shroud so that full current velocities will be provided in the propeller plane. Due to the higher rate of air flow, energy is gained and transformed into thrust which is absorbed by the shroud. Such shrouded propeller drives which are employed, for example, in airplanes, are relatively limited in the form of their shroud. In particular, profile forms with widening cross sections inside the shroud must be avoided because of the diffusion losses which would then result. A further factor to be considered in the design of such shrouds is its profile or cross sectional drop which leads in a shrouded propeller to poorer high speed flight efficiencies than in a free propeller of the same dimension. Only in relatively narrow speed ranges is the thrust gained by the shroud greater than the friction losses. In the known drives using shrouded propellers, for example for airplanes, no optimum solution has been found for the two extreme states of flight, that is, during take-off and high speed cruising flight. Therefore the design of such shrouded propellers must be set either predominately for high specific thrust at low speeds or for high speed with unfavorable static thrust efficiency. It is possible to stretch the effective speed range of the shrouded propeller by rings or by changing the blade angle of the propeller.

In accordance with the present invention substantially equal specific thrust in the drive of a vehicle is provided with a shrouded propeller having constant radiation emissive surface power for the two extreme velocity states, and hence, when employed in airplanes for take off and for high speed flights. For this purpose, the shroud is provided with means for varying its outlet cross section and means are also provided for influencing the boundary layer.

Although traversing gears for vertical take off airplanes with shrouded propellers are known which include expanding flaps, such traversing gears are designed substantially for high speed flight where the expanding flaps associated with the leading edge of the shroud and not with its outlet permit a static thrust increase by influencing the leading edge flow. In the high speed flight the retracted expanding flaps do not produce an additional profile drag. It is known, for example, to provide a nozzle with a variable cross section having an outlet which comprises elastically deformable segments arranged in a circumferential direction and connected with each other for contraction or expansion in radial directions. A reduced reaction is achieved by widening the nozzle outlet.

According to the invention on the other hand, it is possible to change a propeller shroud into an extremely steep diffuser in order to increase the static thrust so that the shroud outlet has a greater flow cross section for take off and for great velocities; and, for high speed flight, the shroud outlet can be reduced to a nozzle configuration. In the case of a diffuser, detachment of the current boundary layer from the shroud walls is prevented by means for influencing the boundary layer. In order to increase the diffuser effect at the same time, stabilized potential vortices can be provided for influencing the boundary layer. In one form an auxiliary current to which flow energy is supplied from the main current flow is employed for influencing the boundary layer. This auxiliary current can be supplied for example also from a pressure chamber.

In one form of the invention the widening of the outlet of the shroud is effected by the use of expanding flaps which surround the shroud and which may be moved inwardly and outwardly at their trailing ends. In the other position they can effect a nozzle like narrowing of the shrouded outlet. A narrowing of the shroud outlet can also be effected by a mouthpiece which is known in itself and which comprises elastically deformable segments which have a convex cross section and are arranged around the circumference and interconnected with each other. Such a shroud outlet has a noise reducing effect in addition to its air flow characteristics.

Means are advantageously provided for supplying a current flow into the shroud inlet for influencing the boundary layer and such means may also be arranged on the outer wall of a central profile body adjacent the shroud. They serve to form stabilized potential vortices by means of flow energy. This principle may also be employed in respect to a shrouded central body such as a front blower engine in which the flow boundary layer on the central body wall can be accelerated by blowing. To this end an annular slot is provided for this purpose.

With the inventive construction, it is possible to operate the shrouded propeller with optimum efficiency in wide velocity ranges so that good specific thrust may be achieved for take off and for high speed flights and also for intermediate speed flying. A favorable side affect is that the rate of travel of a propeller from the take off to the high speed flight can be kept constant by varying the position of the flaps regulating the outlet of the shroud between an outwardly extending diffusing position to an inwardly extending nozzle position. The construction also includes an arrangement in which the propeller is secured inmovably on a central hub.

Accordingly, it is an object of the invention to provide an improved driving engine having a rotatable propeller with a shroud having means for varying the outlet cross section thereof.

A further object of the invention is to provide a driving device for a vehicle such as an aircraft which includes a shrouded propeller, the shrouds having adjustable flaps thereon which may be moved outwardly to provide a diffuser action on the air current and inwardly to provide a nozzle like effect or varied in position between these extremes for achieving desired flow conditions and which also advantageously includes means for influencing the development of vortices both in respect to the shroud and the supporting body therefor.

A further object of the invention is to provide a method of operating a shrouded propeller having adjustable flaps for varying the size of the outlet thereof comprising achieving a high specific static thrust by the use of the shrouded propeller by opening the shroud outlet to permit expanding outward flow of the air current at this location for take off and narrowing the outlet of the shroud for high speed flight to accelerate the main current flow inside the shroud and achieve a great specific thrust with reduced shroud drag.

A further object of the invention is to provide a shrouded propeller drive which is simple in design, rugged in construction, and economical to manufacture.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a partial longitudinal section through a shrouded propeller drive constructed in accordance with the invention;

FIG. 2 is a view similar to FIG. 1 of another embodiment of the invention; and

FIG. 3 is a view similar to FIG. 1 of still another embodiment of the invention.

GENERAL DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings in particular, the invention embodied therein in FIG. 1 comprises a shrouded propeller drive for example, for an aircraft, which includes a propeller blade 1 which is secured on a hub 2 which is rotatably mounted on a body 3 and which is driven from a shaft drive such as a turbine unit (not shown). The hub 2 is arranged behind the central body 3 and it is streamlined to a point in the direction of air or fluid current flow.

The propeller blade 1 is provided at its blade tips with shroud means including a ring 4 which has a streamlined, for example, "tear-drop" cross section. The ring 4 rotates with the blade tips and it defines an annular slot 6 with its front wall and with a tubular member or ring 5 which is located in front of the ring 4 on the central body 3. The tube 5 is provided with an axially extending deflecting nose 7 which extends toward the ring 4. Means (not shown) are provided for securing the tubular member 5 to the central body 3 and such means include the known streamline guide faces or guide vanes.

In accordance with the invention, the shroud means formed by both the ring member 5 and the ring 4 are provided in this embodiment with means for adjusting the outlet of the shroud which include flap elements or covers which may be formed, for example, as an annular cover member 8 which is pivoted to the ring member 5 at a pivot location 50. The flap 8 may be pivoted about the pivotal connection 50 into the dotted line position 8' in which the outlet is expanded greatly and the current flow is as indicated by the dotted line arrows 52 shown on the upper part of FIG. 1. The flaps 8 can also be moved backwardly to a position such as indicated at 8 in solid lines in FIG. 1 wherein the shroud flaps 8 form a nozzle-like flow passage which directs the air as indicated by the dotted line arrows 54 in FIG. 1. The ring member 5 and the shroud ring 4 define a shroud inlet 9. The central body 3 is provided with an annular recess or trough 10 at a spaced location upstream of the inlet 9 for the purpose of accommodating a potential vortex which can be stabilized at such locations by means of flow energy. The apparatus includes an annular slot for providing a stabilizing flow which is in communication through interior ports in the body 3 with a source of high static pressure. The annular slot 11 is so constructed that the auxiliary current fed into it is tangential to the potential vortex in the recess 10. An outflow opening 12 for exhaust gases is arranged at the end of the central body 3 between it and the hub 2. The exhaust gases are also conducted to the annular slot 11.

In the embodiment of FIG. 2, shroud means includes a ring-shaped tube 13 provided with expanding flaps 17 and which is supported by connections to the body 3 (not shown) so as to define an annular flow passage 14. There is a slight amount of play between the tips of the propeller and the ring shaped tube 13 forming the shroud. Instead of mounting the ring 13 so it rotates with the propeller blade 15, the annular tube 13 is provided with an axially extending annular slot 16 and the interior of the tube is connected to a fluid pressure source such as a blast air pipe (not shown). An auxiliary current is fed out through the passage 16 to provide a flow energy which is fed in the area of a potential vortex formed between the walls of the expanding flaps and the annular passage 14. In some instances the pressure delivered to the tube 13 is obtained by a compressor driven by the drive mounted within the body 3'. The connections are then advantageously arranged in the annular passage 14 within guide faces (not shown).

In the embodiment shown in FIG. 3, the shrouded propeller 18 is associated with an engine called a front blower type engine. The propeller blade 18 is mounted on a hub 20 which extends outwardly to the front end from a mounting nacelle 21. A shroud ring 19 which is connected with the shaft of the drive is arranged around the nacelle 21 and the blade 18 with some clearance between it and the blade. The shrouding 19 is provided at its outlet end with expanding flaps 22 which may be extended to the dotted line position indicated at 22' by a drive mechanism 56 which includes a fluid pressure cylinder 58 and a movable piston 60 which is connected to the shroud 22 at a pivot 62. The shroud 22 pivots about a pivot connection 27 located at the trailing end of the shroud ring 19. The outer position of the shroud is indicated at 22' at the upper half of the drawing of FIG. 3.

For aerodynamic reasons it is advisible to arrange, in front of the ring 19, an annular wing (not shown). The shroud ring 19 is also provided on its rear edge 24 with an annular trough 64 providing means to bind a potential vortex. The potential vortex is stabilized by flow energy supplied through an annular slot 25. Another annular slot 26 for an auxiliary current to accelerate the boundary layer of the main current is arranged at the outer wall of the nacelle 21 and is located substantially vertically below the hinge joint 27 for the flaps 22. The drive means 56 and 68 can be provided with additional shroud to improve the current flow.

The method operation of the arrangement is as follows:

In the static thrust position of the shrouded propeller shown in FIG. 1 at the upper portion thereof, the shroud means including the shroud ring 4, the ring member 5 and the flaps 8' are at a position in which there is a delaying action on the main flow. The detachment of the current boundary layer for the expanding flap 8' and the central body wall is avoided by potential vortices. The potential vortex associated with the central body 3 in the annular trough 10 is stabilized by the auxiliary current fed through the annular slot 11. Another potential vortex 28 which surrounds the ring 4 rotates in the propeller blade plane. The stabilizing of the potential vortices avoid a break of the current from the central body wall and effect an increased expansion of the main current in the interior of the shroud. The individual current paths takes substantially the course indicated above the center line by the arrows 52. In this way, a high specific static thrust of the shrouded propeller is achieved.

For high speed flight, the outlet of the shroud is narrowed by closing down the flaps to the position 8 to provide a nozzle flow formation at the interior of the flaps so that the main current is accelerated inside the shroud. A great specific thrust is achieved in this manner with reduced shroud drag with the flow being in the direction indicated by the arrows 54 at the bottom of FIG. 1.

The same effects are achieved by the arrangements represented in FIGS. 2 and 3. With the shrouded propeller in FIG. 2, a potential vortex formed behind the annular passage 14 is stabilized by means of an auxiliary current. In the shrouded propeller construction of FIG. 3, the detachment of the current boundary layer from the inner wall of the expanding flaps 22 is prevented by a potential vortex bound on the rear edge 24 of a shroud ring 19. In addition, the current boundary layer on the nacelle 21 wall is accelerated so that a detachment of the boundary layer particularly in the static thrust portion of the expanding flaps is avoided by vortices formed by the pressure rise on the nacelle wall.

In some instances, the shroud flaps 8 are made of elastically deformable material and are interconnected around their circumference. The flaps may be made up of plates having a convex surface and they may be shaped to permit variation of the outlet cross section. Such flaps are also provided with means for reducing the noise effect. The flaps 8 may also be made with individual flap elements arranged around the circumference without overlap and are connected to each other, for example, by elastic connecting segments.

Tests in a smoke flue with a two-dimensional expanding flap shroud designed according to the invention showed that extremely great diffuser angles of about 70° to 80° can be achieved by potential vortices stabilized by flow energy.

What is claimed is:

1. A shrouded propeller drive comprising a rotatable propeller, shroud means around said propeller including a shroud ring, said propeller having a streamlined hub portion which together with said ring defines a boundary over which a

layer of air is moved by rotation of said propeller, means associated with said ring for varying the outlet cross section from said propeller downstream of said ring, and means adjacent said propeller for generating stabilized potential vortices to influence the air flowing over the boundary surfaces.

2. A shrouded propeller drive, according to claim 1, wherein said means for generating stabilized potential vortices comprises a body on which said hub portion is rotatably mounted including an outer cylindrical portion and an inner portion tapered toward said hub of said propeller, an annular recess defined between said inner tapered portion and said outer portion providing an annular slot for potential vortices.

3. A shrouded propeller drive, according to claim 1, wherein there are first and second axially spaced shroud rings separated by a flow slot therebetween, said first shroud ring having a surface tapered inwardly toward said second ring, said second ring providing means for generating a potential vortices.

4. A shrouded propeller drive, according to claim 1, wherein said means for generating a stabilized potential vortices comprises a ring-shaped tube forming said shroud ring and having a trailing edge with an annular discharge connected to said tube for the delivery of an auxiliary current therethrough.

5. A shrouded propeller drive, according to claim 1, wherein said means for generating stabilized potential vortices comprises an annular groove formed on the trailing end of said ring.

6. A shrouded propeller drive, according to claim 1, including a nacelle mounting said propeller ahead of said nacelle for rotation, and means on said nacelle for supporting said ring in front of said nacelle, said means for varying the outlet cross section from said propeller downstream of said ring comprising a flap pivotally mounted on said ring, and means connected to said flap for moving it outwardly and inwardly.

7. A shrouded propeller drive, according to claim 1, wherein said means for varying the outlet cross section comprises at least one inwardly and outwardly movable flap.

8. A shrouded propeller drive, according to claim 1, including means for directing an auxiliary current in the vicinity of said ring for stabilizing the air flow.

9. A shrouded propeller drive, according to claim 8, including means for directing flow from the main current stream into said auxiliary current flow.

10. A shrouded propeller drive, according to claim 8, including means defining a pressure chamber in the vicinity of said ring for feeding flow energy into an auxiliary current.

11. A shrouded propeller drive, according to claim 1, including a body member rotatably supporting said propeller and having a widened portion upstream of said propeller with an annular trough defined in an end face adjacent said propeller and providing a flow area for influencing the boundary layer in front of said shroud.

12. A shrouded propeller drive, comprising a main body having a hub portion which is rotatable adjacent an end thereof, a propeller carried by said hub portion, a shroud ring surrounding said propeller, at least one annular air outlet defining a flap extending around the circumference of said ring and being pivotal on said ring between inner and outer positions, said flap extending downstream of said ring and being movable outwardly and inwardly at such location for varying the outlet opening from said ring.

13. A shrouded propeller drive, according to claim 12, wherein said main body includes a widened portion upstream of said shroud ring having an annular recessed area defining a trough.

14. A shrouded propeller drive, according to claim 13, including means for introducing a flow in the vicinity of said trough in a direction to stabilize vortices which may develop in such location.

15. A shrouded propeller drive, according to claim 12, including an auxiliary ring arranged forwardly of said shroud ring and having an axially extending tip portion spaced forwardly of said shroud ring and defining an annular opening therewith.

16. A shrouded propeller drive, according to claim 15, including means on said additional ring for pivotally supporting said flap said additional ring twirling flap portion providing means for stabilizing vortices in the vicinity of said shroud ring.

17. A shrouded propeller drive, according to claim 12, wherein said shroud ring comprises an annular duct having a fluid pressure supply and including at least one passage extending outwardly from said duct for directing a portion of the fluid pressure supply into the air stream flowing around the periphery of said propeller.

18. A shrouded propeller drive, according to claim 12, wherein said ring is arranged forwardly of said body, said body comprising a nacelle, and means in said body connected to said flap for moving said flap inwardly and outwardly to vary the outlet opening of said shroud.

19. A shrouded propeller drive, according to claim 18, wherein said ring includes an annular recess on its trailing end defining a trough for stabilizing the air flow.

20. A shrouded propeller drive, comprising rotatable propeller, a shroud ring disposed around said propeller adjacent the periphery thereof and defining with said ring an upstream inlet to said propeller, a flap connected to said ring and extending downstream therefrom and having at least a downstream portion which is pivotal radially outwardly and inwardly in respect to said shroud ring and which defines a variable dimension downstream discharge passage from said propeller, and means adjacent said propeller for generating stabilized potential vortices for stabilizing the air flow to and from said propeller.

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