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B64C 21/00

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GB 1281899 GB 0718498

(58) Field of search
F2R
Selected US specifications from IPC sub-class B64C

(54) Vortex generator and/or boundary-layer separator arrangements

(57) Boundary-layer separators or voltex generators are arranged over substantially the entire span in the region downstream of the greatest thickness of the wing, tail and rudder unit and substantially over the entire fuselage circumference in the tail region of the aircraft.

In order to reduce the pressure resistance on and to improve the inlet proficiency of air inlets (15) in the fuselage or airframe (10) of an aircraft, separators 13 are rigidly arranged on the airframe 10 in front of a closure flap 14 for the air-inlet 15. Instead of separator 13 vortex-generators (11, Fig. 5), or delta-wing vortex generators (11a, Fig. 7) can be provided.

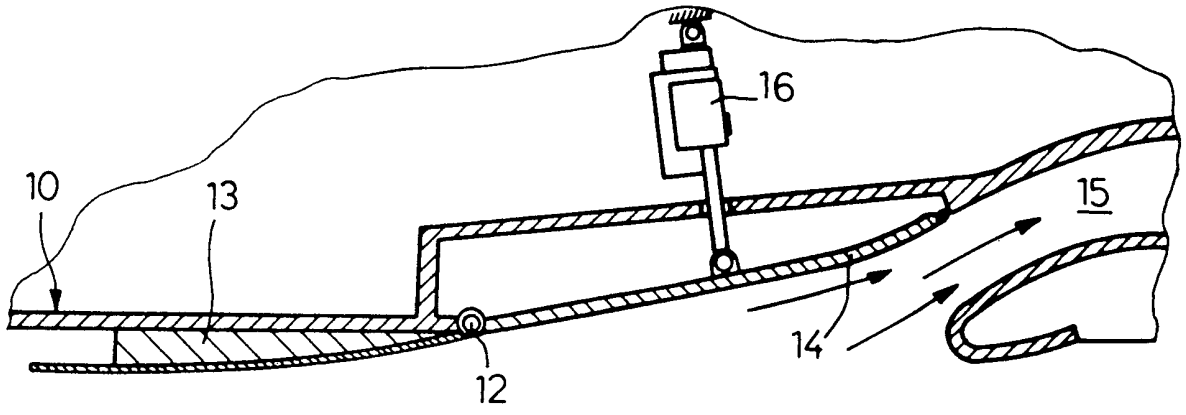

FIG. 2

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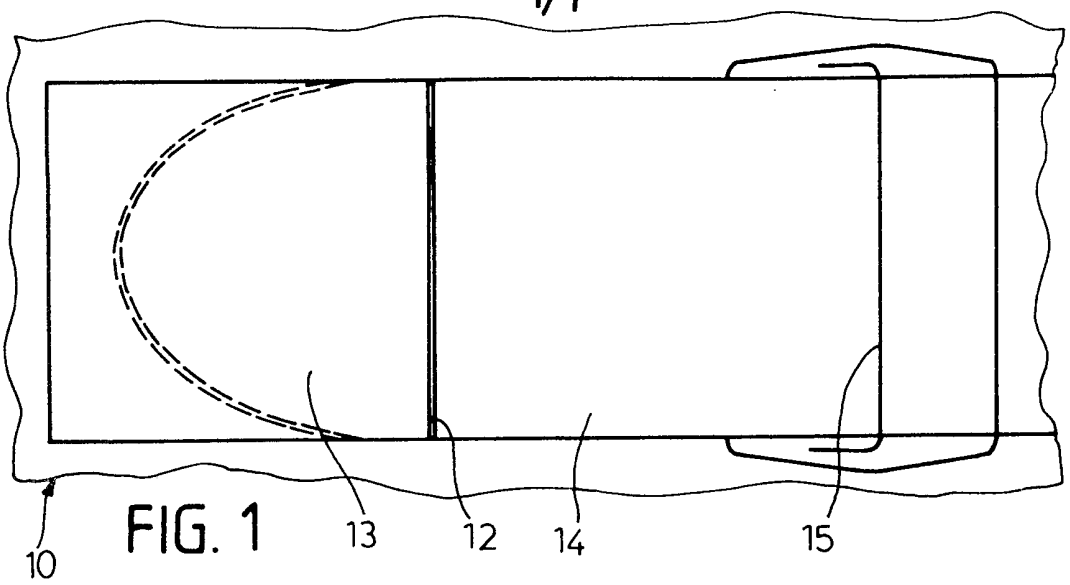


FIG. 1

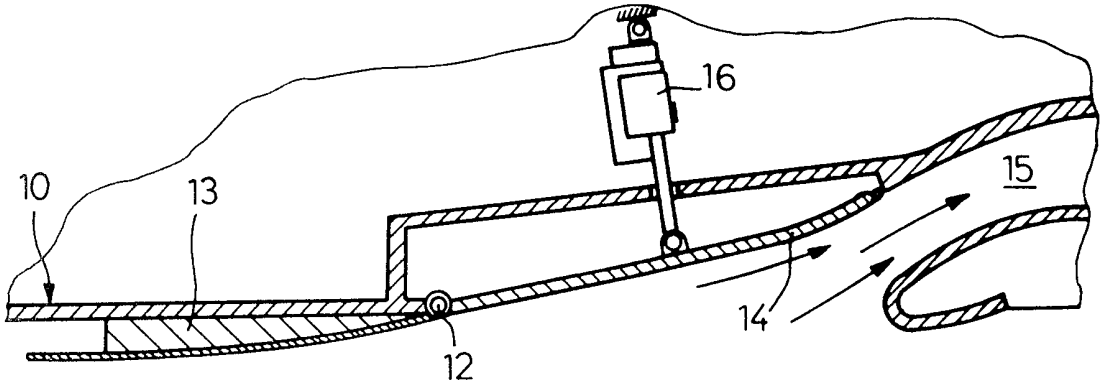


FIG. 2

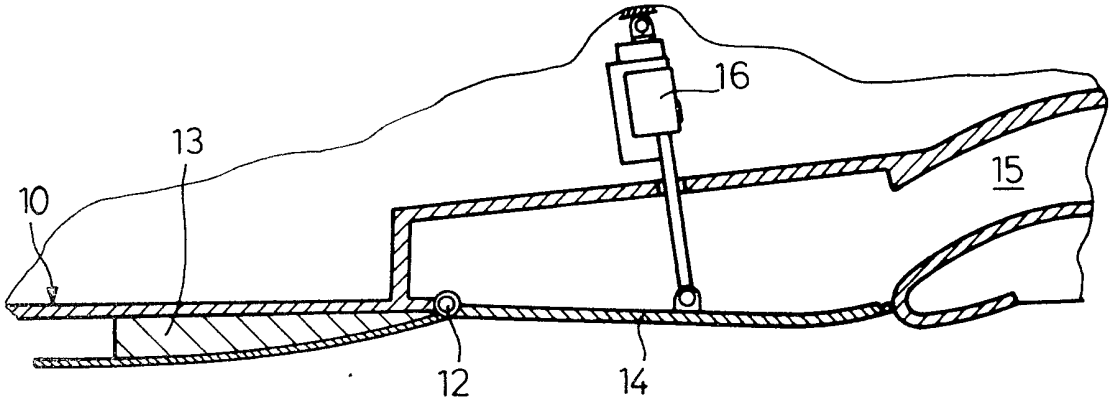


FIG. 3

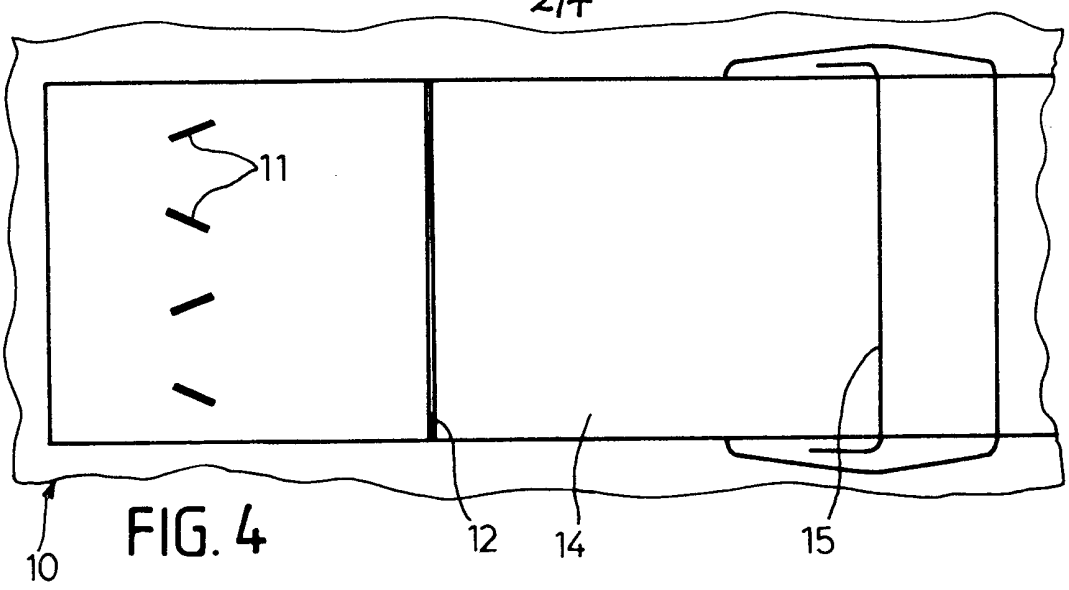


FIG. 4

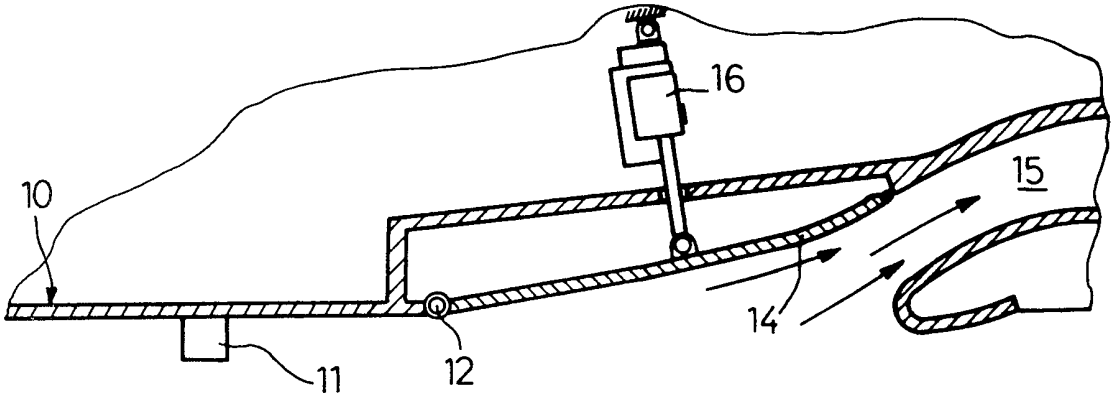


FIG. 5

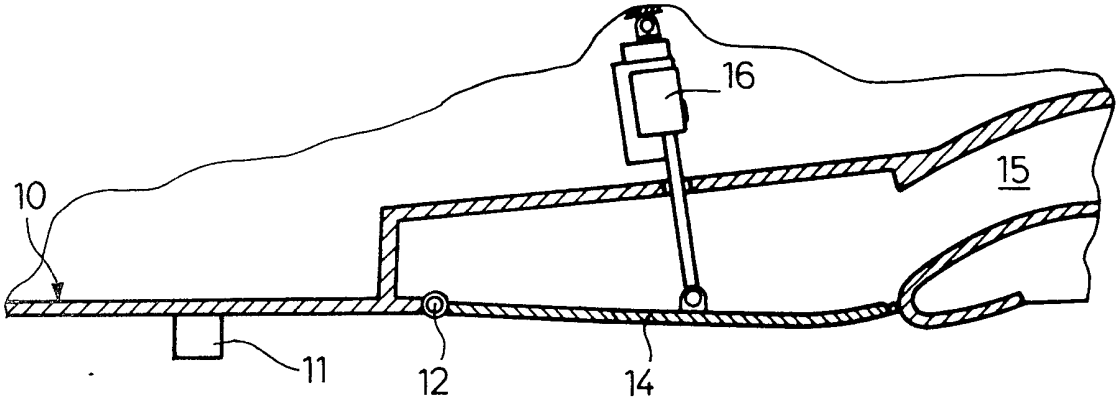


FIG. 6

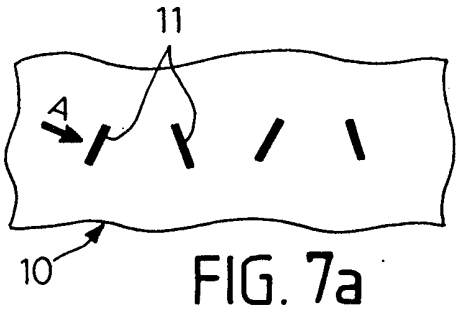


FIG. 7a

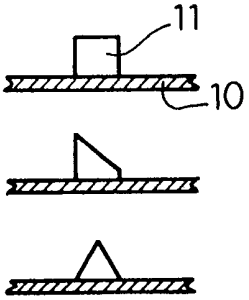


FIG. 7d

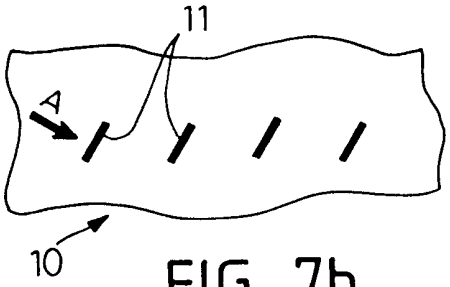


FIG. 7b

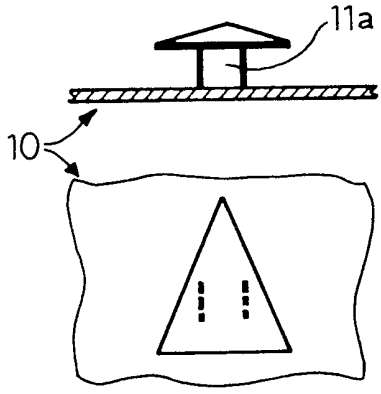


FIG. 7c

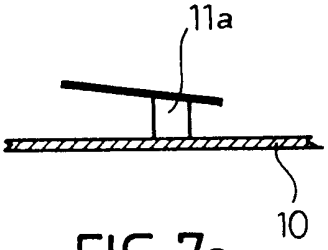


FIG. 7e

FIG. 8

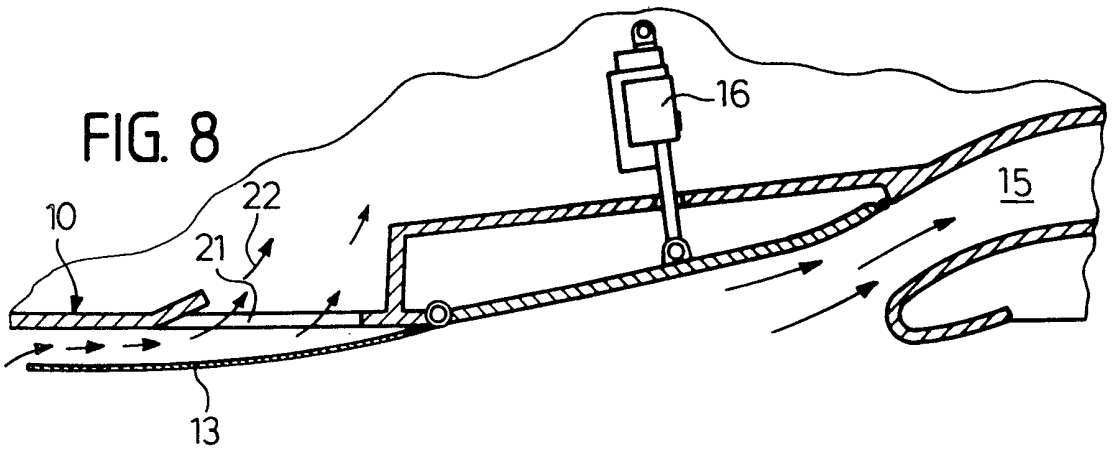
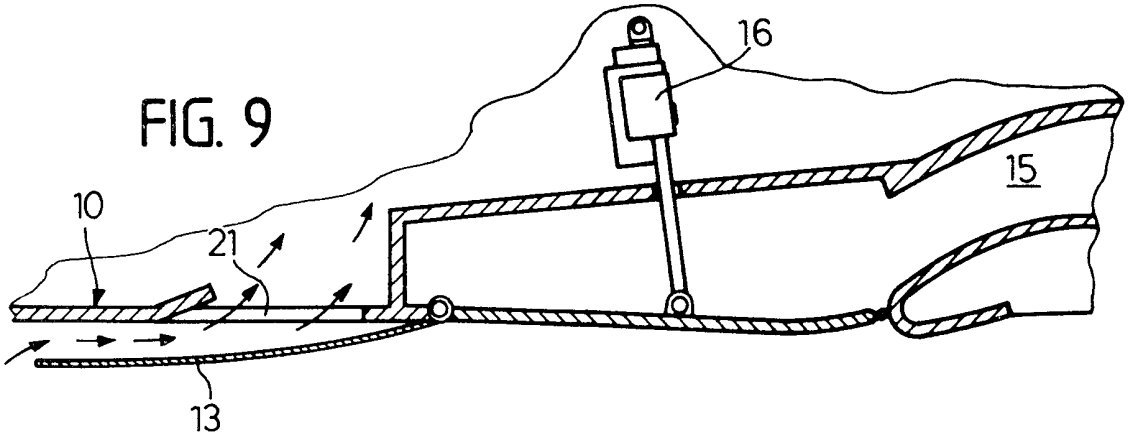


FIG. 9



SPECIFICATION

Vortex generator and/or boundary-layer separator arrangements

This invention relates to an arrangement of vortex generators and/or boundary-layer separators for reducing the pressure resistance or drag on and to improve the inlet proficiency of air inlets of aircraft, motor vehicles and other circumcirculated bodies in any desired media.

It is known to arrange vortex generators or boundary-layer separators to improve the flow conditions on the nose of the fuselage of an aircraft. Thus, for example, from United States Patent No. 4 174 083 it is known to arrange vortex generators in the movable air inlet of an aircraft. A measure for improving the tail resistance condition is, however, not disclosed in the latter said patent document.

Known from United States Patent No. 2 694 357 are air inlets which take high-energy air on board with less additional resistance than in the case of scoops or Pitot inlets. In this respect, these inlets are arranged on the nose, in other words in a region of thin fuselage boundary layers. Moreover, the vortex generators or delta vortex generators are supposed to prevent the separation in the inlet duct. As a result of the measures proposed here, a pressure recovery is obtained and therein an improvement is achieved. However, no kind of reference is given or suggested that an improvement in the inlet inner performance and with appropriate arrangement an improvement in the tail resistance or drag is achievable.

The problem underlying the present invention is to provide an arrangement, of the kind mentioned at the beginning hereof, with which both a tail resistance with abutting flow and an improvement in the inlet inner proficiency is achieved.

This problem is overcome by the present invention in that it provides an arrangement of vortex generators and/or boundary-layer separators for reducing the pressure resistance or drag on and to improve the inlet proficiency in air inlets of aircraft, characterised in that vortex generators, delta-wing vortex generators and/or boundary-layer separators, with or without a subsequently-connected countersunk or flush air inlet, are rigidly arranged substantially over the entire wing span on a line in the region downstream of the greatest thickness of wing, tail- and rudder unit as well as substantially over the entire fuselage circumference in the tail region of the aircraft.

As a result of the proposals of the present invention it has been possible to achieve, in the case of long-distance flights, a further fuel saving of about 2%. As a result of said proposals, however, still further advantageous improvements are achieved, as will become apparent hereinunder from the description of the exemplified preferred embodiments. Advantageous alternative features of the invention are indicated in the sub-claims and explained in the following description.

The invention will be described further, by way of example, with reference to the accompanying drawings in which:

Fig. 1 is an underneath plan view of a flap-controlled gas-turbine air inlet with a fixed boundary-layer separator in front of the inlet opening;

Fig. 2 is a longitudinal part-sectional view of the air inlet and separator of Fig. 1 with the gas-turbine air inlet open;

Fig. 3 is a view comparable with that of Fig. 2 but with the gas-turbine air inlet closed;

Fig. 4 is an underneath plan view of a flap-controlled gas-turbine air inlet with "counter-rotatingly" arranged vortex generators;

Fig. 5 is a longitudinal part-sectional view of the air inlet and generators of Fig. 4 with the gas-tubine air inlet open;

Fig. 6 is a view comparable with that of Fig.5 but with the gas-turbine air inlet closed;

Fig. 7*a* is a schematic plan view of a counter-rotating arrangement of vortex generators in front of the air inlet; Fig. 7*b* is a schematic plan view of an equi-rotating (co-rotating) arrangement of vortex generators in front of the air inlet;

Fig. 7*c* is a schematic plan view of an arrangement of a wing-like vortex generator in front of the air inlet;

Fig. 7*d* is a view in the direction of arrows A of Figs. 7a and 7b showing the shape of vortex generators;

Fig. 7*e* is a side view of an exemplified embodiment of a wing-like vortex generator which can be a delta-rectangle or swept-back wing;

Fig. 8 is a longitudinal part-sectional view of a gas-turbine air inlet with a rigidly arranged boundary-lay separator, associated with which is an additional countersunk air inlet, in which respect the gas-turbine air inlet is open; and

Fig 9 is a view comparable with that of Fig. 8 but with the gas-turbine air inlet closed and with the subsequently-connected countersunk air inlet open.

As has already been mentioned at the beginning of this specification with regard to the prior art, it is known to achieve an improvement in the pressure recovery by the provision of vortex generators or delta wings. In this way it is possible to reduce the loss of power which occurs at great heights and that for the take-over for example of the auxiliary device drives by the separation of the harmful boundary layer the pressure recovery is increased. Now, however, tests made by the applicant firm have shown that yet a considerably greater improvement can be achieved, namely not only in pressure recovery, but lso in the pressure non-uniformity and in the tail resistance upon abutting flow, if vortex gener-

ators 11 (Figs. 4 to 7b and Fig. 7d), delta-wing vortex generators 11*a* (Fig. 7c and 7e) and/or the boundart-layer separators 13 (Figs. 1 to 3, and Figs. 8 and 9) are preferably provided with a countersunk or flush air inlet 15 or 21 respectively and are rigidly arranged over approximately or substantially the entire wing span on a line in the region downstream of the greatest thickness of wing, tail- and rudder unit as well as over substantially the entire fuselage circumference in the rail region of the aircraft.

Thus, as a result of the subsequent connection of the boundary-layer air inlets, a reduction in the pressure resistance is achieved, but at the same time also an improvement in the inlet pressure uniformity and instllation pressure ratio are optimised.

Figs. 1 to 3 show a preferred embodiment of the arrangement of a rigidly arranged boundary-layer separator 13. In front of air inlet duct 15, the boundary-layer separator 13 is arranged rigidly on airframe 10. A flap 14, which is movable by way of an actuator 16, is arranged on a hinge or hinge-like axis 12 and serves for the opening and closing of the air inlet duct 15.

Figs. 4 to 6 show a further preferred embodiment for solving the problem posed at the beginning hereof. Here, on the airframe 10 vortex generators 11 are arranged in front of the air inlet duct 15, which can be opened or closed by a flap 14 also arranged on a hinge or hinge-like axis 12 and movable by actuator 16. In the example shown in Fig. 4, the vortex generators 11 are positioned "counter-rotatingly".

Figs. 7*a* to 7*e* show various examples of arrangements and designs of the vortex generators. In Fig. 7*a* is shown a "counter-rotating" arrangement and in Fig. 7*b* an "equi-rotating" arrangement of the vortex generators 11 on the airframe 10. The shapewise development possibilities of the vortex generators are shown in Fig. 7*d*, in which respect, naturally, other shapes are also conceivable, for example cockscomb-like etc.

Figs. 7*c* and 7*e* show a preferred embodiment of a delta-wing vortex generator 11*a* in plan view, front view and longitudinal view. Here, too, variations are conceivable. Thus, for example, the wing angle may be greater or smller, a specific angle of attack of the delta-wing vortex generator can be of specific importance or generally the areal shape can be rectangular or arrow-shaped in design.

Shown in Figs. 8 and 9 is a further preferred embodiment in which rigidly arranged boundary-layer 13 is associated with an additional air inlet 21 in the airframe 10. The air inlet 21 serves for the introduction of useful air 22. The rigidly prior-connected boundart-layer separator 13 additionally protects the air inlet 21 and auxiliary engine or heat exchanger (not shown) against liquids, such as rain water, skydrol, galley waste water and propellant or fuel, running-off on the fuselage of the aircraft. In this way, the cleaning cycles of air inlet and auxiliary engine etc. are enlarged. Moreover the risk of explosion of the auxiliary engine can be precluded, since no spent or leaking fuel can be sucked in by it. These side-effects emphasize the advantageous of the present invention compared with the prior art.

To sum up, the essential advantages of the invention are: as a result of the proposed measures, an approximately 2% fuel saving in the case of long-distance flights is achieved, the power consumption or power output of auxiliary engines is improved as is equally their re-startability at great altitudes and furthermore an improvement in flight safety occurs, since outflowing propellant is deflected from the air inlet.

CLAIMS

1. An arrangement of vortex generators and/or boundary-layer separators for reducing the pressure resistance or drag on and to improve the inlet proficiency in air inlets of aircraft, characterised in that vortex generators, delta-wing vortex generators and/or boundary-layer separators with or without a subsequently-connected countersunk or flush air inlet, are rigidly arranged substantially over the entire wing span on a line in the region downstream of the greatest thickness of wing, tail- and rudder unit as well as substantially over the entire fuselage circumference in the tail region of the aircraft.

2. An arrangement as claimed in claim 1, characterised in that the vortex generators snd boundary-layer separators are arranged in front of the countersunk air inlet.

3. An arrangement as claimed in claims 1 or 2, characterised in that the vortex generators are arranged counter-rotatingly in front of the countersunk air inlet.

4. An arrangement as claimed in claims 1 or 2, characterised in that the vortex generators are arranged equi-rotatingly in front of the countersunk air inlet. 5. An arrangement of vortex generators and/or boundary-layer separators substantially as hereinbefore described with reference to and as illustrated in Figs. 1 to 3, or in Figs. 4 to 6, or in Figs. 7a to 7e, or in Figs. 8 and 9, of the accompanying drawing.

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