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(56) Documents cited
GB 1591261 A GB 1490641 A GB 1488959 A
GB 1274489 A GB 0598971 A US 4582678 A

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(54) **Thrust nozzle wall construction**

(57) A thrust nozzle for an engine of a rocket or hypersonic aircraft has a wall structure comprising an inner shell 5 of high heat conductivity, penetrated by a number of cooling channels 8, and an outer supporting shell 6. Between the inner shell 5 and the supporting shell 6 there is provided an intermediate layer 7. The intermediate layer may for instance be a cast-in low-melting point alloy, ceramic material or plastic. This arrangement has the advantage that manufacturing tolerances of the inner shell and the supporting shell can be compensated for, so that less arduous demands have to be made on the accuracy of shape of the inner shell and supporting shell especially in manufacturing nozzles of non-circular cross-section.

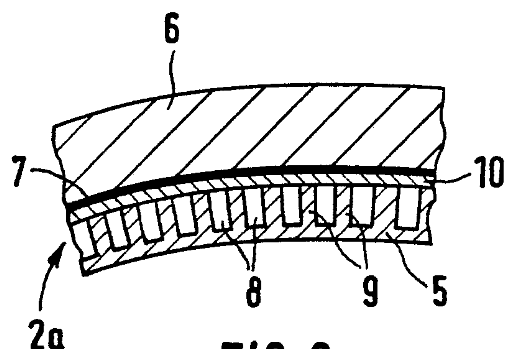

FIG. 2

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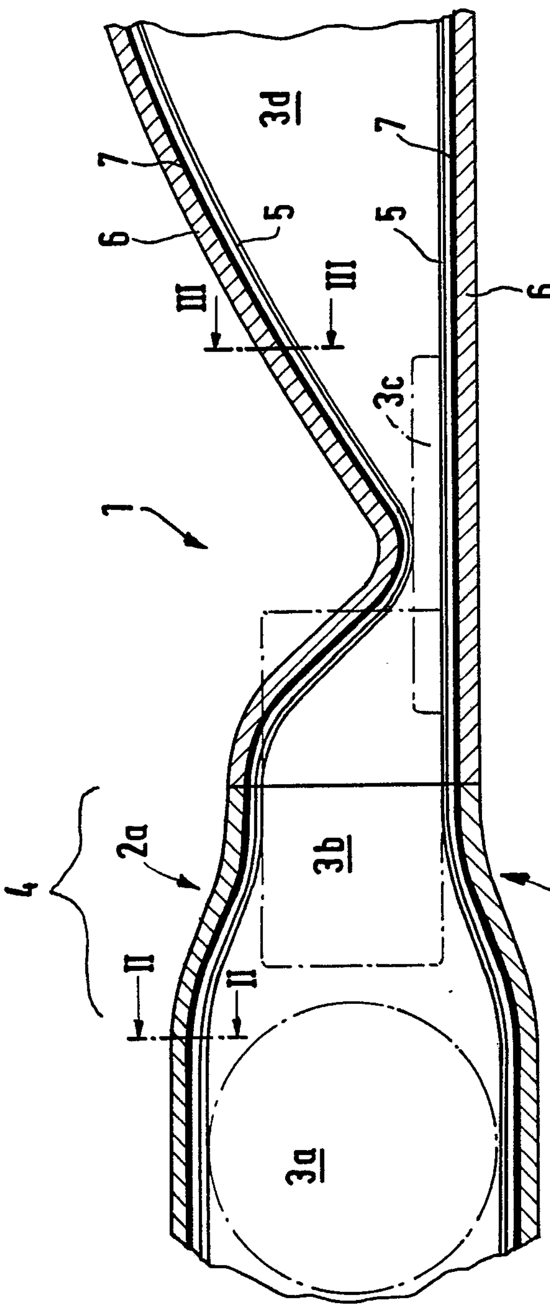

FIG.1

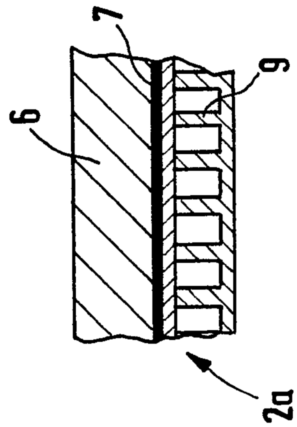

FIG.3

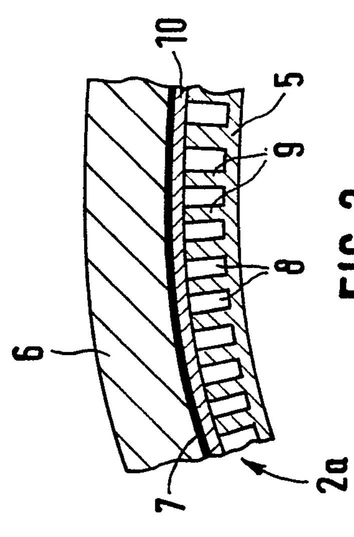

FIG.2

A THRUST NOZZLE FOR AN AIRCRAFT ENGINE

The invention relates to a thrust nozzle for an aircraft engine, having an inner shell of a high heat conductivity and including a number of cooling channels, and surrounded outside by a firm supporting shell, in particular to a wall for such a nozzle.

Thrust nozzles known hitherto for rocket engines for launcher rockets or in space shuttles, for instance, have a rotationally symmetric contour. In particular the circular cross-section tapers from the combustion chamber in the direction of the narrow cross-section and then subsequently widens again. Such a rotationally symmetric contour is simple in terms of manufacturing technology and enables an effective absorbing of the gas forces.

Because of the high temperature of approx. 3000°C, however, the thrust nozzle must be cooled effectively. In the thrust nozzle mentioned above, which consists normally of an inner shell of copper alloy containing embedded circumferential or axial cooling channels, cooling is achieved in that the cooling channels are cooled by a cooling agent, preferably the liquid hydrogen to be burnt in the thrust nozzle. On the outside this inner shell is surrounded without a gap by a supporting shell, which absorbs the gas pressure forces. This supporting shell should have a tensile strength which is as high as possible, whilst, because of the cooling system arranged inside, its thermal stability is not of particular significance.

Efforts at developing so-called hypersonic airplanes are in progress, which also have a thrust nozzle similar to those described above. The problem with thrust nozzles for such airplanes is the high degree of efficiency which is necessary with jet thrust generation, with several engines arranged next to each other. For achieving these requirements thrust nozzles are proposed the cross-sectional contour of which passes from the round cross-section in the region of the combustion chamber to the rectangular cross-section in the region of the nozzle outlet or even of the nozzle narrow cross-section.

This in its turn means that the nozzle wall must have a complicated curved shape. On the one hand, the relatively soft inner shell must have an accurately shaped inner contour, in order to achieve an optimum through-flow, and on the other hand, the supporting shell must for reasons of stability be of such a rigid form that an adaptation to the shape of the inner shell is not possible. The manufacture of both shells with such a high accuracy of shape is very complicated in terms of manufacturing with the complicated geometry.

However, the possibility cannot be ruled out with certainty that even after joining together both shells cavities remain, and these cavities can lead to deformation and cracks in operation and thus to failure.

According to one aspect of the invention there is provided a wall for an aircraft engine, comprising an inner shell of high heat conductivity and including a number of cooling channels, and an outer supporting shell spaced at least in some regions from the inner shell, further including an intermediate layer substantially filling the space between the inner shell and the supporting shell.

Likewise in another aspect there is provided a method for manufacturing the wall of a thrust nozzle, including the steps of: providing an inner shell of heat-conducting material with cooling channels, shaping the shell to the desired form, fitting a supporting outer shell with matching shape while maintaining a gap between the two shells, and filling the gap between the shells.

Embodiments of the invention thus provide a thrust nozzle of the type in question, and a method for manufacturing such a thrust nozzle, which enables production of a nozzle wall with great accuracy of shape and low manufacturing costs, wherein at the same time it is ensured that no cavities remain between the two shells.

By the use of the intermediate layer the manufacturing tolerance of the inner shell and the supporting shell may be compensated for. Hence instead of manufacturing both contours of the inner shell and the inner contour of the supporting shell to a high accuracy, at great expense, and furthermore instead of monitoring the assembly of these shells with great testing complications, only the inner contour of the inner shell need still be manufactured in a dimensionally accurate manner. With regard to the other contours advantageously very few demands are sufficient. Furthermore it is advantageous that the surface quality of all faces except the nozzle inner face, which also require traditionally considerable processing expense, has no influence.

Further, sensors such as temperature- and pressure-measuring probes can be inserted into the nozzle shell without weakening the supporting shell, by casting them integrally in the intermediate layer. With low expense all intermediate spaces between the inner and supporting shell, including undercuts, can be completely filled.

The whole shell face is accurately supported by the supporting shell, particular properties of the shell being determinable by selection of a suitable material for the intermediate layer. It is therefore possible to produce an increased ductility or, by selection of a material which expands in a controlled manner when hardening, a prestress.

Preferably the intermediate layer consists of a metal alloy, in particular an alloy which has bismuth and/or tin as the main component. These alloys have relatively low melting points and thus enable integral casting with relatively low expense. Since the hydrogen cooling gives rise to a very high cooling effect the temperatures in the region of the intermediate layer can be kept very low, so there is no risk of fusing when in operation. For example tin-copper alloys can be used, which have a melting point in the region of 220°C. Bismuth alloys have an even lower melting point. Alternatively by using cadmium alloys a higher melting point can be set in the region of approximately 300°C. Of course the use of metals of higher melting point, for example copper, is also possible, although in this case increased care must be taken to prevent thermal distortion of both shells when casting integrally. Depending on the selection of the components contained in the alloy a defined hardening behaviour, i.e. expansion for producing a determined prestress or expansion freedom for achieving a tension-free arrangement, can be set.

Alternatively it is also possible to manufacture the intermediate layer from other materials, e.g. of a ceramic material in the form of neutralised silicic acid. Finally it is also advantageous to use plastics for the intermediate layer, e.g. a temperature-resistant two-component bonding agent.

In an advantageous further development of the invention the intermediate layer has a thickness of 0.5 - 5 mm, preferably approx. 1 mm. In this way good properties for integrally casting the intermediate layer material with low material consumption are guaranteed.

A further advantage connected to the invention consists in that the intermediate layer can be removed by melting out and the inner shell can be exchanged without the supporting shell being changed. The supporting or pressure housing can advantageously be made of highly resistant and light-weight fibre composite material, such as carbon fibre in either plastics or graphite.

The invention will be illustrated further in the following description of an embodiment with reference to the accompanying drawings, in which:

Figure 1 shows a longitudinal section through a thrust nozzle;

Figure 2 shows a cutaway portion of a nozzle shell, and

Figure 3 shows another cutaway portion of the nozzle shell.

Figure 1 shows a longitudinal section through a thrust nozzle 1, according to the invention, which is constructed substantially of two half-shells of a nozzle shell 2a and 2b, which are bolted together in a manner not shown. The nozzle duct 3 passes from the round cross-section in the region 3a, which is that of the combustion chamber region, in the transition section 4 to the region 3b in the rectangular cross-section. The cross-sections are indicated by the dot-dash lines. In the narrow cross-section 3c the nozzle also has a rectangular contour. The region 3d represents the expansion region of the thrust nozzle 1, in which the rectangular cross-section is also found.

Although the present invention is illustrated with the aid of the thrust nozzle represented in Figure 1, it is also evident that a modification to nozzles with other cross-sections such as drum-shaped or oval is feasible within the scope of the invention.

Both half-shells 2a and 2b of the nozzle shell consist substantially of an inner shell 5, which has cooling channels passing through it, and of a supporting shell 6, which surrounds the inner shell 5. Between the two shells 5 and 6 there is a relatively thin intermediate layer 7, shown black, which is cast in.

Figure 2 shows a section through the nozzle shell 2a along the line II-II according to Figure 1, where the nozzle shell 2a still has a round cross-section. This includes as already mentioned the inner shell 5, which consists of a material of a high heat conductivity. Grooves 8 are formed or embedded at regular intervals in the inner shell 5 so as to extend in the longitudinal direction of the nozzle. The grooves 8 alternate with supporting bars 9. These grooves 8, which face radially outwards in the inner shell 5, form the cooling channels 8, in that the inner shell 5 is surrounded by a thin cover shell 10, which is attached to the supporting bars 9, e.g. by soldering, welding or electro-plating, so that closed cooling channels 8 are formed.

Preferably the cover shell 10 consists of the same material as the inner shell 5. On the outside of the cover the relatively thick supporting shell 6 is arranged, there being a gap of about 1 to 2mm between the inner shell 5, or more accurately the cover shell 10, and the supporting shell 6. This gap is completely filled out with a cast, pressure-tight intermediate layer 7.

Figure 3 shows a section along the line III-III according to Figure 1. The only difference to Figure 2 is seen in that in the region of the section according to Figure 3 the nozzle shell 2a has a rectangular cross-section so that the cutaway portion shown extends in a straight line.

The thrust nozzle 1 according to embodiments of the invention is manufactured by providing an inner shell 5 of a heat conducting material with cooling channels 8, shaping the product to the desired final contour, attaching a supporting shell 6 with a matching shape, while maintaining a gap between the two shells 5 and 6, and finally filling out the gap. The incorporation of the cooling channels can occur for example by means of milling.

If the integral casting method is used, the parts, that is the inner shell 5 and the supporting shell 6, are heated to the casting temperature of the material to be cast, and subsequently the filling material is introduced under pressure in to the vacuum. Preferably this casting is carried out with vibration in order to fill out all cavities reliably.

Although the invention has been described with particular reference to a wall for a thrust nozzle for an aircraft engine, it is clear that it is applicable to any wall construction that has to withstand both high temperatures and high pressures.

Claims

1. A wall for an aircraft engine, comprising an inner shell of high heat conductivity and including a number of cooling channels, and an outer supporting shell spaced at least in some regions from the inner shell, further including an intermediate layer substantially filling the space between the inner shell and the supporting shell.

2. A wall according to claim 1, in which the intermediate layer consists of a metal alloy.

3. A wall according to claim 2, in which the metal alloy has bismuth and/or tin as main component(s).

4. A wall according to claim 1, in which the intermediate layer consists of a ceramic material.

5. A wall according to claim 1, in which the intermediate layer consists of a plastics material.

6. A wall according to any preceding claim, in which the intermediate layer has a thickness of 0.5 - 5 mm, preferably approximately 1 mm.

7. A wall according to any preceding claim and further including sensors for the measurement of nozzle data, embedded in the intermediate layer.

8. A wall according to any preceding claim, in which the supporting shell is made of fibre-reinforced composite material.

9. A thrust nozzle substantially as described with reference to the accompanying drawings.

10. A thrust nozzle comprising a wall as claimed in any of claims 1 to 8.

11. A method for manufacturing the wall of a thrust nozzle, including the steps of: providing an inner shell of heat-conducting material with cooling channels, shaping the shell to the desired form, fitting a supporting outer shell with matching shape while maintaining a gap between the two shells, and

filling the gap between the shells.

12. A method according to claim 11, in which the filling step is performed by casting.

13. A method of manufacturing a thrust nozzle substantially as described with reference to the accompanying drawings.

Patents Act 1977

Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number

9110174.1

Relevant Technical fields

(i) UK Cl (Edition K) F1J (JCA,JCN,JDB,JDX) F4T (TAKI, TAG) B3F (FCC) F2G

(ii) Int Cl (Edition 5) F02K B22D

Databases (see over)

(i) UK Patent Office

(ii)

Search Examiner

H F YOUNG

Date of Search

12.11.91

Documents considered relevant following a search in respect of claims 1 TO 13

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
Y	GB 1591261 (PHILIPS) see Figure 2 and lines 63 to 79 of page 1	11 & 12
X	GB 1490641 (MESSERSCHMITT) See Figures 1 and 2. See lines 85 to 92 of page 6	1
Y	GB 149064	11 & 12
X	GB 1488959 (MESSERSCHMITT) See Figures 1 and 2. See lines 59 to 78 of page 2	1 & 2
Y	GB 1488959	11 & 12
X	GB 1274489 (MESSERSCHMITT) see construction in Figure 5 embodiment	1
Y	GB 1274489	11 & 12
Y	GB 598971 (STANDARD) See Figure 1 and lines from 100 on page 1 to 16 of page 2 and lines 48 to 61 of page 2	11 & 12
X	US 4582678 (NATIONAL) See Figures 10 and 11. See lines 53 to 65 of column 5	1 & 2
Y	US 4582678	11 and 12

SF2(p)

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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