Oct. 24, 1961

R. S. RAE

3,005,309

STREAMLINED RING FOR ASSURING OPTIMUM COMPRESSION IN A RAMJET

Filed Nov. 17, 1952

2 Sheets-Sheet 1

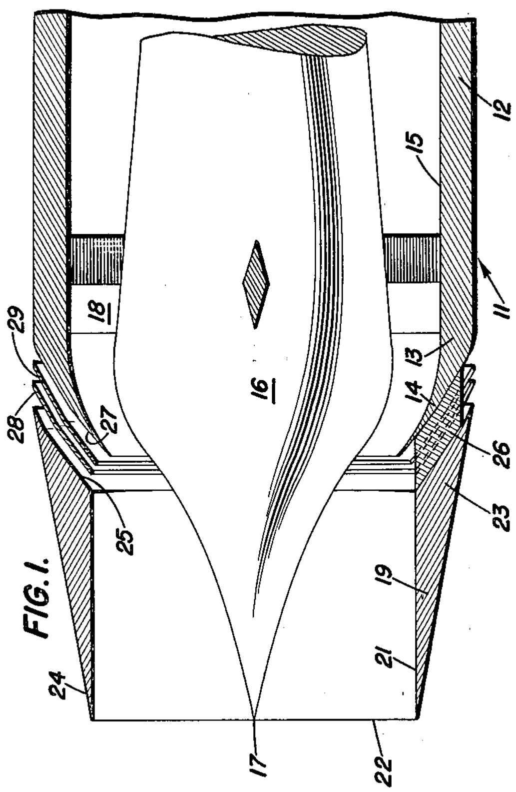

FIG. 1.

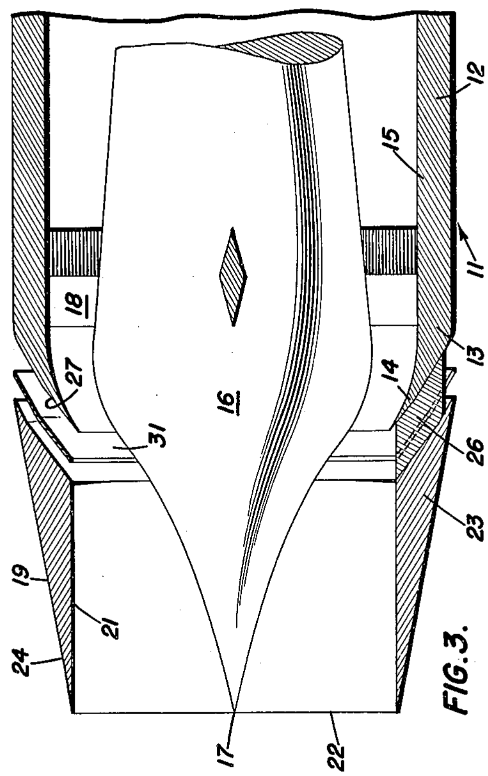

FIG. 3.

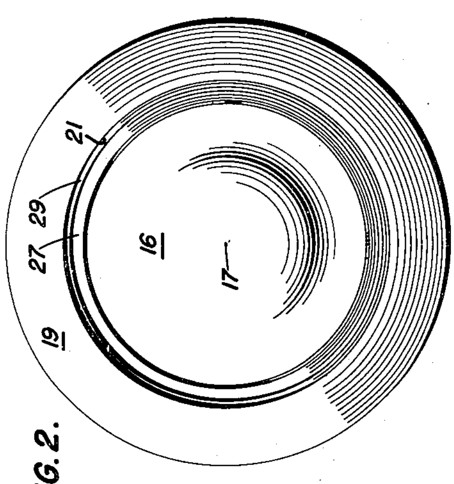

FIG. 2.

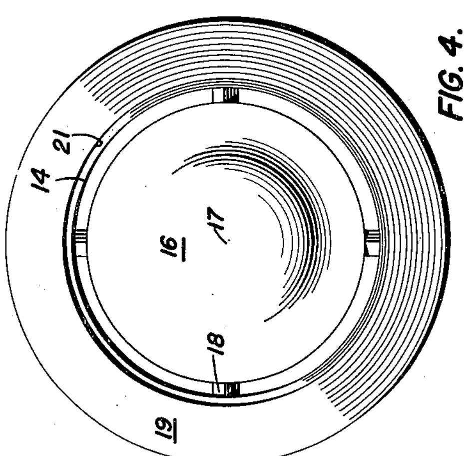

FIG. 4.

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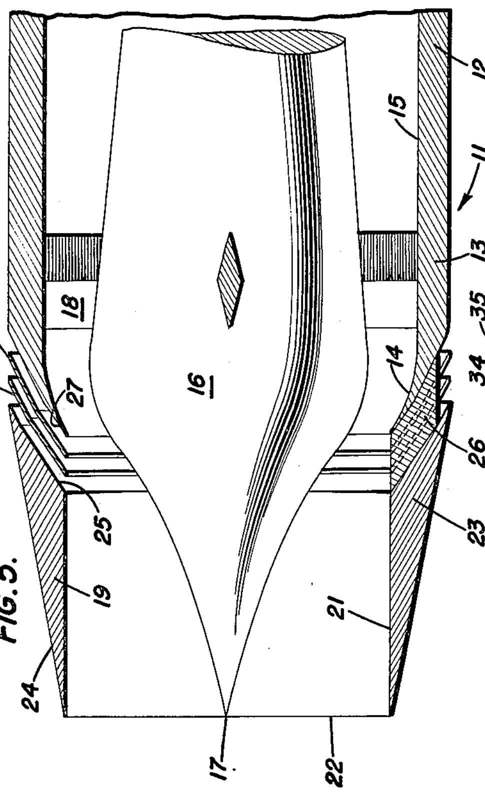

FIG. 5.

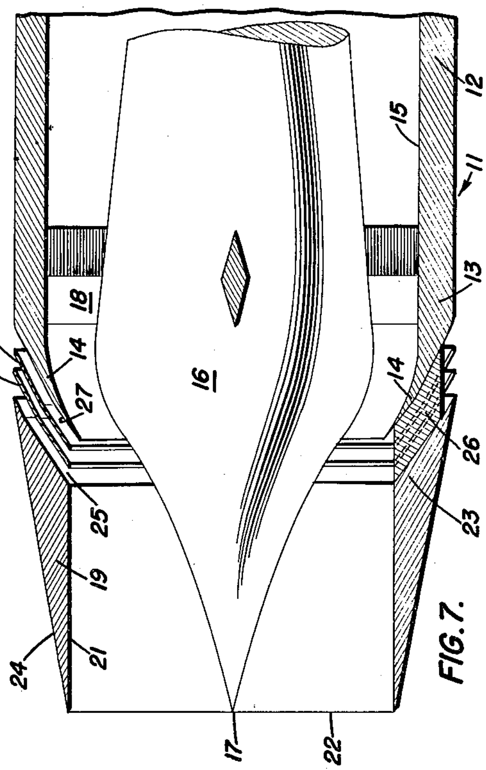

FIG. 7.

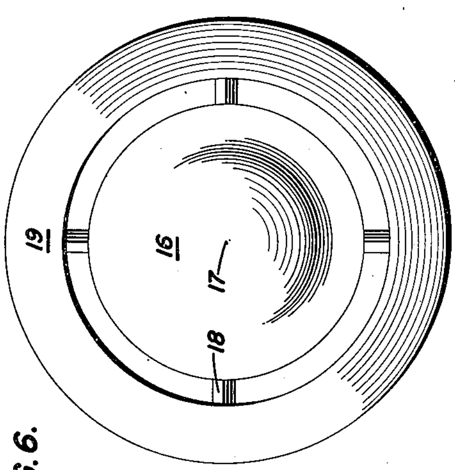

FIG. 6.

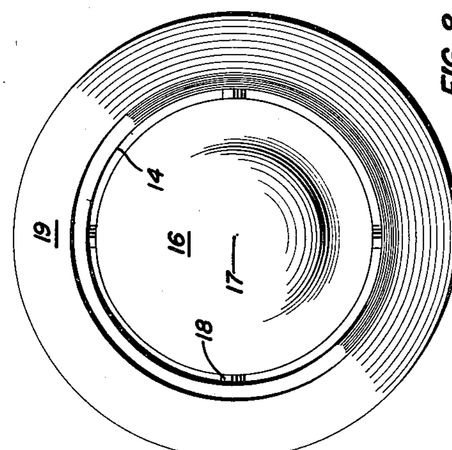

FIG. 8.

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STREAMLINED RING FOR ASSURING OPTIMUM COMPRESSION IN A RAMJET

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Filed Nov. 17, 1952, Ser. No. 320,896
9 Claims. (Cl. 60—35.6)

The present invention relates to aerial missiles and more particularly to air inlets for ramjet missiles. This application is a continuation-in-part of the co-pending application entitled "Streamlined Rings for Assuring Isentropic Compression of Supersonic Stream Through a Conventional Missile Diffuser," Serial Number 127,727, Randolph S. Rae, inventor, filed November 16, 1949 now Patent No. 2,975,587.

The supersonic ramjet inlets now in use, such as the Oswatitsch diffuser, the multiple shock diffuser, and the wing scoop diffuser, have certain inherent defects which detract from their efficient operation. Primarily, in order to attain the fullest isentropic compression possible with an Oswatitsch diffuser, the cowling lip must be disposed at an angle which permits the incoming air to be decelerated smoothly and gradually. This angle is so large that, because of structural considerations, a large surface area is presented to the air stream. As a result, a strong spurious shock wave is formed in front of the lip. Inasmuch as the beneficial weak shock waves produced by the center body of the diffuser are normally all focused upon the lip, the strong spurious shock wave interferes to upset the optimum pattern of the beneficial weak shock waves. This condition is responsible for low compression and the inefficient operation of the diffuser.

A second defect involves an increase in drag forces caused by the large surface area of the lip facing the air stream. High drag forces are undesirable in that they reduce the useful thrust obtainable from the ramjet.

The invention of the above-identified application from which the present application is a continuation-in-part, overcomes these defects by positioning a streamlined ring in front of the cowling lip. In this manner the strong spurious shock wave is eliminated from the region proximate to the lip, thus eliminating interference with the shock wave pattern produced by the center body. In addition, the drag forces are reduced because of the streamlined configuration of the ring, which, in effect, diverts the air stream to either side of the diffuser cowling.

However, while the efficiencies obtained by the use of streamlined rings in accordance with the above-mentioned original application were high, they were not as high as could be expected. It was found that the high pressures existing in the slot between the diffuser lip and the streamlined ring, as a result of spill-over, caused the boundary layer of relatively dead air to separate from the inner surface of the ring. The separated boundary layer interacted with the shock wave pattern at the inlet, thus preventing the fullest possible isentropic compression.

It is therefore an object of this invention to provide a ramjet diffuser inlet which prevents the interference of separated boundary layers with optimum compression, thereby increasing the efficiency of compression.

Another object of the present invention is to provide a ramjet diffuser inlet having a minimum amount of aerodynamic drag and being capable of producing a compression of a supersonic stream approaching isentropic values.

Other objects and many of the attendant advantages of the invention will be readily appreciated as the same

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becomes understood by reference to the following detailed description, when considered in connection with the accompanying drawings, wherein:

FIG. 1 is an axial section, partly in elevation, through the forward end portion of a ramjet, illustrating an embodiment of this invention;

FIG. 2 is a front elevation of the ramjet shown in FIG. 1;

FIG. 3 is an axial section, partly in elevation, through the forward end of a ramjet illustrating a modification of the embodiment shown in FIG. 1;

FIG. 4 is a front elevation of the ramjet shown in FIG. 3;

FIG. 5 is an axial section, partly in elevation, through the forward end of a ramjet illustrating a second modification of the invention;

FIG. 6 is a front elevation of the ramjet shown in FIG. 5;

FIG. 7 is an axial section, partly in elevation, through the forward end of a ramjet illustrating a third modification of this invention; and

FIG. 8 is a front elevation of the ramjet shown in FIG. 7.

Referring to the drawings, and in particular to FIGS. 1 and 2, there is shown the diffuser section **11** of the body **12** of a ramjet. The diffuser consists, in general, of a cylindrical cowling **13**, having a lip **14** and a central duct **15**, and an axially located symmetrical center body **16** which tapers to a vertex **17** at its forward end. Suitable struts **18** are provided to hold and aline the center body within the duct **15** in a fixed relationship to the cowling **13**, with the vertex **17** of the center body **16** located forward of the lip **14**. The structure so far described is substantially the Oswatitsch diffuser which is well known in the art.

To overcome the aforesaid objections to the Oswatitsch diffuser, it is necessary, in accordance with the original application of which this application is a continuation-in-part, to secure in front of and in spaced relation to the lip **14** an annular streamlined ring **19**. The inner surface **21** of the ring **19** is cylindrically shaped and coaxial with the diffuser section. The inside diameter of the ring **19** is greater than the diameter of the circle described by the lip **14**. In this manner, the lip **14** projects a short distance into the cylinder described by the inner surface **21** of the ring **19**. The leading edge **22** of the ring **19** extends generally in front of the vertex **17** of the center body **16**. The aft end **23** of the ring overlaps a portion of the cowling lip **14** and generally extends the contour of the forward end of the cowling **13**. A curved surface **25** is provided at the rear end of the ring **19** and is substantially concentric with the contour of the lip **14** of the cowling **13**. The angle of the outer surface **24** of the ring **19** may be varied by merely increasing or decreasing the overall length of said ring. The ring **19** is provided with struts **26** which aline and secure said ring to the cowling **13** in a fixed relationship with respect to the center body **16**.

By virtue of the position of the ring **19**, i.e. being spaced in front of the cowling **13**, an annular slot **27** is formed which insures the stability of the diffuser when the latter is subjected to pressure fluctuations during flight. Two splitters **28** and **29**, in the form of generally frustoconical bands, are supported by the struts **26** in the slot **27**, thus dividing said slot into three smaller but similarly shaped slots. The forwardmost splitter **28** has the same inside diameter as that of the ring **19**. However, the aftermost splitter **29** has an inside diameter that is smaller than that of the ring **19** but greater than the inside diameter of the circle described by the lip **14**. Hence, the aftermost splitter **29** projects into the cylinder described by the inside diameter of the ring but not as far as does the lip 14.

In operation, the ring 19 prevents the formation of a spurious shock wave at the lip 14 and presents a sharp leading edge 22 to the airstream. Consequently, interference with the beneficial shock waves attached to the lip 14 is eliminated, and the drag forces on the diffuser are reduced.

By the provision of the splitters 28 and 29 within the slot 27, the forward propagation of pressure within said slot is inhibited and the boundary layer along the inner surface 21 is more or less stabilized. However, it has been found that the boundary layer continually builds up and separates from the inner surface 21 regardless of the inhibition of forward pressure propagation. In order to correct for this separation the separated boundary layer is diverted into the outer air stream by the aftmost splitter 29 and the lip 14, thus preventing a disturbance of the beneficial shock wave pattern created by the center body 16.

Any number of splitters may be used to divide the slot 27 into smaller slots and inhibit the forward propagation of pressure to the boundary layer on the inner surface 21 of the ring 19. For example, as shown in FIGS. 3 and 4, a single splitter 31 of frusto-conical shape may be employed. Similar to the embodiment shown in FIGS. 1 and 2, the ring 19 and splitter 31 have inside diameters that are greater than the circle described by the lip 14. Therefore, the lip 14 diverts the separated boundary layer into the outer air stream to prevent interference with the desired shock wave pattern.

Another modification utilizing two splitters 32 and 33 and which is not as effective in preventing disturbances to the shock wave pattern but, nevertheless does inhibit the forward propagation of pressure in the slot and thus reduces the frequency of said disturbances, is illustrated in FIGS. 5 and 6. In this modification the inside diameters of the ring 19, both of the splitters 32 and 33, and the circle described by the lip 14, are substantially equal. Although interference with the shock wave pattern formed by the center body 16 is not altogether eliminated, it is effectively reduced.

A further modification is shown in FIGS. 7 and 8, and involves the use of two splitters 34 and 35 to divide the slot 27 into smaller slots. In this instance the inside diameters of the ring and both of the splitters 34 and 35 are equal but greater than the inside diameter of the circle described by the lip. In addition to the inhibition of forward pressure propagation, the boundary layer is diverted into the outer air stream by the lip 14. In this manner, as explained above, disturbances of the shock wave pattern formed by the center body 16 are averted.

Splitters, similarly applied as those described above, will function equally as well when used in conjunction with the two dimensional wing scoope diffuser provided with a streamlined body as disclosed in the original application. However, splitters of this type will be generally in the form of flat plates that are located in the slot between the lip and the streamlined body.

Obviously many other modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. An air inlet for a ramjet, comprising a cowling defining a duct, a body mounted in said duct but partially extending forwardly therefrom, a streamlined member supported in front of and in spaced relation to said cowling and substantially forming an extension of said cowling which is separated therefrom by a slot, said streamlined member being substantially coextensive with the forwardly extending portion of said body and means for dividing said slot into a plurality of slots, whereby said body produces useful shock waves when the ramjet attains supersonic speeds and the separation of the boundary layer from the streamlined member is inhibited by said means.

2. An air inlet for a ramjet, comprising a cowling defining a duct, a body mounted in said duct but partially extending forwardly therefrom, a streamlined member supported in front of and in spaced relation to said cowling and generally forming an extension of said cowling which is separated therefrom by a slot, and a circumferentially extending dividing member disposed in said slot to form two slots, whereby said body produces useful shock waves when the ramjet attains supersonic speeds and the separation of the boundary layer from the streamlined member is inhibited by said dividing member.

3. An air inlet for a ramjet, comprising a cowling defining a duct, a body mounted in said duct but partially extending forwardly therefrom, a streamlined member supported in a position in front of and in spaced relation to said cowling, said member substantially corresponding to an extension of said cowling which is separated therefrom by a slot, and a plurality of circumferentially extending dividing members located within the space between said streamlined member and said cowling, whereby said body produces useful shock waves when the ramjet attains supersonic speeds and the separation of the boundary layer from the streamlined member is inhibited by said dividing members.

4. An air inlet for a ramjet, comprising a cowling defining a duct, a body mounted in said duct but partially extending forwardly therefrom, a streamlined member supported in front of and in spaced relation to said cowling and substantially forming an extension of said cowling which is separated therefrom by a slot, and two circumferentially extending dividing members located in said slot to form three smaller slots, whereby said body produces useful shock waves when the ramjet attains supersonic speeds and the separation of the boundary layer from the streamlined member is inhibited by said dividing members.

5. An air inlet for a ramjet, comprising a cowling defining a duct and having a circular lip at its forward end, a center body mounted in said duct and partially extending forwardly therefrom, a streamlined ring having a cylindrical inner surface of greater diameter than that of said circular lip, said ring being positioned coaxially in front of and in spaced relation to said cowling thereby forming a slot between said cowling and said ring, said ring also extending forwardly beyond the forwardly extending portion of the center body, and means for dividing said slot into a plurality of slots.

6. An air inlet for a ramjet, comprising a cowling defining a duct and having a circular lip at its forward end, a center body mounted in said duct and partially extending forwardly therefrom, a streamlined ring having a cylindrical inner surface of substantially the same inside diameter as that of the circular lip, said ring being positioned coaxially in front of and in spaced relation to said cowling thereby forming a slot therebetween, and a pair of spaced dividing members mounted in said slot, said members being generally in the form of bands and having inside diameters substantially equal to those of said streamlined ring and circular lip.

7. An air inlet for a ramjet, comprising a cowling defining a duct and having a circular lip at its forward end, a center body mounted in said duct and partially extending forwardly therefrom, a streamlined ring having a cylindrical inner surface of greater diameter than that of said circular lip, said ring being positioned coaxially in front of and in spaced relation to said cowling thereby forming a slot between said cowling and said ring, and means for dividing said slot into a plurality of slots, said means including a single dividing member generally in the form of a band having an inside diameter equal to that of the streamlined ring.

8. An air inlet for a ramjet, comprising a cowling de-

fining a duct and having a circular lip at its forward end, a center body mounted in said duct and partially extending forwardly therefrom, a streamlined ring having a cylindrical inner surface of greater diameter than that of said circular lip, said ring being positioned coaxially in front of and in spaced relation to said cowling thereby forming a slot between said cowling and said ring, and means for dividing said slot into a plurality of slots, said means including a pair of spaced dividing members generally in the form of bands having inside diameters equal to the inside diameter of the streamlined ring.

9. An air inlet for a ramjet, comprising a cowling defining a duct and having a circular lip at its forward end, a center body mounted in said duct and partially extending forwardly therefrom, a streamlined ring having a cylindrical inner surface of greater diameter than that of said circular lip, said ring being positioned coaxially in front of and in spaced relation to said cowling thereby forming a slot between said cowling and said ring, and means for dividing said slot into a pluraltiy of slots, said means including a pair of spaced dividing members generally in the form of bands, the forwardmost dividing member having an inside diameter substantially equal to that of the streamlined ring and the aftmost dividing member having an inside diameter smaller than that of the streamlined ring but greater than that of the circular lip.

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