March 17, 1953 K. M. NORDFORS 2,631,425

COMPRESSION NOZZLE FOR RAM-JET ENGINES

Filed Sept. 7, 1949 2 SHEETS—SHEET 1

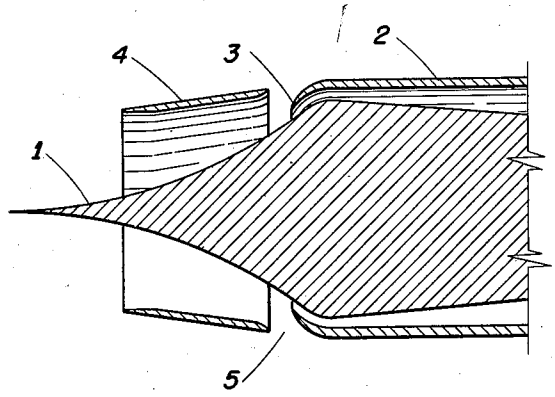


Fig. 1

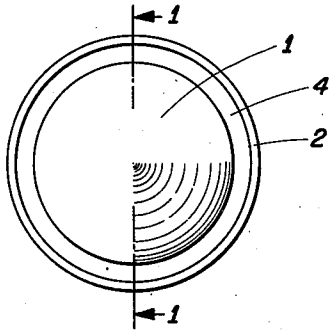


Fig. 2

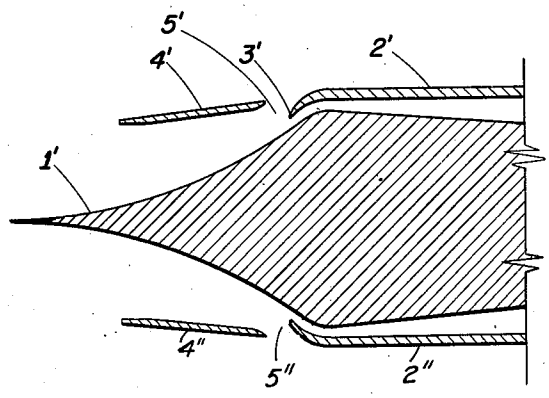


Fig. 3

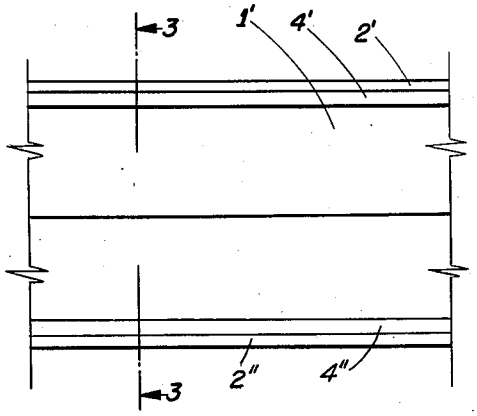


Fig. 4

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COMPRESSION NOZZLE FOR RAM-JET ENGINES

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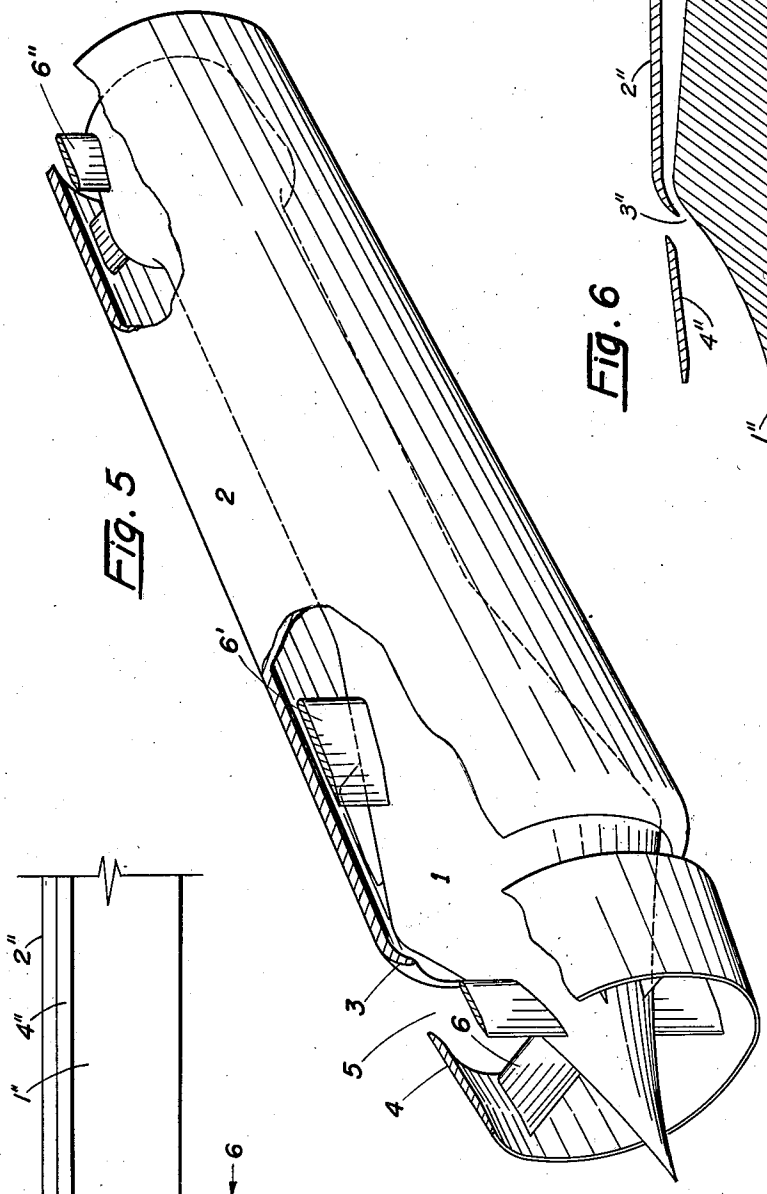


Fig. 5

Fig. 6

Fig. 7

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COMPRESSION NOZZLE FOR RAM-JET ENGINES

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8 Claims. (Cl. 60—35.6)

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This invention relates to athodyds or ram-jet engines used for propelling aircraft and/or self-propelled projectiles at speeds of the order of the speed of sound and those in the supersonic range and is especially directed to improved means for introducing air into the combustion chamber of the engine.

In the early development of ram-jet engines a circular hole at the forward end of the engine housing was provided for the intake of air which at supersonic speeds was found to result in discontinuous compression and considerable power losses due to isenthropic compression and to plane normal shock. In efforts to reduce or eliminate these effects a compression nozzle has been suggested in which a pointed rotary-symmetrical body is positioned at the center of the engine air intake surrounded by a casing or jacket spaced from its surface adjacent its zone of largest diameter providing an annular port defined by the substantially conical surface of the body and the circular inner edge of the outer jacket. At speeds corresponding to a Mach coefficient of 3 the blunt front edge of this jacket causes large air resistance and builds up over-pressure which impedes the satisfactory flow of air into the annular compression nozzle intake port while the high angle of deflection of the air entering the port creates a high resistance against the jacket and interferes with the compression procedure. On the other hand when the front edge of the jacket is at a smaller angle to the axis of symmetry insufficient compression of the air is effected.

It is therefore a principal object of the invention to provide an air intake compression nozzle for a ram-jet or similar propulsive engine providing minimum air resistance at supersonic and comparable speeds and effective to compress uniformly and without material thrust or interference losses air received by the nozzle for introduction into the engine substantially without generation of plane normal shock.

A further object is to provide an auxiliary compression shroud or cowling for a ram-jet air intake compression nozzle effective to eliminate over-pressure and consequent disturbing compression shocks while delivering air at a uniform velocity and pressure to the ram-jet for the purpose of promoting combustion of fuel supplied thereto.

Another object is to provide means for substantially eliminating shock wave in the air through which the ram-jet is travelling and minimizing air resistance of the compression nozzle as a whole.

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Other objects, purposes, and advantages of the invention will hereinafter more fully appear or be understood from the following description of certain embodiments of it, reference being had to the accompanying drawings in which:

Fig. 1 is a fragmentary diagrammatic vertical section on the line 1—1 in Fig. 2 of a compression nozzle constructed in accordance with the invention,

Fig. 2 is a diagrammatic front elevation thereof,

Fig. 3 is a fragmentary diagrammatic vertical section on the line 3—3 in Fig. 4 of a modified embodiment of the invention,

Fig. 4 is a fragmentary diagrammatic front elevation of the apparatus illustrated in Fig. 3,

Fig. 5 is a somewhat diagrammatic perspective view of a ram-jet engine embodying the invention, but with parts broken away to illustrate interior construction, and

Figs. 6 and 7 are views corresponding respectively to Figs. 3 and 4 but showing a further modification providing a laterally elongated nozzle having but a single rectilinear intake port, Fig. 6 being a section on the line 6—6 in Fig. 7.

Referring now more particularly to the drawings, the compression nozzle illustrated in Figs. 1 and 2 comprises a central body 1 the forward portion of which is substantially conical or concavo-conical, with its apex directed toward the direction of travel of the engine, tapering concavely rearwardly toward an intermediate zone of maximum diameter and thence in a reverse flat taper toward the combustion chamber (not shown). A compression jacket 2 substantially cylindrical in general contour but curved inwardly at its forward end to provide a relatively constricted front edge 3 is spaced outwardly from the adjacent surface of the body 1 and extends rearward coaxially therewith from a short distance forward of its zone of maximum diameter. In front of edge 3 and coaxial therewith is positioned a substantially frusto-conical hollow auxiliary shroud or cowling comprising a jacket 4 preferably having beveled front and rear edges to insure minimum air resistance during its passage through the atmosphere, and in cooperation with the concavely tapered portion of the body nose it provides a preliminary compression zone discharging air under compression from its rear edge just forwardly of the intake port.

The rear edge of the jacket 4 is spaced forwardly and outwardly from the front edge 3 of the jacket 2 and defines therewith an annular slot 5 through which over-pressure within the jacket 4 may be relieved and compression shocks in the nozzle thereby substantially eliminated,

insuring smooth, relatively undisturbed passage of air under pressure into the intake port.

Thus as the ram-jet moves forwardly through the air at supersonic or comparable speed the air entering the jacket 4 initially substantially at the pressure of the surrounding atmosphere is rapidly compressed as it passes rearwardly due to the relatively rapidly increasing diameter of the body 1 in relation to the more gradual increase in diameter of the interior of the auxiliary jacket 4 whereby a relatively high degree of compression is attained adjacent the rear edge of said jacket. Excess pressure is relieved through slots 5 and the remaining air passes into the interior of jacket 2 between its edge 3 and the adjacent zone of near maximum diameter of the body 1 in a smooth and uniform flow substantially devoid of compression shocks and at suitable pressure for the operation of the engine.

The ram-jet engine more fully illustrated in Fig. 5 thus comprises substantially cylindrical compression jacket 2 inwardly constricted at its front edge 3, forwardly of which is positioned an auxiliary jacket 4 extending coaxially with the body 1 and jacket 2 and supported from the former by radially extending "streamlined" fins 6 which may be of any convenient number, substantially similar fins 6', 6'' connecting compression jacket 2 with the rearward part of body 1 to support the latter in the jacket.

The embodiments of the invention illustrated in Figs. 3, 4, 6 and 7 are intended for use in association with ram-jet engines or the like designed for so-called two dimensional flow of air for combustion, providing a rectilinear intake port of appropriate transverse length as distinguished from an annular one. Thus a body 1' (Figs. 3 and 4) the form of which may be in section substantially similar to an axial section of the body 1 of the compression nozzle illustrated in Fig. 1, and thus symmetrical with respect to a longitudinal central plane, defines two ports respectively above and below such plane through cooperation with compression shrouds or cowlings 2' conforming in transverse section substantially to radial sections of the jacket 2 in Fig. 1 and extending laterally generally parallel to said central plane of the body 1' to present forward edges 3' spaced therefrom and forming edges of the upper and lower rectilinear intake ports. Positioned forwardly of the cowlings 2' are rectilinear auxiliary shrouds or baffles 4' conforming in section to radial sections of the auxiliary jacket 4 in Fig. 1 but laterally coextensive with the body 1' and cowlings 2'; being spaced from the forward edges 3' of the latter they provide slots 5' the functions and effect of which are substantially similar to those of the slot 5 in Fig. 1.

It will be apparent that a compression nozzle as illustrated in Figs. 3 and 4 may be elongated in directions normal to the plane of section in Fig. 3 to whatever extent is required by the design of the engine with which it is employed and the ends of the parts may conform substantially to segments of corresponding parts of the nozzle illustrated in Fig. 1 or be constructed in any other suitable manner as desired.

The nozzle illustrated in Figs. 6 and 7, substantially similar in operation to one half of that shown in Figs. 3 and 4, comprises a laterally elongated body 1'' having a base defining a plane surface and in transverse section conforming to one of the body 1' (Fig. 3) divided in half along its central plane of symmetry, and hence to a

radial section of the body 1 (Fig. 1), the shroud or cowling 2'' cooperating with the contoured surface of the body 1'' to define a single transversely elongated port or nozzle 3'' and an auxiliary shroud or baffle 4'' corresponding in contour, location, functions and effect to the upper one of the baffles 4' in Figs. 3 and 4. In the same way as the nozzle shown in Figs. 3 and 4 that illustrated in Figs. 6 and 7 may be elongated laterally to whatever extent required by the design of the engine with which it is employed.

While there have been herein diagrammatically illustrated and particularly described certain embodiments of the invention adapted for attaining the objects thereof it will be understood that I do not desire or intend thereby to be limited or confined in any way as changes and modifications in the form, structure, arrangement and relationship of the several parts to each other and to apparatus to which air is to be supplied by the nozzle will readily occur to those skilled in the art and may be made if desired without departing from the spirit and scope of the invention as defined in the appended claims.

Having thus described my invention, I claim and desire to protect by Letters Patent of the United States:

1. In a compression nozzle for gas flow at supersonic speeds comprising a body providing a surface adapted for deflecting at progressively increasing angularity to the direction of travel of the nozzle the gases through which the nozzle travels and a shroud uniformly spaced from and adapted to cooperate with the body adjacent the zone of greatest deflection of the gases and having a forward edge defining with the body an inlet port for said gases, an auxiliary shroud fitted in front of the first shroud and spaced therefrom adjacent a zone of lesser deflection of the gases cooperative with the body for effecting an initial compression of the gases.

2. Apparatus according to claim 1 in which the auxiliary shroud is characterized by such a shape as to minimize air resistance against it under operating conditions having opposed substantially rectilinear surfaces defining its least principal dimension disposed at an angle to a plane normal to the direction of travel of the nozzle intermediate the angles of lesser and greatest deflection of the gases by the body.

3. A compression nozzle for a ram-jet engine or the like comprising a body having a surface disposed in relation to the direction of travel of the nozzle at progressively increasing angularity rearwardly from its forward edge, the body being of minimum transverse thickness at its forward end, tapering rearwardly therefrom to a zone of maximum thickness and of less than said maximum thickness rearwardly of said zone, a compression shroud positioned adjacent said zone defining therewith an air intake port, and an auxiliary shroud disposed at a smaller angle to said direction than the angle of the body surface at said port forward of said zone and spaced forwardly from said port and defining with said angularly disposed surface a compression chamber tapering rearwardly from the forward end thereof to a zone of minimum width adjacent said intake port.

4. A compression nozzle for a ram-jet engine or the like comprising a body having a surface disposed substantially angularly to the direction of travel of the nozzle for deflecting air angularly with relation to said direction during forward travel of the nozzle, a compression shroud

disposed adjacent a rear portion of said surface adjacent its zone of maximum angularity to said direction and defining therewith a port for reception of air deflected by said surface and an auxiliary shroud spaced from said surface and from the first shroud and disposed at a smaller angle to said direction than the body surface at said port adjacent said zone whereby an initial compression of air between the body and the auxiliary shroud is effected during forward motion of the nozzle and at least a portion of such air is delivered to said port under pressure greater than that of the surrounding atmosphere.

5. A compression nozzle for a ram-jet engine or the like comprising a body having a substantially conical forward end portion, a substantially cylindrical jacket surrounding and spaced from the body adjacent its zone of maximum diameter defining therewith a substantially annular intake port for reception of air deflected by the body while it is travelling in the direction of the apex of the peripheral surface of said portion and an auxiliary jacket surrounding said portion of the body between the first jacket and said apex having a frusto-conical inner surface spaced from the body and defining therewith an initial compression chamber adapted to deliver said deflected air under pressure toward said port.

6. A compression nozzle for a ram-jet engine or the like comprising a body having a substantially conical forward end portion, a substantially cylindrical jacket surrounding and spaced from the body adjacent its zone of maximum diameter defining therewith a substantially annular intake port for reception of air deflected by the body while it is travelling in the direction of the apex of the peripheral surface of said portion and an auxiliary jacket surrounding said portion of the body between the first jacket and said apex having a frusto-conical inner surface spaced from the body and defining therewith an initial compression chamber adapted to deliver said deflected air under pressure toward said port, said auxiliary jacket being also spaced forwardly from the forward edge of the first jacket and defining therewith an annular slot adapted for passage of a portion of said air outwardly beyond the first jacket.

7. A compression nozzle for a ram-jet engine or the like comprising a body having a transverse substantially rectilinear surface disposed at a rearwardly progressively increasing angle to the direction of travel of the nozzle adapted to deflect air angularly to said direction during forward travel of the nozzle, a cowling having a rectilinear edge disposed transversely of said direction adjacent said surface defining therewith a transversely elongated intake port and an auxiliary baffle having a surface converging with said substantially rectilinear surface toward said port and cooperative therewith during forward travel of the nozzle to compress air deflected by the body to thereby deliver said air under pressure toward said port.

8. A compression nozzle for a ram-jet engine or the like comprising a body having a transverse substantially rectilinear surface disposed at a rearwardly progressively increasing angle to the direction of travel of the nozzle adapted to deflect air angularly to said direction during forward travel of the nozzle, a cowling having a rectilinear edge disposed transversely of said direction adjacent said surface defining therewith an elongated intake port and an auxiliary baffle having a surface converging with said substantially rectilinear surface toward said port and cooperative therewith during forward travel of the nozzle to compress air deflected by the body to thereby deliver said air under pressure toward said port, said auxiliary baffle being spaced forwardly from the forward edge of the cowling and defining therewith a rectilinear slot adapted for passage of some of said air outwardly beyond the cowling during passage of the remainder thereof into said port.

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(Third Addition to No. 779,655)