

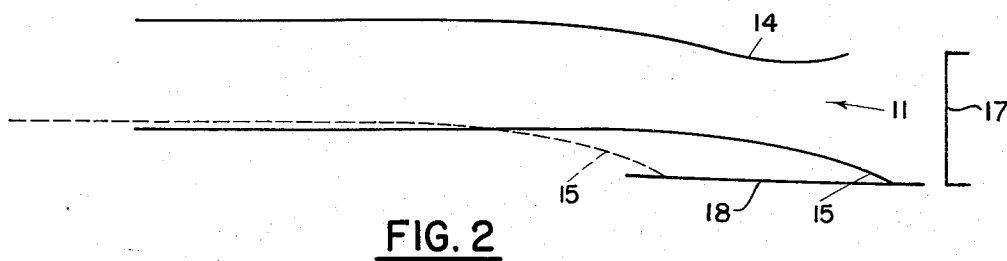
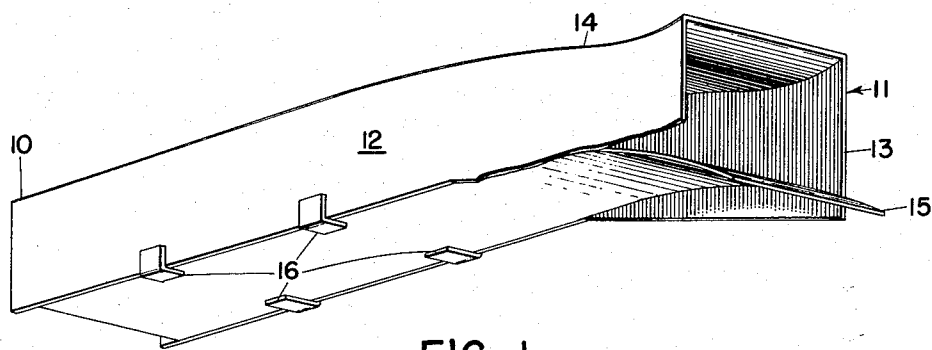
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ASYMMETRIC ADJUSTABLE SUPERSONIC NOZZLE

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ASYMMETRIC ADJUSTABLE SUPERSONIC
NOZZLE

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sec. 266)

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This invention relates to improvements in nozzles, and more particularly to improvements in supersonic nozzles.

The principal object of this invention is to provide a nozzle in which the flow Mach number is continuously adjustable.

Another object of this invention is to provide a nozzle in which the flow passage is asymmetrical and adjustable to define various Mach numbers.

In the accompanying drawings, forming a part of this specification, and in which like numerals are employed to designate like parts throughout the same,

Fig. 1 is an isometric drawing of a nozzle embodying my invention and shows a wall broken away at the inlet end of the nozzle to better illustrate the construction.

Fig. 2 is a longitudinal section of Fig. 1 showing the nozzle conventionally positioned relative to a source of fluid flow 17 and supported as at 18 to permit longitudinal movement of wall 15.

No claim is made to a specific source of fluid flow or to a particular supporting structure, these being of any convenient known construction.

In a wind tunnel in order to provide a supersonic Mach number at the section of the flow passage in which the model undergoing tests is located, known as the test section, the area of the passage upstream of the test section must be varied in an amount dependent upon the Mach number desired at the test section. The ratio of the area of the test section to the area of the throat, or minimum section, upstream of the test section uniquely determines the Mach number at the test section.

There have been, in general, two methods employed in the past for changing the Mach number in supersonic wind tunnels. One method has been to employ interchangeable nozzles designed to attain specific Mach numbers at the test section. This method suffers from the disadvantages that as many nozzles as desired test section Mach numbers must be constructed, and that the Mach number cannot be easily varied through small increments.

The other method has been to provide the nozzle section upstream of the test section with one or more walls which could be flexed by using a series of jacks to vary the ratio of test section to throat section area and so vary the test section Mach number. This method suffers from mechanical complexity resulting from the required system of jacks necessary for the manipulation of the flexible section of the nozzle.

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In addition, overstressing of the flexible section can easily occur by improper jack operation thus resulting in permanent set or structural failure. In order to prevent such an occurrence it is necessary to employ elaborate safety devices thereby increasing the cost of production and maintenance.

In the new type of nozzle of the present invention, the passage is asymmetric and the construction of the nozzle is such that the required adjustment of area ratio necessary to change the Mach number can be accomplished by sliding one of the walls of the nozzle longitudinally, or nearly longitudinally, relative to the other walls. This type of nozzle affords a continuously adjustable Mach number at the test section, an advantage not obtained by the fixed nozzle method previously discussed, and possesses greater mechanical and structural simplification as compared with the flexible-wall type of nozzle.

Large scale tests of asymmetric nozzles indicate that, with suitable design, satisfactory aerodynamic characteristics, such as shock wave, compression ratio, boundary layer growth, etc., can be obtained which give satisfactory flow throughout the entire desired range of Mach number setting for all positions of the adjustable wall. If the flow at all stations is less than unity i. e. subsonic, it is well known that the Mach number increases as the area decreases. The reverse is however true at supersonic speeds and it can be shown mathematically that for a supersonic sound tunnel the speed of the test section is uniquely determined by the ratio of the test-section area to the minimum or throat area ahead of it. Furthermore, this adjustable wall may be moved parallel to the high speed section walls, thus maintaining a constant section height at the high speed section. The direction of motion can, however, be varied somewhat so that a greater or lesser height of passage is obtained at the high speed section as the Mach number is changed.

My nozzle can find application in steam or gas turbines, in the exit of jet motors and in supersonic wind tunnel test sections.

In the drawings, wherein for the purpose of illustration, is shown a preferred embodiment of my invention, the reference numeral 10 designates a tubular body portion having a restricted, asymmetric flow passage 11 defined by parallel side plates 12 and 13, inwardly curved top plate 14, and outwardly flared bottom plate 15. Bottom flared plate 15 is in sliding engagement with parallel sides 12 and 13, and is movable longi-

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tudinally in guides 16 which are secured to the side plates by spot welding or other suitable means.

In operation, as indicated in Fig. 2, the fluid from the source, schematically represented at 17, enters the inlet or upstream end of the nozzle in the direction indicated by the arrow 11. When the nozzle is employed in a wind tunnel, the test section, i. e., the section wherein a model is mounted for studying aerodynamic flow, is located at the opposite or downstream end of the nozzle. With the adjustable wall or plate at the position indicated by the dotted line 15, the area ratio is high and accordingly the Mach number at the test section, or downstream end, is low. Progressive forward motion of the movable plate to a position shown by the solid line 15, decreases the area ratio and, therefore, increases the Mach number at the test section. It is apparent that either the plate 14 or the plate 15 may be fixed, the opposite plate being adjustable.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. An asymmetrical supersonic nozzle for use with a wind tunnel said nozzle having an inlet end and a test section at the opposite end and comprising a pair of fixed parallel walls, a fixed curved wall, and a movable wall having a curvature substantially inverse to that of said curved wall so as to form a flared inlet end for said nozzle, said walls defining a passage of substantially rectangular cross-section, the movement of said movable wall permitting the adjustment of the relative areas within said passage to obtain a continuous adjustment of the Mach number at the test section of said passage the upper limit of the ratio of the cross sectional areas at the inlet end and test section being unity.

2. An asymmetrical supersonic nozzle for use with a wind tunnel said nozzle having an inlet end and a test section at the opposite end, and comprising a pair of fixed parallel walls, a fixed wall contiguous with said parallel walls and having a curved inlet end portion, a longitudinally movable wall contiguous with said parallel walls and positioned opposite said curved wall; said movable wall having an inlet end portion of reverse curvature with respect to the first-mentioned curved portion whereby longitudinal movement of said movable wall varies the relative areas within the passage defined by said walls to thereby adjust the Mach number at the test section of said nozzle, the upper limit of the ratio of the cross-sectional areas at the inlet end and the test section being unity.

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3. An asymmetrical supersonic nozzle suitable for use with a wind tunnel, said nozzle having an inlet end and a test section at the opposite end and comprising a pair of fixed parallel walls, a fixed wall having a concave inner surface at the inlet end of the nozzle, a longitudinally translatable wall having a convex inner surface at the inlet end, said four walls forming a passage, the cross-sections of which substantially define rectangles, guide means for the longitudinally translatable wall, said concave and convex surfaces of the walls being relatively movable to vary the ratio of the area of the passage in the inlet portion with respect to the area of the test section, and hence the Mach number at the test section.

4. The combination set forth in claim 3 further defined in that a continuous adjustment is provided by movement of the longitudinally translatable wall and that the ratio of the minimum cross-section area of the inlet end and test section does not exceed unity.

5. An asymmetrical supersonic nozzle having an inlet end and a test section at the opposite end thereof and comprising four walls the inner surfaces of which form substantially rectangular sections along the length of the nozzle, two opposite walls being fixed, and the other two opposite walls being relatively movable longitudinally of each other, a guide means for a movable wall, said relatively movable walls each having an oppositely curved portion at the inlet end of the nozzle for varying the cross-section area of the passageway near the inlet end, and said cross section area of the inlet end never exceeding the cross-section area of the test section of the nozzle in any adjusted position of the nozzle.

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