July 7, 1953 M. C. SANZ ET AL 2,644,296

LAMINATED JET VANE

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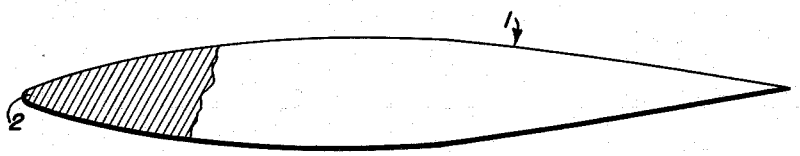

FIG. 1

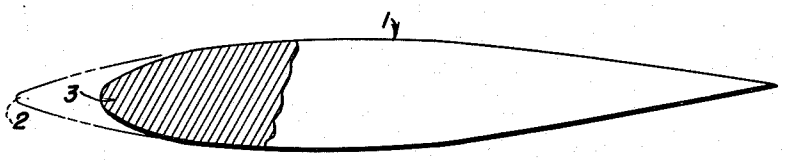

FIG. 2

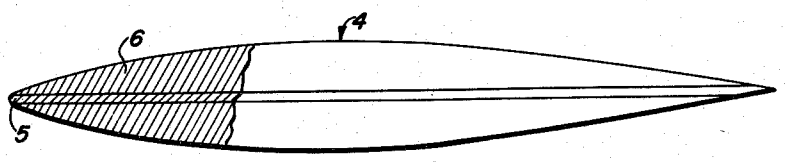

FIG. 3

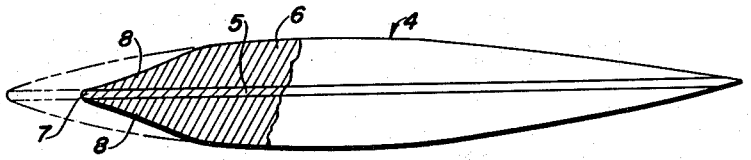

FIG. 4

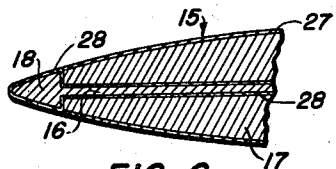

FIG. 6

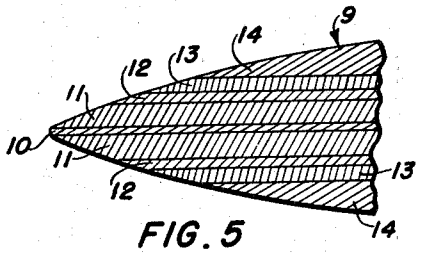

FIG. 5

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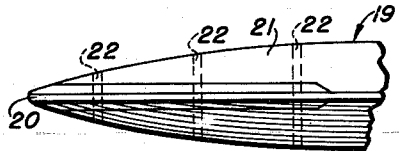

FIG. 7

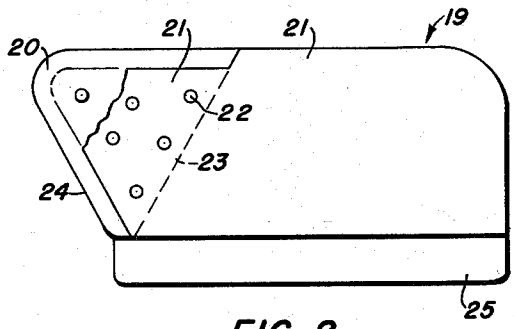

FIG. 8

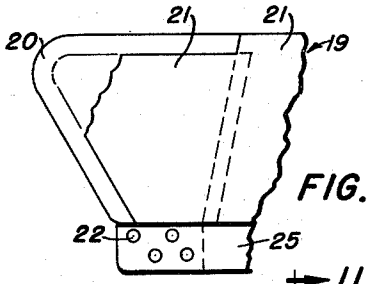

FIG. 9

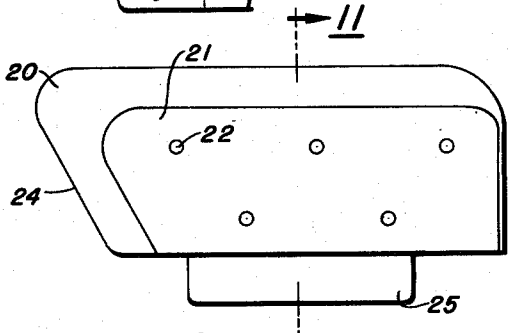

FIG. 10

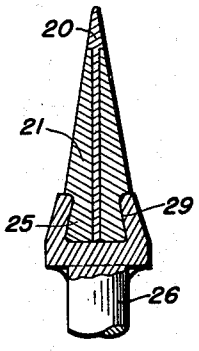

FIG. 11

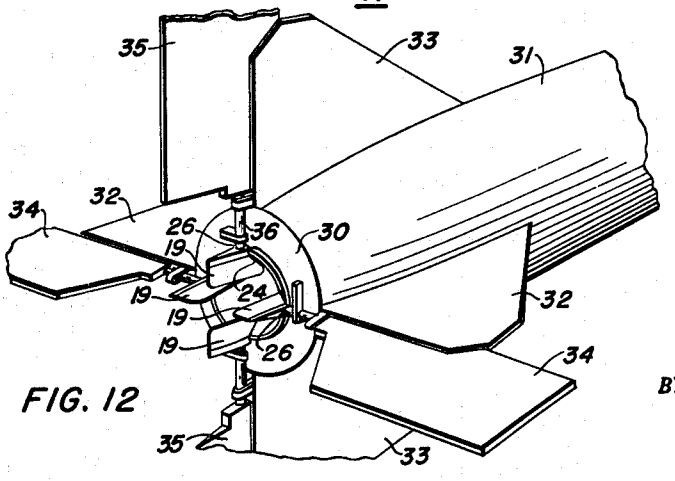

FIG. 12

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LAMINATED JET VANE

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Application January 15, 1948, Serial No. 2,465

15 Claims. (Cl. 60—35.6)

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This invention relates to vanes for assisting in the guidance and control of jet propelled vehicles—such as rockets—during launching and the initial part of their flight.

These vanes are operatively positioned either partially within or just outside of the divergent section of the exhaust nozzle and within the path of the jet stream. As a result, vane efficiency has been somewhat low because of the character of erosion to which the leading edges of the vanes have been subjected.

Accordingly, it is an object of this invention to provide a vane which maintains a sharp leading edge.

It is a further object of this invention to provide a vane of sandwich construction for the purposes of the invention.

It is a further object of this invention to provide a vane composed of materials having different erosion characteristics under the action of jet stream gases.

It is yet another object of this invention to provide vanes which function efficiently during their operative life and which—in order to reduce aerodynamic drag—are either entirely consumed or become automatically detached when they have served their purpose.

Other objects of invention will become apparent from the following description taken in connection with the accompanying drawings, in which

Figs. 1 and 2 are side elevational views, partly in section, of typical vanes used prior to this invention, showing their condition before and after being subjected to the erosive effects of hot exhaust gases.

Figs. 3 and 4 are views similar to Figs. 1 and 2, respectively, illustrating an embodiment of the invention and showing, in Fig. 4, the contour which the leading edge maintains under conditions of hot gas erosion;

Fig. 5 is a cross-sectional view of a modified form of the invention;

Fig. 6 is a sectional view of still another modified form of construction;

Fig. 7 is a side elevational view of yet another modified form of the invention;

Fig. 8 is a plan view of the arrangement shown in Fig. 7;

Fig. 9 is yet another modified type of construction and particularly an insert and retaining means therefor;

Fig. 10 is a plan view of yet another modified type of construction showing a pair of superimposed plates overlying the upper and lower surfaces of the main body of the vane.

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Fig. 11 is a sectional view along line 11—11 of Fig. 10 and additionally showing vane holding means.

Fig. 12 is a partial perspective view showing the arrangement of the vanes with respect to the rocket motor.

Referring to the drawings, there is shown in Fig. 1 a conventional vane 1, prior to being subjected to the blast of hot gases emanating from the rocket motor. It may be noted that vane 1 is provided with a relatively sharp leading edge 2. In Fig. 2 the vane is shown after having been subjected to the erosive effect of hot exhaust gases, the sharp leading edge 2 having been eroded away with the result that it has become blunt or rounded as at 3.

In Fig. 3 there is illustrated a vane 4 constructed in accordance with the invention, comprising an inner sheet 5 of relatively stiff material and an outer covering 6 shaped in the form of a vane. Inner sheet 5 is of material which has a higher tensile strength than the material of covering 6. In the preferred embodiment of the invention sheet 5 and covering 6 are formed of molybdenum and copper, respectively. Molybdenum has greater resistance to erosion, or tendency to combine chemically with the exhaust products of the combustion of the rocket motor, than the copper material. Accordingly, when subjected to the exhaust gases, the copper erodes as shown in Fig. 4, leaving a sharp leading edge 7 of the relatively thin central material, and a pair of streamline surfaces 8 which provide the vane with a sharp edge effect. In this particular construction the copper, having high conductivity characteristics, tends to convey the heat away from the molybdenum with the result that, in effect, a controlled burning of the leading edge is obtained.

By reason of the construction shown in Figs. 3 and 4, there obtains greater control efficiency of the rocket during take-off and the initial portion of its flight, which efficiency is maintained during the effective life of the vane from the standpoint of the areodynamic effect which it has upon the guidance of the rocket.

In the modified form of the invention illustrated in Fig. 5 there is shown a vane 9 of sandwich construction, composed of a series of laminas. Thus, the vane may be composed of an inner sheet 10 of molybdenum, steel, or the like, and successive layers 11, 12, 13, and 14, of copper, chromium, molybdenum, and copper, respectively. It is to be understood, of course, that different materials may be used in different arrangements, according to results desired.

In the embodiment of the invention illustrated in Fig. 6 the vane 15 is composed of a molybdenum sheet 16 and a copper portion 17, similar to that in Fig. 3, but with the addition of a leading edge portion 18 of sheet 16 which is provided with a nose portion of increased sectional thickness, as illustrated. This arrangement increases the initial life of the vane and particularly during the launching operation in view of the higher melting point of the molybdenum nose section 18, as contrasted with the more readily consumable copper. However, instead of the nose section 18 tending to become rounded, as in the arrangement shown in Fig. 2, it will, upon consumption, result in an arrangement similar to that in Fig. 4. This embodiment of the invention may be chrome plated, if desired, as at 27. A coating 28 of ceramic material also may be provided.

The form of invention illustrated in Figs. 7 and 8 provides a vane 19 having an insert 20 of molybdenum, or the like, fastened to copper portions 21 by means of rivets 22 which may also be of copper. The molybdenum in this modification of the invention may take the form of an insert extending only partially along the length of the vane to the line 23, as shown in Fig. 8.

The leading edge of the nose section may be cut at an angle rearwardly, as shown at 24. In this form of the invention the molybdenum and copper are consumed back to line 23 until rivets 22 give way and are no longer effective to hold the molybdenum insert to the body of the vane, whereupon the unconsumed portion of the insert becomes detached, exposing the remaining body of the vane to the hot exhaust gases. By this time the rocket is already launched and in the initial period of its flight, whereupon the vanes are no longer needed and, to obtain reduced drag, rapid consumption of the same is desired. Release of the insert and exposure of the remainder of the vane to the exhaust gases facilitates such rapid consumption.

The form of invention illustrated in Fig. 9 is similar to that in Fig. 8 except that the rivets or retaining pins 22 are located in the tongue portion of the vane rather than being exposed directly to the hot gases as in the arrangement illustrated in Fig. 8.

In Figs. 10 and 11 there is illustrated still another arrangement of a molybdenum insert 20, of copper side walls 21 and rivet or pin holding means 22, together with a tongue arrangement 25 adapted to engage a suitable groove in the holder 26 in the rocket motor.

The vanes are adapted to be held in operative position with respect to the rocket motor by means of tongue 25 adapted to fit in a suitable groove 29 in holder 26 which, in turn, is positioned on motor 30 of rocket 31 as illustrated in Fig. 17.

The rocket is provided with fixed horizontal and vertical control surfaces, 32 and 33 respectively, and movable horizontal and vertical control surfaces, 34 and 35 respectively. The movable control surfaces are interconnected with other mechanism, such as gyros or the like, for guiding the rocket. Functioning of the guiding mechanism depends upon the aerodynamic effect obtained on the movable control surfaces by passage of the rocket through a fluid medium. During takeoff and a small portion of the initial flight there is insufficient aerodynamic effect on such surfaces to control the rocket as desired. Accordingly, the vanes 19 are interconnected, through holder 26, with a common shaft 36 attached to the movable control surfaces so as to be utilized in conjunction with exhaust gases from the motor 30 for that purpose. Obviously, it is desirable that vanes 19 become detached as quickly as possible when they have served their function.

It is to be understood that different materials could be used than those described and illustrated herein. Although the central material has been generally described as molybdenum and the outer material as copper, it has been found that the central material does not necessarily have to have a higher melting point than the outer material. Neither is the construction limited to the combination of the materials shown. The central material may be of appropriate size, shape, and configurations, according to the results desired. Further, the central material may extend for any predetermined portion of the length of the vane and may have any predetermined configuration, depending upon the results desired. Thus, a vane is obtained which maintains its aerodynamic characteristics until the portion thereof having an effect upon the guidance of the rocket is consumed, at which time that which remains, if any, becomes automatically detached. In the various laminated types of construction, different materials may be selected, depending upon their rates of consumption, which will give the desired contour of the vane during consumption and predetermined guide characteristics.

The physical and chemical properties of the materials used in the fabrication of jet vanes of the sandwich construction type are of such a nature that the rate of consumption of the core is slower than that of the outer layers. The relative rates of consumption are such as to allow the maintaining of a leading edge of efficient aerodynamic configuration for a predetermined length of time, depending upon the amount of guidance desired. Variations in temperature, time, and jet stream characteristics permit the obtaining of these desirable features with different types and combinations of materials. For instance, the core may be composed of molybdenum, tungsten, or chromium, or alloys or metallic carbides or oxides thereof, whereas the outer layers may comprise copper, aluminum, silver, or alloys thereof, or wood, laminated phenolics, resin impregnated glass, graphite, or metallic carbides or oxides. Also, one or more of these materials may be coated with a suitable material such as chromium or the like for the purpose of better controlling its rate of consumption.

Although the invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of this invention being limited only by the terms of the appended claims.

We claim:

1. A vane adapted for use in guidance and control of a jet motor propelled vehicle during launching and initial flight and associated with such motor in such a manner as to be eventually consumed by the hot gases thereof, comprising a vane formed of a plurality of sheets of different material, one of which is centrally disposed, said materials differing in thermal conductivity and melting point and having differing reaction rates with said hot gases, and said sheets being superimposed with those of higher conductivity and lower melting point covering those with lower

conductivity and higher melting point whereby as said vane is consumed progressively from leading edge to trailing edge by action of said hot gases its aerodynamic effectiveness as a vane is preserved throughout a major portion of its life.

2. A vane as recited in claim 1 in which the outer of the plurality of sheets are streamlined in contour and in which said sheets are arranged over said centrally disposed sheet in order of decreasing resistance to destruction by said gases to thereby maintain a streamlined shape throughout a major portion of the life of the vane.

3. A vane as recited in claim 1 in which the centrally disposed sheet is molybdenum and the other sheets are copper to thereby provide the vane with a sharp leading edge throughout its life.

4. A vane as recited in claim 1 in which said centrally disposed sheet is attached to the other sheets by predeterminately spaced consumable fastening means to thereby provide for jettisoning of said vane when the usefulness thereof has ended.

5. A vane as recited in claim 1 in which said centrally disposed sheet is molybdenum and said other sheets are copper, all of said sheets being fastened together by copper rivets so spaced as to be consumed when the launching and initial flight period is complete.

6. A vane as recited in claim 1 in which the leading edge of the nose section of the vane is placed at an acute angle with respect to the longitudinal direction of the vane.

7. A vane for use in the exhaust stream of a rocket motor comprising a composite streamlined member composed of a sheet of material centrally positioned between layers of other material, said latter material being of higher thermal conductivity and lower melting point than said centrally positioned material and having faster reaction rates than said centrally positioned material with the gases in said exhaust stream.

8. A device as recited in claim 7 in which said centrally positioned sheet is of higher tensile strength than said other material.

9. A vane adapted for use with jet propelled vehicles to assist in guiding the same by use of exhaust gases thereupon and so associated therewith as to be consumed by said hot gases, comprising a vane formed of a plurality of sheets of materials the outer of said sheets being composed of materials having higher conductivity and lower melting point than the materials composing the innermost said sheets.

10. A composite streamlined jet vane for use with a rocket motor comprising a central sheet of high melting point material and a plurality of sheets of alternately low and high melting point materials symmetrically arranged with respect to such central sheet.

11. A vane as recited in claim 10 in which said central sheet is molybdenum and successive pairs of sheets are composed of copper, chrome plate, copper, and steel, respectively.

12. A vane adapted for use with jet propelled vehicles to guide the same and eventually be consumed by the hot exhaust gases thereof, comprising a member formed of a plurality of sheets of material one of which is centrally disposed and composed of structural material, and the others of which are of a nonstructural material which is less resistive than said structural material to the action of said exhaust gases and has higher heat conductivity than said centrally disposed sheet.

13. A vane as recited in claim 12 in which the other sheets of material are less resistive to the action of the gases thereby to provide a sharp leading edge for the vane during its life.

14. A vane as recited in claim 12 in which said centrally disposed sheet comprises molybdenum coated with a ceramic material.

15. A jet vane for use in controlling the flight of a jet propelled vehicle comprising a streamlined plate formed of a plurality of layers of material having differing resistances to the effects of hot gases from said vehicle, said layers being arranged with the less resistant layers on the surfaces of said plate whereby as said plate is consumed by said hot gases a streamlined shape is maintained.

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