Dec. 26, 1961 C. A. ANDERSON 3,014,410

BLAST DEFLECTORS

Filed March 10. 1958 2 Sheets-Sheet 1

Fig.1.

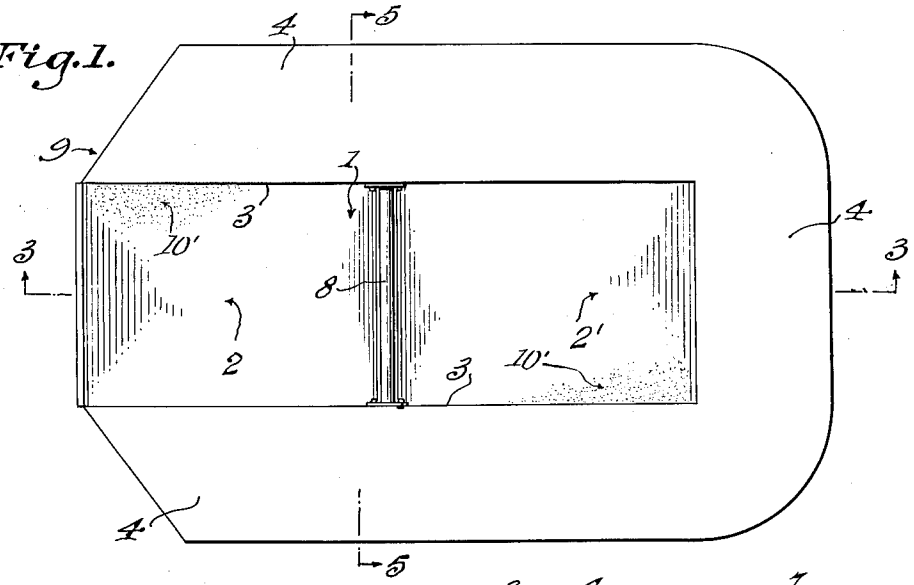
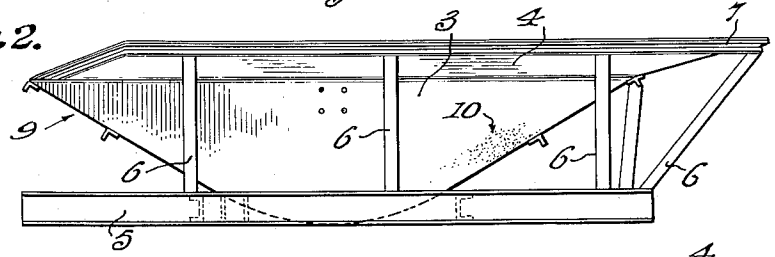


Fig.2.



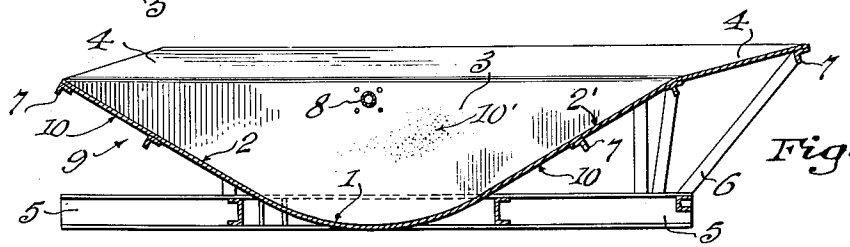


Fig.3.

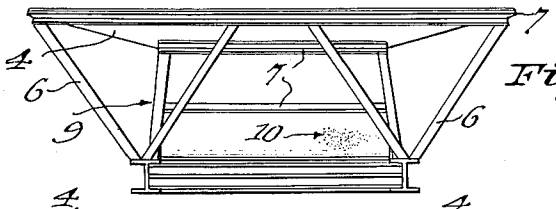


Fig.4.

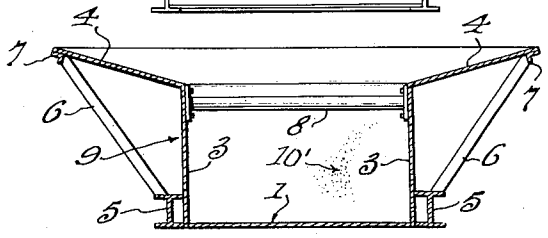


Fig.5.

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BLAST DEFLECTORS

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Fig. 6.

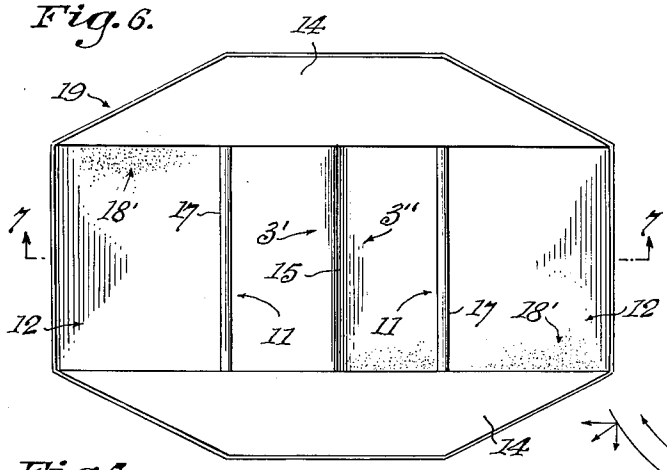


Fig. 12.

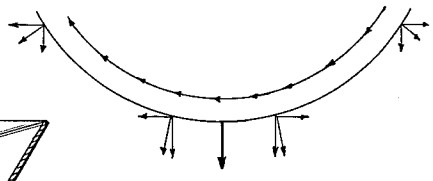


Fig. 7.

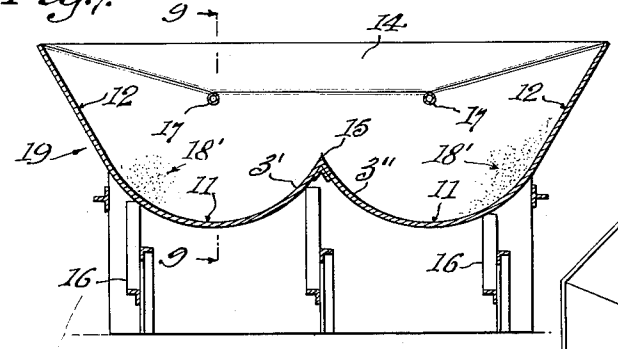
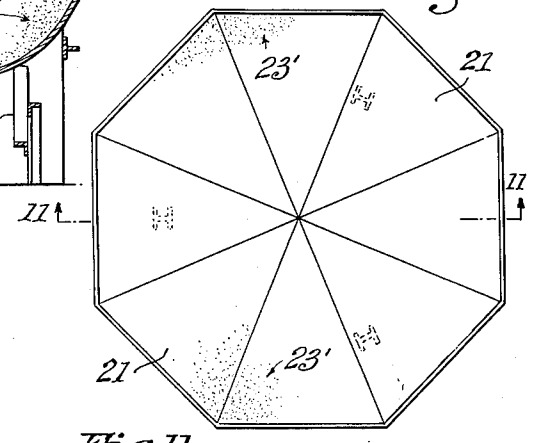


Fig. 10.



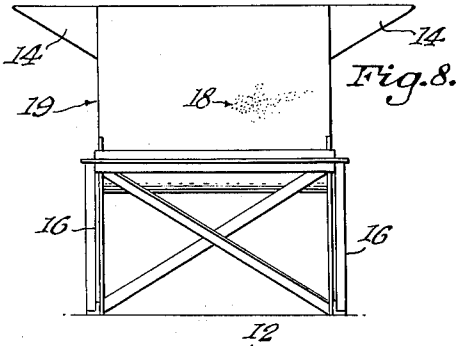


Fig. 8.

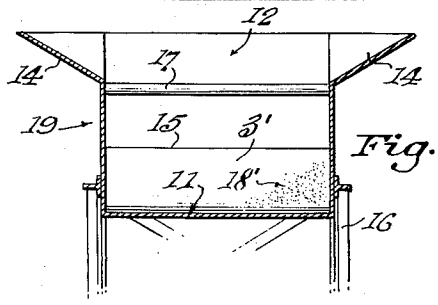
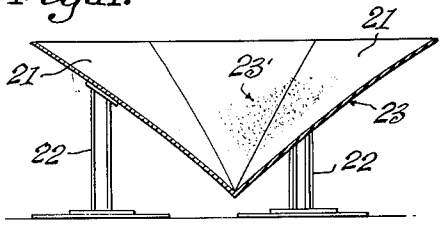


Fig. 9.

Fig. 11.



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United States Patent Office 3,014,410 Patented Dec. 26, 1961

3,014,410

BLAST DEFLECTORS

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1 Claim. (Cl. 89—1.7)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

This invention relates generally to a means for mechanically deflecting the exhaust blast emanating from solid or liquid fueled jet type propulsion units.

An object of this invention is to eliminate ground erosion and alleviate dust during missile launchings in the field for the purpose of reducing enemy detection and counter-battery.

A further object is to accomplish the mission of deflecting the exhaust blast and reducing detection with a structure of minimum weight and size, and still have the strength to withstand force and pressure loads.

Another object of this invention is to produce a blast deflector for missile launchings having good mobility and maneuverability.

A further object is to produce a blast deflector having the capability to be used for a maximum number of exposures and yet having the capability of being manufactured economically from non-critical materials.

A further object is to provide a blast deflector so designed as to effect a balancing of external forces acting upon it, thereby eliminating time-consuming anchorage.

The novel structures herein described and claimed are based on the combination of four principles.

The first principle recognizes that exposure of any material to a gas which is at elevated temperatures and flowing at supersonic velocities, will produce a temperature rise in the material. Any material thus exposed, however, will be found not to change in practical physical structure for a finite period of time early in the span of temperature rise of the material.

The second principle concerned is the substantial increase of the period of time of "no physical change in the material." This is accomplished by designing the blast deflector so that the blast is not allowed to expand laterally until after it is turned in direction, incorporating laminar flow principles in so doing. This may be stated as "confining and turning" the blast. By maintaining laminar flow in confining and turning the blast the highest velocity flow is automatically positioned close to the turning surface or surfaces of the blast deflector creating an effect which delays temperature radiation into the material.

The third principle upon which this invention is based relates to the structural strength of blast deflectors. Observance of the principles set forth heretofore dictates that the design of the blast deflectors incorporates a minimum of flat unsupported surfaces. It will be later noted that where the design does require flat surfaces, such flat surfaces are never in the region of highest pressure unless they are supported by curved laminar flow shapes. This results in material and weight saving advantages.

The fourth principle incorporated in th instant invention relates to utilizing the blast forces to anchor the blast deflector in position. This is accomplished by balancing horizontal force vectors so that their net effect is either zero or negligible in relation to the vertical force vectors. This is quite important because in the actual use of deflecting device, time to set up and move out again is critical. Any form of anchorage of the deflector to the ground would be undesirable from this standpoint.

The instant invention is designed for use with large rockets and guided missiles to deflect propulsion unit discharge blast away from supporting surfaces or nearby objects and into a selected region where the blast has little or no adverse effect. Its design is such as to be strong and yet light of weight. It is usable for an indefinite number of launchings even though made of non-critical material.

Basic hydraulic theories and, to some extent, laws of physics relating to subsonic gas flows have helped to explain some of the phenomena occurring during the blast. However, some of these theories have to be applied with caution as they are not always in conformance with the experimental results. For example, a fortunate combination of two effects occurred early in the experimental stages of the instant invention which points up this disparity between theory and experiment. An attempt was made to turn gas discharge with configurations of mild steel. The gases were directed harmlessly into space, and the deflecting device, contrary to normal subsonic thermal theories, showed no melting effects from the high combustion temperatures. According to known theory at that time, the steel should have melted in a fraction of a second. Flat plates of steel inserted in the flame had melted through in a fraction of a second. Another material which can be used is mild steel with the exposed surfaces "flame spray" coated with zirconia which withstands the high combustion temperature very well.

There are two probable explanations for this relatively long time delay for melt through which occurs when the gases are confined and turned through an arc:

(1) The gas flows in several velocity layers, the fastest of which occurs at the surface of the steel shaped to form an arc causing lower temperatures there; or (2) the high velocity leaves a thin layer of dead air a few molecules thick against the steel forming the arc, acting as insulation.

Another major observed phenomenon was that of further increasing the said period of time of "no physical change" by adding reflecting material to the interior deflecting surfaces and/or by adding thermal insulating material to the exterior deflecting surfaces. The latter can be accomplished by applying a thin sheet of asbestos to the outside wall of a deflector.

In accordance with the invention, the foregoing objects are accomplished by providing devices designed in each case for the particular missile or rocket concerned but having in common curved surfaces at strategic points which confine and turn the blast.

Preferred embodiments of the invention have been chosen for purposes of illustration and description and are shown in the accompanying drawings forming a part of the specification wherein:

FIG. 1 is a top plan view of a device in accordance with the present invention illustrating one embodiment thereof;

FIG. 2 is a side elevation thereof;

FIG. 3 is a longitudinal section taken on line 3—3 of FIG. 1;

FIG. 4 is an end elevation;

FIG. 5 is a transverse section taken on line 5—5 of FIG. 1;

FIG. 6 is a top plan view of a device in accordance with the invention illustrating another embodiment thereof;

FIG. 7 is a longitudinal section taken on line 7—7 of FIG. 6;

FIG. 8 is an end elevation;

FIG. 9 is a transverse section taken on line 9—9 of FIG. 7;

FIG. 10 is a top plan view of a device in accordance

with the invention illustrating still another embodiment thereof;

FIG. 11 is a section in line **11—11** of FIG. 10; and

FIG. 12 is a sketch showing force vectors acting upon the turning arc.

Looking now with more particularity at FIGS. 1 to 5, it is seen that they illustrate a blast deflector intended for use with a missile that is launched on a variable angle from the horizontal. This variable quadrant of elevation (Q.E.) is inherent in certain types of missiles as can be readily understood. The angular direction of the gas discharge varies accordingly. By designing the deflector to accommodate the highest load (occurring at 50° Q.E.) alignment of the deflector can be made to accommodate quadrant elevations from 50° down to 30°. As shown in FIGS. 1 through 5, **1** is the blast turning surface or turning arc of the receptacle **9**. The radius of this surface will vary depending on how much room is available in the normal blast area and how much thrust is produced by a particular engine producing the blast. The width of this blast turning surface is dependent upon the diameter of the "column" of the blast. Due to the very great effectiveness of this invention as regards increasing the period of time of "no physical change in the material," the ratio of width of turning surface to diameter of blast can be in the vicinity of 2 to 1. This sacrifices some of the period of no physical change but gains advantage in reducing spillover of blast as the missile moves away from its initial position. The rate of acceleration of a missile of this type is such that time of exposure of the deflector to blast is still well within safe limits for adverse heat effects even at a 2 to 1 ratio. Surfaces **2** and **2'** of receptacle **9** are the ingress and egress surfaces, respectively, tangent to the turning surface **1**. These surfaces are 30° with the horizontal in the instant device. The ingress tangent **2** combined with the sides **3** adjacent to it provides confinement of the blast to keep the blast from expanding before it reaches the turning surface and also to keep fringes of the blast off the ground surface ahead of the turning surface. The egress tangent surface **2'** leads the blast far enough above the ground surface after deflection to avoid drawing the egressed blast back toward the ground surface and to allow sufficient space for indrawn ambient air to reduce to velocities of low order at the ground surface. Tangent surfaces such as **2** and **2'** have no force vectors from the blast as long as the blast is parallel to them.

The sides **3** confine the blast during entrance, deflection, and exit. The area of greatest pressure on these sides is near where they are attached to the turning surface **1**. The aprons **4** deflect the edges of the blast during the brief period when the vehicle moves away and until blast effects on the deflector are gone. Approximately 80 percent of the blast effects are nullified without these aprons. The base members **5** add rigidity in all three dimensions to the deflector structure. References **6** are apron supports, **7** are stiffener members, and **8** are internal spreader members. To further reduce the rate of heat flow through the walls, a coating **10'** of any heat reflective material is applied on the interior of the deflector walls, while a coating **10** of insulating materials is added to the exterior of the deflector walls.

In operation, this deflector is placed behind the vehicle to be fired. The fore and aft positioning of the deflector in relation to the centerline of blast is critical to the extent of affecting fore and aft balancing of horizontal force vectors. This positioning is critical within an inch or two if the deflector is not otherwise to be anchored. Lateral positioning of the deflector in relation to the centerline of blast is not critical as far as forces are concerned, however, spillover of blast will occur to one side or another proportionately to the amount lateral positioning is off center. Alignment of the centerline of blast fore and aft is made by sighting. As pointed out, the 30° angle of the ingress and egress tangential surfaces **2** and **2'** accommodates vehicles with gradients of elevation from 30° to 50°. With the center of the turning arc **1** in a horizontal plane, horizontal components are almost exactly in equilibrium and their net effect so small in relation to the vertical force that the deflector will not move as a result of the blast.

FIG. 12 shows the force vectors acting upon the turning arc **1**. The force at any point is perpendicular to the tangent to the arc at that point. This is true irrespective of the direction of the gas flow. The horizontal and vertical components of the forces at several points are also shown. The horizontal forces are seen to be opposite in direction from the side of the bottom tangent point of the arc to the other. If this bottom tangent point is also the center of the arc, the sum of the horizontal components on one side is equal in magnitude to the sum of the horizontal components on the other side, and therefore cancel each other in net effect on the tangent arc. The vertical components of force are additive downward on each side of the center of the arc with the net effect on the turning arc of one force vector at the center of the arc. This applies substantially to all embodiments shown herein.

The formula used to determine the magnitude of the forces is based on the standard hydraulic formula for determining the force of a jet impinging against a deflecting surface,

$$F=2T \sin \frac{\theta}{2}$$

where T is the thrust of the missile. In the first embodiment,

$$\frac{\theta}{2}$$

is the quadrant elevation to which the missile is elevated, in degrees of angle with the ground surface.

The design factors necessary to be taken into account are (1) the rated total thrust of the engine or engines in pounds, (2) the diameter of the nozzle at the exit end, (3) distance or range of distances from nozzle to ground surface, (4) quadrant elevation or range of quadrant elevation, (5) amount of missile swing in azimuth while on the launcher, (6) final position adjustments just before firing, (7) fixed gimbaled or pivoted engine(s), (8) overall dimensions and configuration of launcher, (9) time interval from ignition until exhaust flame leaves the ground, (10) time interval from ignition to maximum combustion pressure, (11) the maxium time a deflector would be exposed to the exhaust discharge under emergency conditions, (12) configuration, location, and dimensions of fins near the nozzle, (13) existence and location of launcher legs or other ground equipment, and (14) configuration of the exhaust flow in air, especially the length and maximum width of the turbulence.

The procedure of design in general terms is to lay out to scale the physical factors such as clearance between nozzle and ground, direction or directions the gas should be deflected to dissipate it without adverse effects on the ground, the missile, or other equipment, and then consider how to contain the pressures, minimize temperature effects, encompass the turbulence, balance forces, etc.

FIGS. 6 to 9 inclusive illustrate another embodiment of this invention. This embodiment contemplates a divided discharge deflector. Space requirements are severe for this deflector, requiring short turning radii for the twin deflecting surfaces **3'**, **3''**. These short radii result in relatively high pressures within the main body of the deflector. This configuration is used so as to deflect the exhaust blast above obstructing launcher legs and yet not allow the blast to be close enough to the aft control surfaces of the vehicle to damage them, and also to balance the load more easily.

Reference **11** represents the blast turning surfaces and

12 represents the entrance and exit surfaces tangent to the turning surface 11. These surfaces (11 and 12) serve the same purpose as do 1 and 2 in the first embodiment shown, except that here are two turning surfaces. The aprons 14 deflect the fringe blast and 15 is the knife edge which divides the blast. This knife edge is more critical in regard to heat effects than any other part of the configuration. For vehicles with high acceleration and fast pressure rise time, a safe margin exists for heat effects if the 60 degree tangent angle at the knife edge is maintained. Base members 16 add stiffening to the structure as well as support the deflector so that existing blast will clear the launcher. Internal spreader members 17 are necessary because of the short turning radii which cause relatively high internal pressures. Reference 19 represents the entire receptacle, while to further reduce the rate of heat flow through the walls, a coating 18' is a heat reflective material applied on the interior of the deflector walls and 18 is an insulating material added to the exterior of the deflector walls. As in the first embodiment, forces are counterbalanced so that stability of the deflector structures without other anchoring is accomplished.

FIGS. 10 and 11 show a third embodiment of the invention. Substantially triangularly shaped segments 21 are connected side to side with the apexes of the triangles meeting at a common point to form an inverted convexo-conical surface. It will be noted that the segments have convex surfaces facing upwardly and inwardly toward an imaginary vertical axis of symmetry passing through the meeting point of the segment apexes. This curvature of the segments serves to strengthen and stiffen the receptacle by forming a series of rigid arches at the junctions of the various segments 21. These surfaces are segments for reasons of practical fabrication. A configuration circular in horizontal cross section would be equally efficient. Here the blast itself creates the real turning surface, the lower portion of each segment confining the gas, the center portion completing the turning, and the upper portion drawing the blast away from the aft end of the vehicle by the surface curvature and controlling the exit blast. Base members 22 support the deflector structure which needs no further strengthening because of its inherent shape. This deflector is used with vehicles having a quadrant elevation of 90° only. The vehicle is centered over the deflector so that horizontal forces are balanced and thus their net effect is vertically downward without the necessity of anchoring the deflector. To further reduce the rate of heat flow through the walls, a coating of heat reflective material 23' is applied on the interior of the deflector walls and 23 is an insulating material applied on the exterior of the deflector walls.

To operate any of the three embodiments shown, it is simply a matter of laterally centering the device behind the nozzle of the vehicle so that the blast from the vehicle will enter the deflector at the tangential ingress. The design of all three embodiments will insure their being held in place by the blast itself without the necessity of tie-downs.

I claim:

A blast deflector for deflecting a vertically descending exhaust blast emanating from jet propelled units, said deflector comprising an inverted conical-shaped receptacle having a plurality of substantially triangularly shaped plate segments symmetrically disposed around a vertical axis of symmetry and sloping upwardly from a horizontal plane, said segments being sequentially joined at adjacent sides with the apexes of all said segments joined at said vertical axis of symmetry, each segment having a convex surface facing said vertical axis, and support means for said receptacle.

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