US 20190112079A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2019/0112079 A1

(43) Pub. Date: Apr. 18, 2019

Renzi

(54) LAUNCH PAD FLAME DEFLECTOR STRUCTURE AND METHOD OF MAKING THE SAM

(71) Applicant: **Peter Nicholas Renzi**, E. Sandwich, MA (US)

(72) Inventor: **Peter Nicholas Renzi**, E. Sandwich, MA (US)

(73) Assignee: **RENZI FAMILY TRUST**, E. Sandwich, MA (US)

(21) Appl. No.: **16/216,985**

(22) Filed: **Dec. 11, 2018**

Related U.S. Application Data

(62) Division of application No. 15/487,388, filed on Apr. 13, 2017, now Pat. No. 10,150,580.

(60) Provisional application No. 62/497,119, filed on Nov. 10, 2016.

Publication Classification

(51) **Int. Cl.**

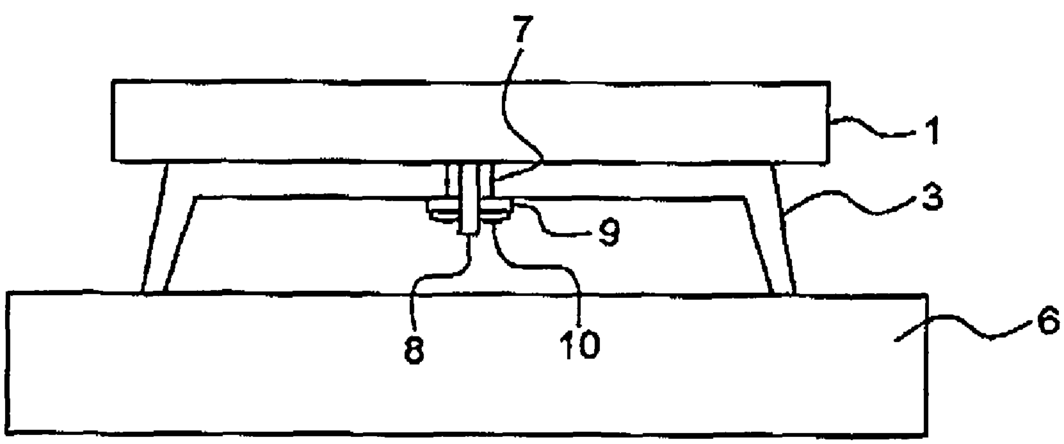
B64G 5/00	(2006.01)
C23C 30/00	(2006.01)
B05D 7/14	(2006.01)
B05D 3/02	(2006.01)

(52) **U.S. Cl.**

CPC ***B64G 5/00*** (2013.01); ***B05D 3/0254*** (2013.01); ***B05D 7/14*** (2013.01); ***C23C 30/005*** (2013.01)

(57) **ABSTRACT**

Flame deflectors for rocket launchpads have historically been constructed on-site by spraying on a layer of refractory cement material, resulting in large monolithic structures which lack durability and are vulnerable to degradation by ambient weather. By assembling together a plurality of metal modules and refractory material modules, one obtains a flame deflector structure whose set of modules is matched to an expected heat distribution pattern of the exhaust from the rocket to be launched. Further, modules can be prefabricated at another location, under controlled conditions, and subsequently installed. In case of damage during a launch, any damaged modules can be swapped out and replaced by new modules, thereby minimizing cost and downtime before a subsequent launch event. The modules can be made more weather-resistant by applying an epoxy sealant to their rocket-facing surfaces.



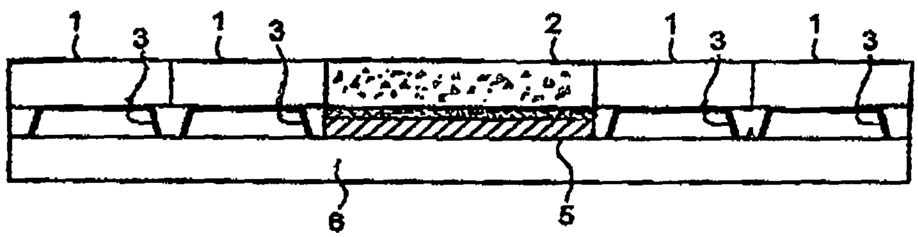


FIG. 1

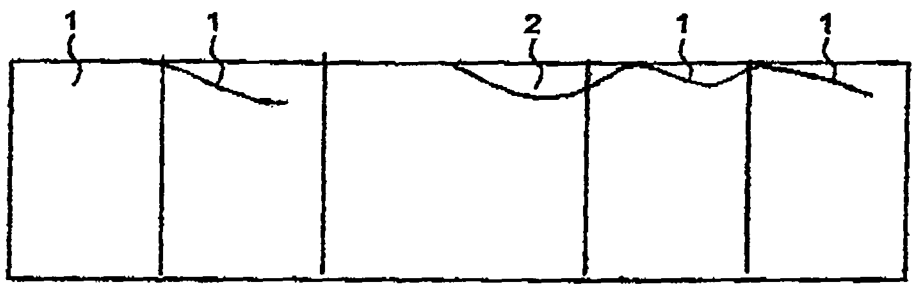


FIG. 2

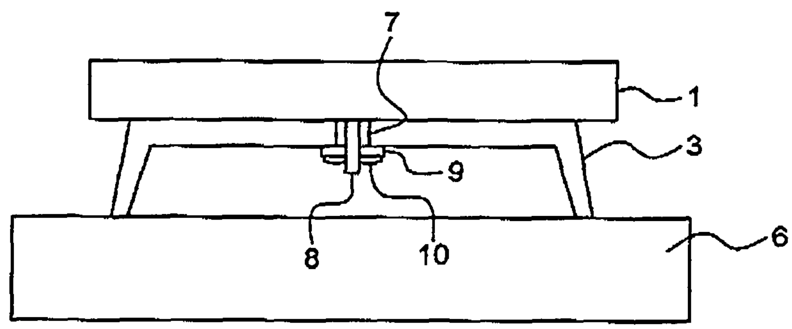


FIG. 3

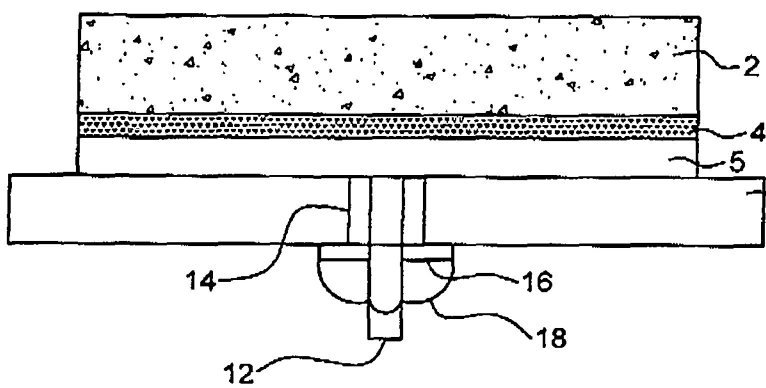
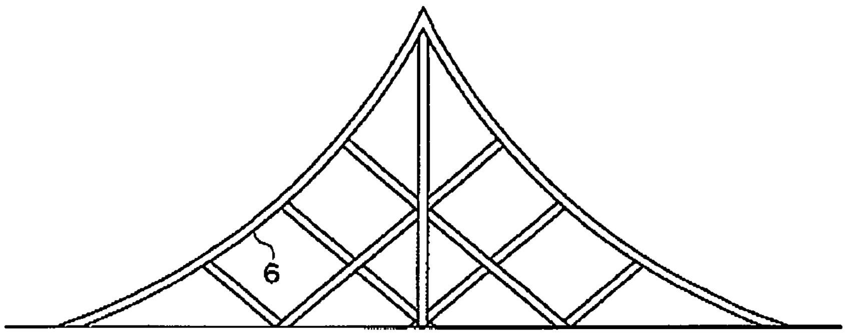


FIG. 4



PRIOR ART

FIG. 5

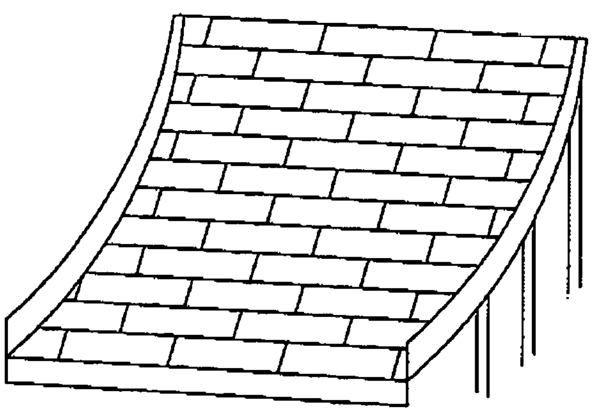


FIG. 6

LAUNCH PAD FLAME DEFLECTOR STRUCTURE AND METHOD OF MAKING THE SAM

[0001] CROSS-REFERENCES:

[0002] This application claims priority from my provisional application Ser. No. 62/497,119, filed Nov. 10, 2016, and incorporates by reference said provisional and the following technical literature:

DATE	AUTHOR(S)	TITLE
1966 March	Lays et al	"Design Handbook for Protection of Launch Complexes from Solid Propellent Exhaust," prepared by Martin Marietta Co. for NASA-KSC (56 pages).
2010 April	Calle+	"Refractory Materials for Flame Deflector Protection," (AIAA Conference Paper, 10 pages).
2009 January	Calle+	NASA/TM-2013-216316, "Refractory Materials for Flame Deflector Protection System Corrosion Control: Coatings Systems Literature Survey" (17 pages).
2009 January	Calle+	NASA/TM-2013-216321, "Refractory Materials for Flame Deflector Protection System Corrosion Control: Flame Deflector Protection System Life Cycle Analysis Report" (74 pages).
2009 January	Calle+	NASA/TM-2013-217910, "Refractory Materials for Flame Deflector Protection System Control: Similar Industries and/or Launch Facilities Survey" (78 pages).
2009 May	Calle+	NASA/TM-2010-216294, "KSC Launch Pad Flame Trench Environment Assessment" (84 pages).
2009 May	Calle+	NASA/TM-2010-216280, "Prefabricated Refractory Panels for Use in KSC's Flame Deflectors: A Feasibility Study" (102 pages).
2011 August	Harris+Vu	"Modeling of Heat Transfer and Ablation of Refractory Material Due to Rocket Plume Impingement" (34 pages).

FIELD OF THE INVENTION

[0003] The present invention relates generally to launch pads for rockets and, more particularly, to structures and production methods which make a flame deflector, underneath the rocket, resistant to adverse environmental influences and resistant to damage caused by the flaming gases ejected by a rocket during launch. \

BACKGROUND

[0004] Early engineering work in rocketry in America was performed by Dr. Robert Goddard (1882-1945). Subsequent to 1945, additional progress was made by teams headed by Dr. Wernher von Braun (1912-1977). This led to the creation in 1958 of the US National Aeronautics & Space Administration (NASA) which maintains launch facilities in Florida, now known as the Kennedy Space Center (KSC). The US Department of Defense (DoD) also maintains a launch facility at Vandenberg Air Force Base in California. Contractors for NASA and the DoD have developed technology to maximize launch success and to minimize damage to launch facilities, resulting from degradation by hot gases and flying debris. During a development program (circa 1957-78) for the Titan I rocket, a flame deflector having a generally J-shaped radial cross-section, with a horizontal exit for the flames, was developed.

[0005] Two J-shaped structures can be used, so that their respective exits point in opposite directions along a common axis, as shown in FIG. 1 on page 3 of the APR. 2010 AIAA Conference Report cited above. The basic structure is a metal base framework, on which is applied a rocket-facing protective layer of Portland cement. Subsequent launchpads, dealing with more severe conditions, used a refractory material sold by the Pryor Giggey Co. of Alabama under the trademark FonduFyre, as described in the above-cited Martin-Marietta *Design Handbook*. As of this writing, FonduFyre is the only refractory material approved by the Kennedy Space Center to protect flame-impinged surfaces. The KSC acknowledges, in its 2009 technical reports, that there are problems associated with FondueFyre, and has sought to determine whether alternative refractory materials would meet the performance requirements for KSC's launchpad technical application. However, to the best of my knowledge, no changes have been made since 2009 by the KSC to its list of approved refractory materials. This FondueFyre cement has generally been applied to the metal base by spraying, on location, in a manner analogous to construction of a swimming pool, known colloquially as "guniting." Experience has shown that the structures produced in this manner fail to exhibit uniformly high resistance to rocket flames, and often need to undergo expensive repairs after a launch. Further, the refractory surface is also vulnerable to tropical rains, salt deposition, and other adverse environmental influences.

[0006] A series of NASA reports detail various attempts at a solution, with less-than optimal results. See the APR. 2010 AIAA Conference Paper, referenced above.

SUMMARY OF THE INVENTION

[0007] Accordingly, an object of the present invention is to provide a reliable flame deflector surface which can be manufactured uniformly, in a controlled environment, as a plurality of modules, transported to the launch facility, and secured together to produce a durable flame deflector surface. The uniformly heat-resistant structure which results, thereby minimizes spalling of the refractory during a launch event, and minimizes the risk that flying debris will damage either the ascending rocket, the gantry, or nearby ground facilities. Minimizing launch-related damage thereby (A) avoids repair costs and (B) avoids down-time which would delay subsequent launch efforts.

[0008] BRIEF FIGURE DESCRIPTION

[0009] FIG. **1** is a cross-sectional view, showing a metal deflector plate substrate, supporting a combination of refractory modules and metal bar modules.

[0010] FIG. **2** is a plan view schematically illustrating arrangement of a plurality of refractory modules and of metallic modules, in abutting relationships, entirely covering a rocket-facing surface of a metallic deflector structure;

[0011] FIG. **3** is a cross-sectional view, showing a preferred structure for attaching each metal bar to a flame deflector metal backplate;

[0012] FIG. **4** is a cross-sectional view, showing a preferred structure for attaching a refractory module to the same flame deflector metal backplate;

[0013] FIG. **5** is a side cross-sectional schematic view of a prior art launchpad flame deflector having two concave rocket-facing metal surfaces, supported by a metal supporting substructure; and

[0014] FIG. **6** is a schematic perspective view of modules of the present invention, arranged to cover a concave rocket-facing surface of the prior art launchpad flame deflector.

DETAILED DESCRIPTION

[0015] FIG. **1** schematically shows a metal backplate or substrate **6** of a flame deflector. An upper, rocket-facing surface of the backplate supports a plurality of modules **1**, **2** which will be impacted by the flames and any debris coming out of the rocket. Suitable modules Include metal bar or plate modules **1**, preferably composed of a metal having high thermal conductivity, such as copper, carbon steel or alloy steel, and refractory material modules **2**, preferably composed of a calcium aluminate cement (CAC) having high resistance to thermal degradation.

[0016] During the Titan I program, mentioned above, a Portland cement was used; see standards ASTM C150 or European EN 197-1. The module has either a generally flat front face or a front face curved to conform to the shape of the metal deflector substrate, and four side faces, each orthogonal to the front face. The module has a rear face, adapted for attachment to a supporting metal substrate. Preferably, based upon the engine structure of the rocket to be launched, an expected heat distribution pattern of the rocket exhaust will be determined, by computer simulation or by actual operational experience, and the choice of a module **1** or a module **2** at particular locations on the deflector will be matched to that heat distribution pattern and to a desired abrasion resistance profile. The height and width of the modules can be selected for ease of handling, and their arrangement can be matched to the configuration of the rocket intended to be launched. For example, certain rockets have a combination of liquid-fueled engines and solid-fueled boosters. Metal bar or plate modules **1** would likely be suitable for deflector regions impacted by the exhaust from liquid-fueled engines, while refractory modules **2** would likely be suitable for deflector regions impacted by exhaust from solid fuel, which tends to include particulates which are more abrasive. Any lateral gaps between adjacent side-by-side modules are preferably minimized by forming the modules to precise dimensions but, to the extent such gaps exist or arise during use, those interstices are filled with a ceramic fiber filler material such as that sold under the mark FIBERFRAX (US TM Reg. numbers 567,698; 574,223 and 702,089 of Unifrax I LLC, Niagara Falls N.Y. 14305, USA). This prevents damage to the metal sub-structure, from flames which might otherwise penetrate gaps between adjacent modules.

[0017] FIG. **2** schematically shows, in plan view, an example of a configuration of modules. In a central region, where the greatest abrasion is expected, refractory modules **2** are placed. In peripheral regions where somewhat less heat flux and abrasion are expected, metal bar or plate modules **1** are placed.

[0018] Some rockets have a central liquid-fueled engine and a plurality of solid-fuel boosters arranged symmetrically about the central engine. Since solid-fuel boosters are known to eject solid particles with high momentum, which tend to abrade the flame deflector, placement of refractory modules **2** in the regions most impacted by these solid particles is advantageous in minimizing damage to the deflector, and in minimizing the associated repair costs and downtime for repair.

[0019] FIG. **3** illustrates schematically a preferred structure for securing a metal bar module **1** to the flame deflector backplate **6**. Preferably, a lower or rear surface of module **1** is formed with a plurality of posts or studs **7**. An elongated channel **3** of steel or other high-strength metal, formed with a plurality of longitudinally slotted holes **8**, is aligned beneath each bar module **1**, and the post or stud **7** is threaded through the corresponding slotted hole **8**.

[0020] A washer **9** is placed over each post or stud **7**, on the underside of channel **3**, and assembly is completed with a stop-nut **10**, in order to secure bar **1** and channel **3** together. The bar-and-channel assembly is secured to the backplate **6** by welding respective studs to the undersides of the channels, passing the studs through holes in the deflector back plate, and securing the studs to the rear side of the back plate with washers and nuts.

[0021] FIG. **4** illustrates schematically a preferred structure for securing a refractory module **2** to flame deflector backplate **6**. Module **2** preferably comprises an upper layer, about 6 inches or 15 cm thick, of refractory material such as calcium aluminate cement (CAC).

[0022] A monolithic (non-modular) layer of Portland cement was used in the Titan I program, so this material could also be used in a modular context. Underneath that is a layer of expanded metal **4** about 0.75 inches (19-20 mm) thick, preferably a stainless steel or equivalent. Underneath that is a plate **5**, whose function is to keep the expanded metal **4** in position. Each plate **5** is preferably formed with a plurality of posts **12** which extend perpendicularly from the underside of plate **5** and penetrate respective holes **14** formed in deflector plate **6**. A washer **16** and a nut **18** are placed on each post **12** on a backside of deflector plate **6**, in order to secure module **2** to deflector plate **6**.

[0023] According to a first preferred embodiment, the material of refractory module **2** is a two-component phenolic ablative coating and adhesive having a specific gravity 1.30 and a Shore hardness 90, commercially available from Ametek Chemical Products of Newark Del. USA, sold under the mark HAVAFLEX TA-117.

[0024] According to a second preferred embodiment, the material of refractory module **2** is a concrete aggregate containing 40% hard alumina particles with calcium aluminate cement, commercially available from Kerneos Inc. of Chesapeake Va., USA, sold under the marks FONDAG RS (regular set) and FONDAG DG (dry gunning). Once cured, this material has abrasion resistance several times better than 5000 psi Portland cement concrete. It resists corrosion by sulphates and dilute acids for pH 3.5-7.

[0025] According to a third preferred embodiment, the material of refractory module **2** is a mixture of 40-60% aluminum oxide, mullite, 2.5-10% Christobalite and 10-20% other components, marketed as KRUZITE-70 by Harbison-Walker International of Moon Township, Pennsylvania 15108, USA.

[0026] In order to enhance resistance of the refractory modules to infiltration of water, either from sprays of cooling water used during a launch, or from rainstorms between launch events, the front face of each module can be coating with a suitable sealant, such as a high-temperature-tolerant epoxy. Preferably, this coating is applied in a controlled environment such as a factory, prior to shipment of the finished module to a launch site and assembly of the modules together to form a finished deflector surface.

[0027] A significant advantage of the above-described structure is that, instead of preparing refractory material by spraying concrete-like material, on-site at the launch facility, with non-uniform results, depending upon the skill of the operator of the spraying mechanism, the refractory modules can be prepared in a factory setting, under controlled environmental conditions. For example, a kiln operating at more than 100 degrees Celsius can be used to drive off excess water content, and an external coating can be applied, to minimize later degradation which might otherwise occur in an outdoor installation setting. Preferably, the resulting refractory material has a weight-percent of water not exceeding 3.

[0028] Post-production quality testing can be performed, and any modules not conforming to a predetermined specification can be re-worked or discarded.

[0029] From the foregoing, it will be apparent, to those having ordinary skill in the construction of rocket launchpad flame deflectors, that the modular structure described above offers significantly lower costs and higher-quality results than the prior art "guniting" approach to construction of launchpad flame deflectors.

[0030] Various changes and modifications are possible within the scope of the inventive concept. Therefore, the invention is not limited to the specific structures and steps described above, but rather is defined by the following claims.

APPENDIX OF NUMBERED ELEMENTS

[0031] **1** metal bar module
[0032] **2** refractory module
[0033] **3** metal channel
[0034] **4** expanded metal layer
[0035] **5** metal back plate
[0036] **6** steel deflector substrate
[0037] **7** slot or hole
[0038] **8** post on back of metal bar **1**
[0039] **9** washer
[0040] **10** stop-nut
[0041] **12** post of refractory module
[0042] **14** hole in metal substrate **6**
[0043] **16** washer
[0044] **18** nut to secure refractory module **19** epoxy sealant
[0045] **20** FiberFrax refractory filler

What is claimed is:

1. A flame deflector adapted for use during firing of a rocket generating thrust in excess of ten thousand pounds (about forty-five hundred kilos), said flame deflector having a metal understructure,

a generally concave rocket-facing metallic surface (**6**), and at least one layer of refractory material affixed between said generally concave metallic surface (**6**) and an exhaust plume from said rocket,

wherein said refractory material comprises:

a plurality of refractory material modules (**2**) placed side by side on said generally concave surface, a sheet of refractory fiber material filling lateral interstices between said modules, and

post elements (**8**, **12**) extending from rear faces of said refractory modules through apertures formed in said generally concave surface, thereby securing said modules to said surface, with sufficient strength to keep said modules in position, in spite of forces applied to said flame deflector (**6**) during a rocket launch.

2. The flame deflector of claim **1**, wherein each of said refractory material modules has a rectangular front face, four side faces, each orthogonal to said front face, and a thickness in a range of 10-20 centimeters.

3. The flame deflector of claim **1**, further comprising at least one module of highly thermally conductive metal material, arranged alongside at least one of said modules of refractory material.

4. The flame deflector of claim **2**, wherein

said front face of said refractory material module consists essentially of a phenolic ablative material having a specific gravity about 1.3 and a Shore hardness value about 90.

5. The flame deflector of claim **2**, wherein

said front face of said refractory material module consists essentially of a calcium aluminate cement containing about 40 percent hard alumina aggregate particles.

6. The flame deflector of claim **2**, wherein said front face of said refractory material module composed of a mixture of 40-60% aluminum oxide, mullite, 2.5-10% Christobalite, and 10-20% other components.

7. The flame deflector of claim **2**, wherein

said front face of said refractory material consists essentially of Portland cement.

8. The flame deflector of claim **2**, further comprising

a high-temperature-tolerant coating, resistant to infiltration of water, applied to said front face of said refractory material module.

9. The flame deflector of claim **7**, wherein said coating consists essentially of an epoxy sealant.

10. A method of making a rocket launchpad flame deflector, which is resistant to degradation during a rocket launch, comprising the steps of:

forming a plurality of modules, each with a metal substrate (**5**);

covering said substrate (**5**) with a layer of expanded metal (**4**); applying a slurry of refractory material on top of said expanded metal layer (**4**);

drying said refractory material in a heated environment to drive off free water, hydrated products and chemically bound water;

applying a seal-coating of epoxy sealant to an outer surface of said refractory material to create a refractory module; and

securing a plurality of refractory modules together, side-by-side, to form said rocket launchpad flame deflector.

11. The method of claim **10**, wherein said drying step comprises drying each module in a kiln at a temperature exceeding 100 degrees Celsius until a weight-percent of water in said module is less than three weight-percent.

* * * * *