NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO ATTN OF: GP

June 30, 1971

MEMORANDUM

TO: KSI/Scientific & Technical Information Division
Attn: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures contained in the Code GP to Code USI memorandum on this subject, dated June 8, 1970, the attached NASA-owned U.S. patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. :	2,926,123
Corporate Source :	Lewis Research Center
Supplementary Corporate Source :	
NASA Patent Case No.:	XLE-00035

Gayle Parker

Enclosure:
Copy of Patent

FACILITY FORM 602

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Patented Feb. 23, 1960

1

2,926,123

TEMPERATURE REDUCING COATING FOR METALS SUBJECT TO FLAME EXPOSURE

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No Drawing. Application March 30, 1956
Serial No. 575,291

1 Claim. (Cl. 204—37)

(Granted under Title 35, U.S. Code (1952), sec. 266)

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.

This invention relates to heat reduction coatings for surfaces exposed to flames.

In present day uses of machinery and apparatus, metal parts are frequently exposed to flames and thereby stressed or weakened by excessive heat, an example of such parts being the metal turbine blades of turbo-jet aircraft subjected to combustion chamber flames.

Prior methods employed for heat reduction at these heated areas involved coating the exposed metal surfaces with materials intended to increase the emissivity of radiation from the surface, or, alternatively, providing an insulating layer between the flame and the object. However, the heat decreases secured by these prior methods have been relatively small, and, consequently, the usual practice is to omit all coatings, the difficulty and expense of applying the coatings counteracting any gains secured in heat reduction.

Generally stated, the present invention involves the use of a type of coating which inhibits recombination of flame-generated free radicals on the surfaces to be protected, thereby reducing the temperature at these surfaces. Since this reaction of recombination occurs in contact with the metal surfaces and the heat of recombination is produced in a very thin layer (approximately one atom thick) this phenomenon is particularly effective in increasing the temperature of these surfaces. Elimination of this surface reaction has proven most effective.

The primary object of the invention, therefore, is to provide means for obtaining heat reduction at flame swept surfaces. An additional object is to provide a temperature reducing coating which has firm adherence to the base article with resistance to mechanical and chemical disintegrating agents. An object, also, is to provide simple means for applying the coating to the surfaces to be protected. Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description.

It is common knowledge that any gas or vapor which contains molecules of more than one atom will, when heated to a sufficiently high temperature, contain fragments formed by the thermal decomposition of such molecules and commonly called free radicals. Some of these fragments may consist of only one atom. These fragments, depending on practical factors such as temperature, flow rate of fuel and oxidant and shape of combustion chamber, may consist of unburned fuel and oxidant, partially burned fuel and oxidant or completely burned fuel and oxidant; and with a substantial amount of unburned or partially burned fuel and oxidant present, there is a continuous recombination of radicals taking place with continuous liberation of heat. Unfortunately this reaction of recombination proceeds most readily on

2

the surfaces of turbine blades and other engine parts exposed to the flames producing the flame-generated free radicals since these parts are most usually composed of alloys of the so-called transition metals, which are particularly good catalysts. For this reason, these surfaces are particularly bad with respect to increase of surface temperature from the surface recombination of flame-generated free radicals.

In order to reduce temperatures at the exposed surfaces, it is proposed to apply a coating thereto which contains chemical substances acting to prevent recombination of the free radicals found in flames. The presence of the coating, therefore, prevents the heat of such recombination from developing on the coated surface and, thereby, the surface and internal temperatures of the coated object are lowered beyond the point resulting when the surfaces are unprotected. In this way the recombination is removed from the coated surfaces and is allowed to take place at some point downstream where the heat of recombination is easier to cope with.

Substances found most effective in coatings for inhibiting radical recombination include the phosphates, chlorides, fluorides, sulfides, borates, tungstates, and certain oxides. As an example of one method of forming a coating, a specimen metal, which must contain at least about 3 percent by weight of iron, is immersed as an anode in water diluted ortho-phosphoric acid (O—H_3PO_4 85%), adjusted to a pH of 1.5 to 2.2, and anodized. After removal, the coating is heated in a gas flame (Bunsen burners) until dry. The cell voltage used is around 45, the current about 70 milliamperes (ma.) the current density per unit area of sample 18 ma./in.^{2}, and the time of electrolysis 10–15 minutes. The drying step, which takes place at temperatures usually in excess of 1200° C., produces a reaction between the acid and metal to form a tightly adhering metal layer which appears to be a metal phosphate. The thickness of the layer formed ranges from 0.025 to 1.2 mils.

Alternatively, the metal to be coated may be dipped directly into the phosphoric acid (a liquid at 42.35° C.) for 10 to 15 minutes and then heated in a gas flame until dry, as in the first described example.

For cold rolled steel the same procedure is followed producing a coating composition of phosphates of iron and manganese. For S816 alloy, phosphates of iron and oxides of chromium and nickel are produced. S816 alloy is composed of carbon 0.4%, chromium 20.0%, nickel 20.0%, cobalt 43.7%, molybdenum 4.0%, tungsten 4.0%, columbian 4.0% and iron 2.8%.

Using the above described coating substances, a coating is secured which not only inhibits recombination of free radicals on the metal surface to be protected but also possesses desirable mechanical resistance to hot gases, has adequate adherence to the substrate metal which is substantially permanent, and resists decomposition, flaking and other modes of deterioration while in use, over long intervals of time.

To determine the inhibiting properties of the coating, two similar samples are prepared, one coated and the other uncoated. Both samples are bored axially to permit installation of appropriate thermocouples and then placed symmetrically in a gas flame, the temperature differences being continuously recorded. A temperature difference of between 100 to 200° F. is usually indicated, at approximately 2100° F. As a specific example, an uncoated specimen of high temperature alloy (S–816) used in the construction of aircraft engines registered a surface temperature under test of 2200° F., whereas a coated specimen heated under similar conditions showed a temperature of 2050° F.

It is pointed out that because of the extreme thinness of the coatings the performance of machine parts, such as turbine blades, is not disadvantageously affected. Also, the use of the coating in special equipment subject to extremely high temperatures, such as aircraft engine parts, is particularly important since these parts are vulnerable to small temperature increases at peak values.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claim the invention may be practiced otherwise than as specifically described.

What is claimed is:

A process of making a temperature reducing coating for high temperature metal alloys containing at least about 3 percent of iron which comprises connecting said alloy as an anode in an aqueous solution of phosphoric

acid having a pH of about 2.2, subjecting said anode to current flow at a density of about 18 milliamperes per square inch for about 10 minutes, and removing and drying said alloy at a temperature in excess of 1200° C.

References Cited in the file of this patent

UNITED STATES PATENTS

870,937	Coslett	Nov. 12, 1907
1,610,362	Coslett	Dec. 14, 1926
2,132,439	Romig	Oct. 11, 1938
2,501,846	Gifford	Mar. 28, 1950
2,554,250	Horstman et al.	May 22, 1951
2,748,037	Burnham	May 29, 1956
2,790,739	Frederick et al.	Apr. 30, 1957