(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 375 931 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
10.01.1996 Bulletin 1996/02

(51) Int Cl.[6]: **C23C 4/12**, B05B 7/20, C23C 4/04

(21) Application number: **89121559.2**

(22) Date of filing: **21.11.1989**

(54) High velocity powder thermal spray method for spraying non-meltable materials

Verfahren zum thermischen Aufspritzen von nicht schmelzbaren Materialien mit hoher Geschwindigkeit

Procédé de pulvérisation de matériaux non fusibles par projection à grande vitesse des particules

(84) Designated Contracting States:
CH DE FR GB IT LI

(30) Priority: **28.12.1988 US 290928**

(43) Date of publication of application:
04.07.1990 Bulletin 1990/27

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- **PATENT ABSTRACTS OF JAPAN, vol. 8, no. 156 (C-234)[1593], 19th July 1984; & JP-A-59 59 873 (NIHON SANSO) 05-04-1984**
- **PATENT ABSTRACTS OF JAPAN, vol. 12, no. 391 (C-537)[3238], 18th October 1988; & JP-A-63 137 154 (TOYOTA MOTOR CORP.) 09-06-1988**

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Description

This invention relates to a method for producing a coating with a thermal spray gun, according to the preamble of claim 1

BACKGROUND OF THE INVENTION

. Thermal spraying, also known as flame spraying, involves the melting or at least heat softening of a heat fusible material such as metal or ceramic, and propelling the softened material in particulate form against a surface which is to be coated. The heated particles strike the surface where they are quenched and bonded thereto. A thermal spray gun is used for the purpose of both heating and propelling the particles. In one type of thermal spray gun, the heat fusible material is supplied to the gun in powder form. Such powders are typically comprised of small particles, e.g., between 100 mesh U. S. Standard screen size (149 microns) and about 2 microns. Heat for powder spraying is generally from a combustion flame or an arc-generated plasma flame. The carrier gas, which entrains and transports the powder, may be one of the combustion gases or an inert gas such as nitrogen, or it may simply be compressed air. Quality coatings of certain thermal spray materials have been produced by spraying at high velocity. Plasma spraying has proven successful with high velocity in many respects but it can suffer from non-uniform heating and/or poor particle entrainment which must be effected by feeding powder laterally into the high velocity plasma stream. U.S. Patent No.s 2,714,563 and 2,964,420 (both Poorman et al) disclose a detonation gun for blasting powdered material in a series of detonations to produce coatings such as metal bonded carbides. High density and tenacity of coatings are achieved by high impact of the powder particles, and the short dwell time in the heating zone minimizes oxidation at the high spray temperatures.

A rocket type of powder spray gun can produce excellent coatings of metals and metal bonded carbides, particularly tungsten carbide, and is typified in U.S. Patent Nos. 3,741,792 (Peck et al.) and 4,416,421 (Browning). This type of gun has an internal combustion chamber with a high pressure combustion effluent directed through a nozzle chamber. Powder is fed laterally into the flame or into the nozzle chamber to be heated and propelled by the combustion effluent.

Short-nozzle spray devices are disclosed for high velocity spraying in French Patent No. 1,041,056 and U.S. Patent No. 2,317,173 (Bleakley). Powder is fed axially into a melting chamber within an annular flow of combustion gas. An annular air flow is injected coaxially outside of the combustion gas flow, along the wall of the chamber. The spray stream with the heated powder issues from the open end of the combustion chamber.

Since thermal spraying involves melting or at least surface heat softening the spray material, non-meltable powders such as certain carbides and nitrides cannot be sprayed into successful coatings without incorporating a binder into the material. For example, powders may be formed by cladding a metal onto a core of non-meltable material as disclosed in U.S. Patent No. 3,254,970 (Dittrich et al.) or vice versa as disclosed in U.S. Patent No. 3,655,425 (Longo and Patel). However, such compositioning has not been fully sufficient for producing high quality coatings and optimum deposit efficiency with conventional thermal spray guns, vis. plasma or low velocity combustion.

According to GB 742387, a method of applying a coating of a high melting point material to a workpiece had become known according to which the coating material employed consists alternatively of comminuted molybdenum, tungsten, cobalt-chromium-tungsten alloy, nickel-molybdenum alloy, boron carbide, a tungsten carbide composition, a mixture of a soft metal powder with a powdered hard material, or a mixutre of iron, chromium and nickel powder.

The French 1148292 also disclosed a thermal spray method in which a powder is fed with high velocity and an increased temperature towards a substrate in order to cover the surface of the said substrate with different metals, alloys, metallic composites, plastic materials, ceramics and minerals.

Thermoplastic polymer powders such as polyethylene melt easily and many can readily be thermal sprayed. However, thermoset polymer powders generally do not melt, at least without first decomposing and/or oxidizing at the high thermal spraying temperature. Certain of these thermoset powders, as disclosed in U.S. Patent No. 3,723,165 (Longo and Durman) (assigned to the predecessor in interest of the present assignee) may undergo a superficial chemical or physical modification of the polymer surface of each particle so as to become surface heat softenable. An example is the poly (paraoxybenzoyl) ester powder described in U.S. Patent No. 3,784,405 (Economy et al). As further explained in Example 1 of the aforementioned U.S. Patent No. 3,723,165 such polyester may be utilized in a blend with aluminum alloy powder. Plasma spraying such a blend has been highly successful for producing abradable coatings for gas turbine engine seals and the like. However, the basic unmeltability of the polymer still results in poor deposit efficiency, so that even with the high heat available from a plasma gun, a significant portion of the polymer constituent is lost. Since this polymer is quite expensive, there is a need to improve the thermal spraying of the polymer-aluminum blend. There also has been an on-going need for improvements in abradability and erosion resistance of the coatings.

Therefore, objects of the present invention are to provide an improved method for thermal spraying non-meltable materials, to provide a method for high velocity thermal spraying particles having a non-meltable component and a heat softenable component, to provide an improved method of including non-meltable particles in thermal sprayed coatings at reasonable cost, and to provide a method for producing improved coatings of certain thermoset plastics. These objects are achieved by the features as described in claim 1.

Preferably, the polymer grains comprise poly (paraoxybenzoyl)ester. According to a further embodiment, the polymer grains consists essentially of a copolyester of poly(paraoxybenzoyl)ester. The powder further also may comprise aluminum metalic component or aluminum base alloy powder.

Where the powder comprises particles having heat stable non-meltable cores and heat softenable surfaces, the said particles comprise metallic particles.

In a preferred method, the thermal spray gun includes a nozzle member with a nozzle face and a tubular gas cap extending from the nozzle member and having an inwardly facing cylindrical wall defining a combustion chamber with an open end and an opposite end bounded by the nozzle face. This method comprises injecting an annular flow of combustible mixture of a combustion gas and oxygen from the nozzle coaxially into the combustion chamber, injecting an annular outer flow of pressurized non-combustible gas adjacent to the cylindrical wall radially outward of the annular flow of the combustible mixture, feeding a powder in a carrier gas axially from the nozzle into the combustion chamber and injecting an annular inner flow of pressurized gas from the nozzle member into the combustion chamber coaxially between the combustible mixture.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevation of a thermal spray gun used in the present invention.

FIG. 2 is a section taken at 2-2 of FIG. 1.

FIG. 3 is an enlargement of the forward end of the section of FIG. 2.

FIG. 4 is a section taken at 4-4 of FIG. 1, and a schematic of an associated powder feeding system.

FIG. 5 is a schematic view of the gun of FIG. 1 producing a supersonic spray stream according to the present invention.

FIG. 6 is the view of FIG. 5 with a substrate in place.

DETAILED DESCRIPTION OF THE INVENTION

An example of a preferred thermal spray apparatus for effecting the present invention is disclosed in the not prepublished EP 0 341 672 of the applicant. The apparatus is illustrated in FIG. 1, and FIG. 2 shows a horizontal section thereof. A thermal spray gun **10** has a gas head **12** with a tubular member in the form of a gas cap **14** mounted thereon, a valve portion **16** for supplying fuel, oxygen and air to the gas head, and a handle **17**. The valve portion **16** has a hose connection **18** for a fuel gas, a hose connection **19** for oxygen and a hose connection **20** for air. The three connections are connected respectively by hoses from a fuel source **21**, oxygen source **22** and air source **24**. Orifices **25** in a cylindrical valve **26** control the flow of the respective gases from their connections into the gun. The valve and associated components are, for example, of the type taught in U.S. Patent No. 3,530,892, and include a pair of valve levers **27**, and sealing means for each gas flow section that include plungers **28**, springs **29** and O-rings **30**.

A cylindrical siphon plug **31** is fitted in a corresponding bore in gas head **12**, and a plurality of O-rings **32** thereon maintain a gas-tight seal. The siphon plug is provided with a tube **33** having a central passage **34**. The siphon plug further has therein an annular groove **35** and a further annular groove **36** with a plurality of inter-connecting passages **38** (two shown). With cylinder valve **26** in the open position as shown in FIG. 2, oxygen is passed by means of a hose **40** through its connection **19** and valve **26** into a passage **42** from whence it flows into groove **35** and through passage **38**. A similar arrangement is provided to pass fuel gas from source **21** and a hose **46** through connection **18**, valve **26** and a passage **48** into groove **36**, mix with the oxygen, and pass as a combustible mixture through passages **50** aligned with passages **38** into an annular groove **52**. Annular groove **52** feeds the mixture into a plurality of passages **53** in the rear section of a nozzle member **54**.

Referring to FIG. 3 for details, nozzle member **54** is conveniently constructed of a tubular inner portion **55** and a tubular outer portion **56**. (As used herein and in the claims, "inner" denotes toward the axis and "outer" denotes away from the axis. Also "forward" or "forwardly" denotes toward the open end of the gun; "rear", "rearward" or "rearwardly" denotes the opposite.) Outer portion **56** defines an outer annular orifice means for injecting the annular flow of the combustible mixture into the combustion chamber. The orifice means preferably includes a forward annular opening **57** with a radially inward side bounded by an outer wall **58** of the inner portion. The orifice system leading to the annular opening from passages **53** may be a plurality of arcuately spaced orifices, but preferably is an annular orifice **59**.

The combustible mixture flowing from the aligned grooves **52** thus passes through the orifice (or orifices) **59** to produce an annular flow which is ignited in annular opening **57**. A nozzle nut **60** holds nozzle **54** and siphon plug **28** on gas head **12**. Two further O-rings **61** are seated conventionally between nozzle **54** and siphon plug **31** for gas tight seals. The burner nozzle **54** extends into gas cap **14** which is held in place by means of a retainer ring **64** and extends forwardly from the nozzle.

Nozzle member **54** is also provided with an axial bore **62**, for the powder in a carrier gas, extending forwardly from tube passage **33**. Alternatively the powder may be injected through a small-diameter ring of orifices (not shown) proximate the axis **63** of the gun. With reference to FIG. **4** a diagonal passage **64** extends rearwardly from tube **33** to a powder connection **65**. A carrier hose **66** and, therefore, central bore **62**, is receptive of powder from a powder feeder **67** entrained in a carrier gas from a pressurized gas source **68** such as compressed air by way of feed hose **66**. Powder feeder **67** is of the conventional or desired type but must be capable of delivering the carrier gas at high enough pressure to provide powder into the chamber **82** in gun **10**.

With reference back to FIGS. 2 and 3, air or other non-combustible gas is passed from source **24** and a hose **69** through its connection **20**, cylinder valve **26**, and a passage **70** to a space **71** in the interior of retainer ring **64**. Lateral openings **72** in nozzle nut **60** communicate space **71** with a cylindrical combustion chamber **82** in gas cap **14** so that the air may flow as an outer sheath from space **71** through these lateral openings **72**, thence through an annular slot **84** between the outer surface of nozzle **54**, and an inwardly facing cylindrical wall **86** defining combustion chamber **82** into which slot **84** exits. The flow continues through chamber **82** as an annular outer flow mixing with the inner flows, and out of the open end **88** in gas cap **14**. Chamber **82** is bounded at its opposite, rearward end by face **89** of nozzle **54**.

Preferably combustion chamber **82** converges forwardly from the nozzle at an angle with the axis, most preferably between about 2° and 10°, e.g. 5°. Slot **84** also converges forwardly at an angle with the axis, most preferably between about 12° and 16°, e.g. 14.5°. Slot **84** further should have sufficient length for the annular air flow to develop, e.g. comparable to chamber length **102**, but at least greater than half of such length **102**. In addition, the chamber should converge at a lesser angle than the slot, most preferably between about 8° and 12°, e.g. 10° less. This configuration provides a converging air flow with respect to the chamber to minimize powder buildup on the chamber wall.

The air flow rate should be controlled upstream of slot **84** such as in a rearward narrow orifice **92** or with a separate flow regulator. For example slot length is 8 mm, slot width is 0.38 mm on a 15 mm circle, and air pressure to the gun (source **24**) is 4.9 kg/cm^2 (70 psi) to produce a total air flow of 425 std 1/min (900 scfh) with a pressure of 4.2 kg/cm^2 (60 psi) in chamber **82**. Also, with valve **26** in a lighting position aligning bleeder holes as described in aforementioned U.S. Patent No. 3,530,892, an air hole **90** in valve **26** allows air flow for lighting, and the above-indicated angles and dimensions are important to allow such lighting without backfire. (Bleeder holes in valve **26** for oxygen and fuel for lighting, similar to air hole **90**, are not shown.)

The inner portion **55** of nozzle member **54** has therein a plurality of parallel inner orifices **91** (e.g. 8 orifices 0.89 mm diameter) on a bolt circle (e.g. 2.57 mm diameter) which provide for an annular inner sheath flow of gas, preferably air, about the central powder feed issuing from bore **62** of the nozzle. This inner sheath of air contributes significantly to reducing any tendency of buildup of powder material on wall **86**. The sheath air is conveniently tapped from passage **70**, via a duct **93** (FIG. 2) to an annular groove **94** around the rear portion of siphon plug **31** and at least one orifice **96** into an annular space **98** adjacent tube **33**. Preferably at least three such orifices **96** are equally spaced arcuately to provide sufficient air and to minimize vortex flow which could detrimentally swirl the powder outwardly to wall **86** of chamber **82**. The inner sheath air flow should be between 1% and 10%, preferably about 2% and 5% of the outer sheath flow rate, for example about 3%. The inner sheath may alternatively be regulated independently of the outer sheath air, for better control.

Chances of powder buildup are further minimized by having the inner portion **55** of the nozzle member protrude into chamber **82** forwardly of the outer portion **56** as depicted in FIGS. 2 and 3. A chamber length **102** may be defined as the shortest distance from nozzle face **89** to open end **88**, i.e. from the forwardmost point on the nozzle to the open end. The forwardmost point on the inner portion should protrude forwardly from the outer portion **56** by a distance between about 10% and 40% of chamber length **102**, e.g. 30%.

A preferred configuration for the inner portion is depicted in FIGS. 2 and 3. Referring to the outer wall **58** of inner portion **55** of the nozzle, which defines annular opening **57**, such wall **58** should extend forwardly from the annular opening with a curvature inward toward the axis. The curvature should be uniform. For example, as shown, the curvature is such as to define a generally hemispherical face **89** on inner portion **58**. It is believed that the combustion flame is thereby drawn inwardly to maintain the flows away from chamber wall **86**.

As an example of further details of a thermal spray gun incorporating the present invention, siphon plug **31** has 8 oxygen passages **38** of 1.51 mm each to allow sufficient oxygen flow, and 1.51 mm diameter passages **50** for the gas mixture. In this gas head central bore **62** is 3.6 mm diameter, and the open end **88** of the gas cap is 0.95 cm from the face of the nozzle (length **102**). Thus the combustion chamber **82** that also entrains the powder is relatively short, and generally should be between about one and two times the diameter of open end **88**.

A supply of each of the gases to the cylindrical combustion chamber is provided at a sufficiently high pressure, e.g. at least 2,11 kg/cm^2 (30 psi) above atmospheric, and is ignited conventionally such as with a spark device, such that the mixture of combusted gases and air will issue from the open end as a supersonic flow entraining the powder. The heat of the combustion will at least heat soften the powder material such as to deposit a coating onto a substrate. Shock diamonds should be observable. Because of the annular flow configuration, an expansion type of nozzle exit is not necessary to achieve the supersonic flow.

The combustion gas may be propane or hydrogen or the like, but it is preferable that the combustion gas be propylene gas, or methylacetylene-propadiene gas ("MPS"). These latter gases allow a relatively high velocity spray stream and excellent coatings to be achieved without backfire. For example with a propylene or MPS pressure of about 7 kg/cm^2 gauge (above atmospheric pressure) to the gun, oxygen at 10 kg/cm^2 and air at 5.6 kg/cm^2 at least 8 shock diamonds are readily visible in the spray stream without powder flow. The appearance of these shock diamonds **108** in spray stream **110** is illustrated in FIG. 5. The position of the substrate **112** on which a coating **114** is sprayed is preferably about where the fifth full diamond would be as shown in FIG.6, e.g. about 9 cm spray distance.

According to the method of the present invention certain powders are thermal sprayed with supersonic combustion spray guns. Although the preferred apparatus is as described above, the method may alternatively utilize other supersonic guns such as described in the aforementioned U.S. Patent No. 4,416,421. The certain powders are those that contain a heat-stable, non-meltable component in each powder grain. As used herein and in the claims the term "heat-stable" means that the referenced component will not substantially decompose or oxidize under the temperature and time conditions of the flame of the thermal spray gun; similarly the term "non-meltable" means that the referenced component will not substantially melt in the flame. As a test, the non-meltable component may be fed through a thermal spray gun to be used for the spraying thereof, collected and inspected microscopically and/or metallographically for decomposing, oxidizing or melting. For example, normal flattening of the particles on a substrate will indicate melting. Thus material that merely softens viscously, without a specific melting point to allow flattening on a substrate, is non-meltable for the purpose of this invention. Published handbooks on melting points are alternate sources of meltability information.

The group of heat-stable non-metallic materials contemplated for the method herein consists of thermoset polymers. Thermoset is used broadly herein and in the claims to conventionally cover hydrocarbons (plastics) polymerized by heat, catalyst or reaction whereby the polymer is not ordinarily softenable by heating, for example without some chemical modification by the flame. The poly (paraoxybenzoyl) ester and copolyesters thereof of the aforementioned U.S. Patent Nos. 3,723,165 and 3,784,405 fall in this group, as may others such as certain epoxies and polyimides including those that may be in the form of an incompletely polymerized powder. A feature of these selected polymers is that only a surface portion is heat softened in the flame. This surface softening maybe is effected by chemical modification during the short exposure to the hot flame, changing a surface layer from thermoset to at least partially thermoplastic. Thus, for the purpose of the presently claimed invention, the surface layer is effectively a heat-softenable component and the core remains a heat-stable non-meltable component, even though the initial particle may be homogeneous. Alternatively a non-meltable thermoset polymer may be clad or otherwise composited with a meltable polymer such as polyamide, polyethylene or incompletely polymerized polyester or epoxy, or a copolyester of the type disclosed in aforementioned U.S. Patent No. 3,784,405. Characteristic powder according to the invention may be sprayed neat or blended with a more conventional thermal spray material such as a metal. Quite surprisingly, the method of supersonic combustion thermal spraying of the above-described powders is effected with relatively high deposit efficiency, and produces dense, high quality coatings. The high deposit efficiency is especially surprising because the short dwell time of particles in the supersonic flame would be expected to cause lesser deposit efficiency, especially with non-meltable components. The improved deposit efficiency provides not only a cost benefit per se but allows cost-favorable modification of blends to achieve a specified coating composition.

A preferred example is a blend of heat-stable polyester and aluminum alloy, as detailed in Example 1 below. Conventional plasma spraying, despite high heat, loses a considerable portion of the polyester relative to the alloy. Conventional, low-velocity combustion spraying chars the polyester or, with lesser heat, results in poorly cohesive deposits. Spraying with a supersonic combustion flame provides high deposit efficiency which allows a lesser proportion of polyester to be in the initial blend to obtain the originally specified proportions in the coating, and provides excellent coatings.

EXAMPLE 1

A blend of polyester plastic and aluminum alloy similar to the blend is prepared as described under Example 1-A of aforementioned U.S. Patent No. 3,723,165, except the plastic powder is 30% and the alloy is 70% by weight of the blend. The plastic is a high temperature aromatic poly (paraoxybenzoyl) ester sold under the trade name of EKONOL (TM) by the Metaullics Division of the Carboundary Company, Sanborn, N.Y. and has a size of -88 +44 microns, and the alloy is aluminum 12% silicon with a size of -44 +10 microns.

The blend is sprayed with the preferred apparatus described above with respect to FIGS. 1-3, specifically a Metco Type DJ (TM) Metaullics Division of the Carboundary Compass, Sanford, N.Y. Gun sold by The Perkin-Elmer Corporation, Westbury, New York, using a No 3 insert, No 3 injector, a size "A" shell, No 2 siphon plug and No 2 air cap. Oxygen was 10.5 kg/cm^2 (150 psig) and 212 l/min (450 scfh), propylene gas at 7.0 kg/cm^2 (100 psig) and 47 l/min (100 scfh), and air at 5.3 kg/cm^2 (75 psig) and 290 l/min (615 scfh). A high pressure powder feeder of the type disclosed in the present US-A-4 900 199 and sold as a Metco Type DJP powder feeder by Perkin-Elmer is used to feed the powder blend at 23 gm/min (3 lb/hr) in a nitrogen carrier at 8.8 kg/cm^2 (125 psig) and 7 l/min (15 scfh). Spray distance is 20 cm and the substrate is grit blasted nickel alloy.

Comparisons were made with the 40% powder and spraying thereof of Example 1-A of the '165 patent, the 40% powder being sold as Metco 601NS by Perkin-Elmer and containing 40% plastic powder, i.e. 1/3 more than the present 30% powder. The Example 1-A 40% powder was plasma sprayed conventionally with argon-hydrogen plasma gas. The 30% powder blend sprayed with the supersonic combustion gun yielded a deposit efficiency of 85%, vs typical 65% deposit efficiency for the 40% powder plasma sprayed. Of more importance is the fact that the coatings were of essentially the same composition as each other, reflecting the better deposit efficiency of the plastic constituent of the 30% powder with the supersonic combustion gun. Abradability and erosion resistance of the coatings were also essentially the same. -Porosity for the high velocity coating was about 1% and uniformly dispersed, vs 5% non-uniform porosity for plasma sprayed 40% powder. Hardness for the high velocity coating was R15y 78 to 83, vs 65 to 75, i.e., again more uniform.

EXAMPLE 2

Example 1 is repeated except that the polyester is replaced with a copolyester of recurring units of Formula I, III, and IV as disclosed in the aforementioned U.S. Patent No. 3,784,405 (incorporated herein by reference) and sold as Xydar(TM) by Dartco Manufacturing Inc., Augusta Georgia. Similar results are effected.

Claims

1. A method for producing a coating with a thermal spray gun

   having a tubular member (14) defining a combustion chamber (82) therein with an open end for propelling combustion products into the ambient atmosphere at supersonic velocity, the method comprising injecting into the chamber a combustible mixture of combustion gas and oxygen, feeding into the chamber a powder,

   combusting the combustible mixture in the chamber whereby a supersonic spray stream containing the powder is propelled through the open end, and directing the spray stream toward a substrate such as to produce a coating thereon,

   characterised in that

   the combustion gas and oxygen is injected at a pressure in the chamber of at least two atmospheres above ambient atmospheric pressure,

   the powder comprises particles having a heat-stable non-meltable polymer component and a metallic component,

   wherein the polymer comprises thermoset polymer grains being surface heat softenable by the spray stream.

2. A method according to claim 1 wherein the combustible mixture is injected at a sufficient pressure into the combustion chamber (82) to produce at least 8 visible shock diamonds in the spray stream in the absence of powder-carrier gas feeding.

3. A method according to claim 1 or 2 further comprising selecting the combustion gas from the group consisting of propylene gas and methylacetylene-propadiene gas.

4. A method according to claim 1 wherein the polymer grains comprise poly(paraoxybenzoyl)ester.

5. A method according to claim 4 wherein the polymer grains consist essentially of poly(paraoxybenzoyl) ester.

6. A method according to claim 4 wherein the polymer grains consist essentially of a copolyester of poly (paraoxybenzoyl)ester.

7. A method according to one of the claims 1 to 4, wherein the powder comprises aluminum metallic component or aluminum base alloy powder.

8. A method according to one of the claims 1 to 4, wherein the thermal spray gun includes a nozzle member (54) with a nozzle face (89), the tubular member comprises a tubular gas cap (14) extending from the nozzle member and having an inwardly facing cylindrical wall defining the combustion chamber (82) having the open end (88) and an opposite end bounded by the nozzle face, the combustible mixture is injected from the nozzle as an annular flow coaxially into the combustion chamber, the powder is fed in a carrier gas axially from the nozzle into the combustion chamber, and the method further comprises injecting an annular outer flow of pressurized non-combustion gas adjacent to the cylindrical wall radially outward of the annular flow of the combustible mixture, and injecting an annular inner flow of pressurized gas from the nozzle member into the combustion chamber coaxially between the combustion mixture and the powder-carrier gas.

Patentansprüche

1. Ein Verfahren zum Erzeugen einer Beschichtung mit einer Flammspritzpistole

   die ein röhrenförmiges Teil (14), das eine Verbrennungskammer (82) darin mit einem offenen Ende zum Austreiben von Verbrennungsprodukten in die Umgebungsatmosphäre mit Überschallgeschwindigkeit bildet, aufweist, wobei das Verfahren die Einführung einer brennbaren Mischung aus brennbarem Gas und Sauerstoff in die Kammer, die Zuführung eines Pulvers in die Kammer,

die Verbrennung der verbrennbaren Mischung in der Kammer, wobei ein Überschallstrahl, der das Pulver enthält, durch das offene Ende ausgetrieben wird, und das Richten des Sprühstrahls in Richtung auf ein Substrat, um so eine Beschichtung darauf zu erzeugen, umfaßt,

dadurch gekennzeichnet, daß

das Verbrennungsgas und Sauerstoff bei einem Druck in der Kammer von wenigstens zwei Atmosphären oberhalb des Umgebungsatmosphärendrucks eingeführt wird,

das Pulver Partikel mit einer wärmestabilen, nicht schmelzbaren Polymerkomponente und einer Metallkomponente umfaßt,

wobei das Pulver thermostatplastische Polymerkörner umfaßt, welche durch den Sprühstrahl an der Oberfläche durch Wärme aufweichbar sind.

2. Ein Verfahren nach Anspruch 1, wobei die brennbare Mischung mit einem genügenden Druck in die Verbrennungskammer (82) eingeführt wird, um wenigstens acht sichtbare Schockdiamanten in dem Sprühstrahl bei abwesender Pulver-Trägergaszuführung zu erzeugen.

3. Ein Verfahren nach Anspruch 1 oder 2, welches ferner das Auswählen des Verbrennungsgases aus der aus Propylengas und Methylacetylen-Propadiengas bestehenden Gruppe umfaßt.

4. Ein Verfahren nach Anspruch 1, wobei die Polymerkörner Poly (poraoxybenzoyl)ester umfassen.

5. Ein Verfahren nach Anspruch 4, wobei die Polymerkörner im wesentlichen aus Poly(paraoxybenzoyl) ester bestehen.

6. Ein Verfahren nach Anspruch 4, wobei die Polymerkörner im wesentlichen aus einem Kopolyester von Poly(paraoxybenzoyl) ester bestehen.

7. Ein Verfahren nach einem der Ansprüche 1 bis 4, wobei das Pulver eine Aluminiummetallkomponente oder ein auf Aluminium basierendes Legierungspulver umfaßt.

8. Ein Verfahren nach einem der Ansprüche 1 bis 4, wobei die Flammspritzpistole ein Düsenteil (54) mit einer Düsenstirnfläche (89) enthält, das röhrenförmge Teil eine röhrenförmige Gaskappe (14) umfaßt, die sich von dem Düsenteil erstreckt und eine nach innen weisende zylindrische Wand aufweist, welche die Verbrennungskammer (82) mit einem offenen Ende (88) und einem durch die Düsenstirnfläche begrenzten gegenüberliegenden Ende bildet, wobei die brennbare Mischung von der Düse als eine ringförmige Strömung koaxial in die Verbrennungskammer eingeführt wird, das Pulver in einem Trägergas axial von der Düse in die Verbrennungskammer eingeführt wird, und das Verfahren ferner die Einführung einer ringförmigen äußeren Strömung von unter Druck stehendem, nicht brennbarem Gas angrenzend an die zylindrische Wand radial nach außen zu der ringförmigen Strömung der verbrennbaren Mischung und die Einführung einer ringförmigen inneren Strömung von unter Druck stehendem Gas von dem Düsenteil in die Verbrennungskammer koaxial zwischen der brennbaren Mischung und dem Pulver-Trägergas umfaßt.

Revendications

1. Procédé de production d'un revêtement avec un pistolet de pulvérisation à chaud

ayant un membre tubulaire (14) définissant dans celui-ci une chambre de combustion (82) comportant une extrémité ouverte pour projeter à vitesse supersonique des produits de combustion dans l'atmosphère ambiante, le procédé coomprenant l'injection dans la chambre d'un mélange combustible de gaz de combustion et d'oxygène, l'introduction dans la chambre d'une poudre,
la comobustion du mélange combustible dans la chambre, un jet de pulvérisation supersonique contenant la poudre étant ainsi propulsé à travers l'extrémité ouverte, et la direction du jet de pulvérisation vers un substrat de façon à produire un revêtement sur celui-ci,
caractérisé en ce que
le gaz de combustion et de l'oxygène sont injectés dans la chambre à une pression supérieure d'au moins deux atmosphères à la pression atmosphérique ambiante,
la poudre comprend des particules ayant un composant polymère non fusible thermostable et un composant métallique,
le polymère comprenant des grains polymères thermodurcis qui peuvent être ramollis par la chaleur en surface par le jet de pulvérisation.

2. Procédé selon la revendication 1, dans lequel le mélange combustible est injecté dans la chambre de combustion (82) à une pression suffisante pour produire au moins 8 losanges de choc visibles dans le jet de pulvérisation en l'absence d'injection de gaz porteur de poudre.

3. Procédé selon la revendication 1 ou 2, comprenant en outre la sélection du gaz de combustion dans le groupe composé du gaz propylène et du gaz méthylacétylène-propadiène.

4. Procédé selon la revendication 1, dans lequel les grains polymères comprennent un ester poly (paraoxybenzoyle).

5. Procédé selon la revendication 4, dans lequel les grains polymères sont essentiellement constitués d'ester poly(paraoxybenzoyle).

6. Procédé selon la revendication 4, dans lequel les grains polymères sont essentiellement constitués d'un copolyester d'ester poly(paraoxybenzoyle).

7. Procédé selon l'une quelconque des revendications 1 à4, dans lequel la poudre comprend un composant métallique d'aluminium ou une poudre d'alliage à base d'aluminium.

8. Procédé selon l'une des revendications 1 à 4, dans lequel le pistolet de pulvérisation à chaud comprend un membre formant tuyère (54) avec une face de tuyère (89), le membre tubulaire comprend un culot tubulaire (14) se prolongeant à partir du membre formant tuyère et ayant une paroi cylindrique tournée vers l'intérieur définissant la chambre de combustion (82) présentant l'extrémité ouverte (88) et une extrémité opposée délimitée par la face de tuyère, le mélange combustible est injecté coaxialement de la tuyère, sous forme de jet annulaire, dans la chambre de combustion, la poudre est injectée axialement, dans un gaz porteur, de la tuyère dans la chambre de combustion et le procédé comporte en outre l'injection d'un flux annulaire extérieur de gaz non combustible pressurisé, adjacent à la paroi cylindrique, radialement vers l'extérieur du flux annulaire du mélange combustible et l'injection d'un flux annulaire intérieur de gaz pressurisé du membre formant tuyère dans la chambre de combustion, coaxialement entre le mélange de combustion et le gaz porteur de poudre.

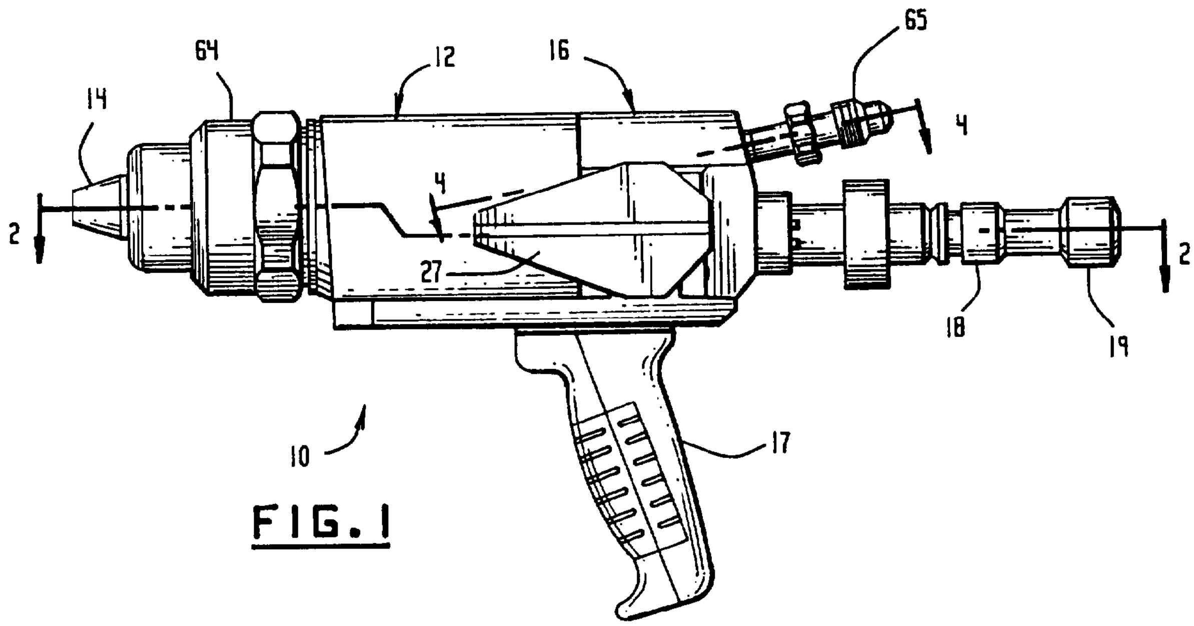
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FIG. 1

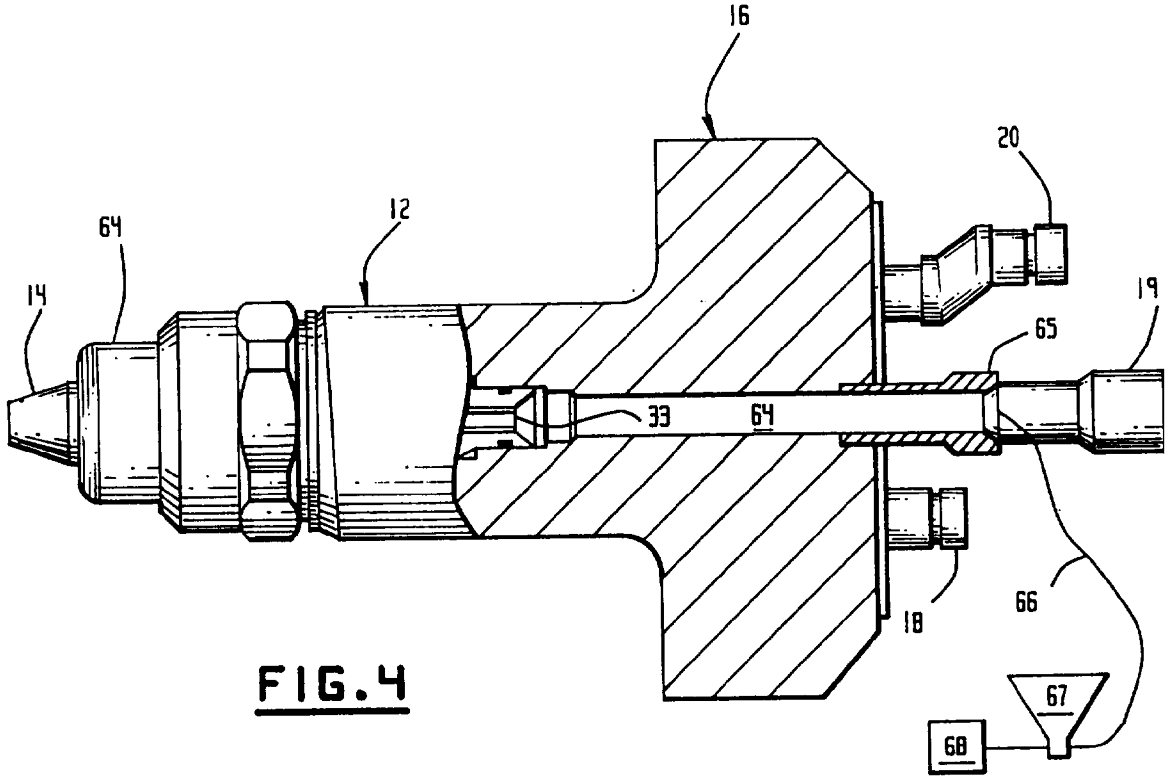
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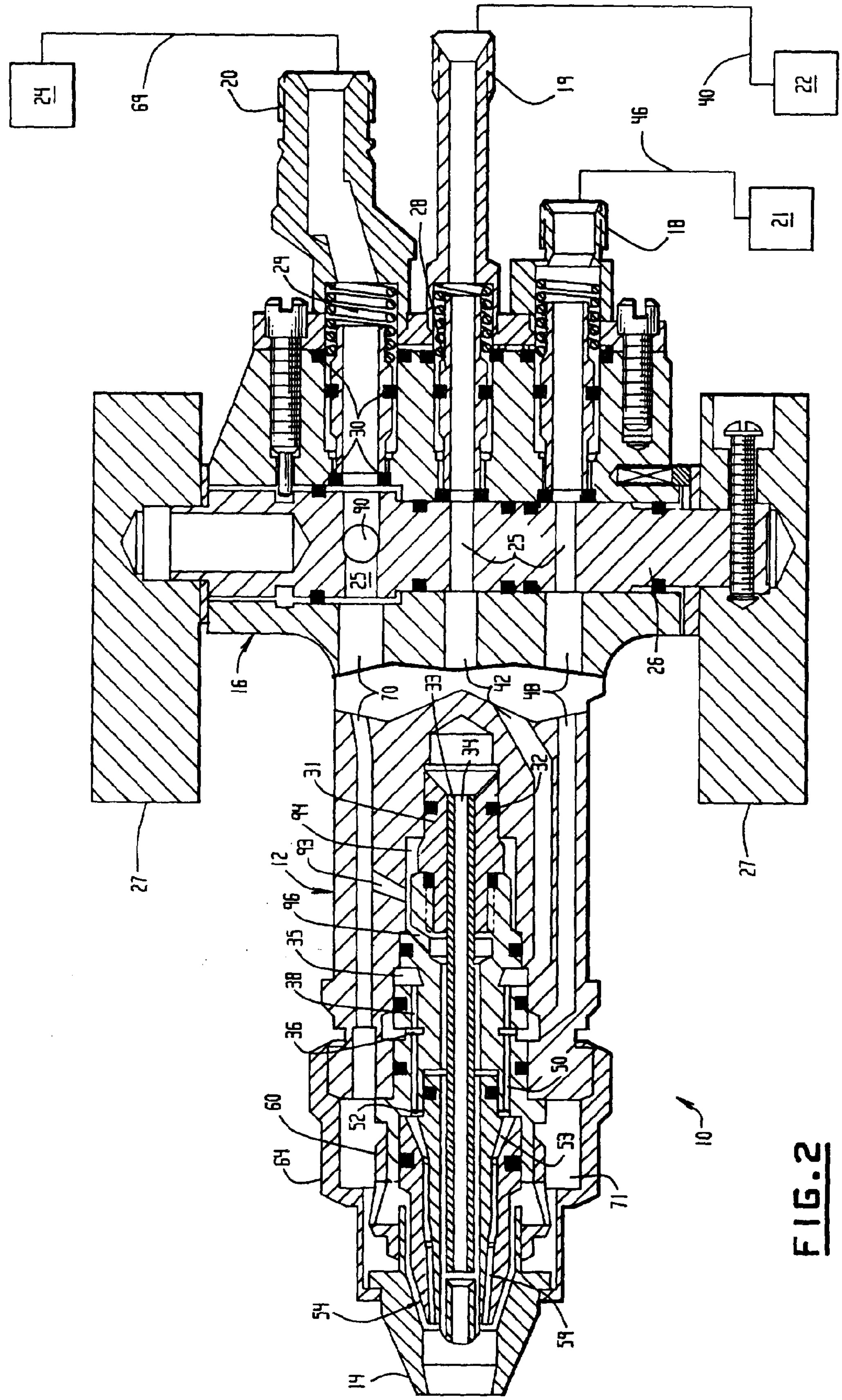
FIG. 4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14

FIG.2

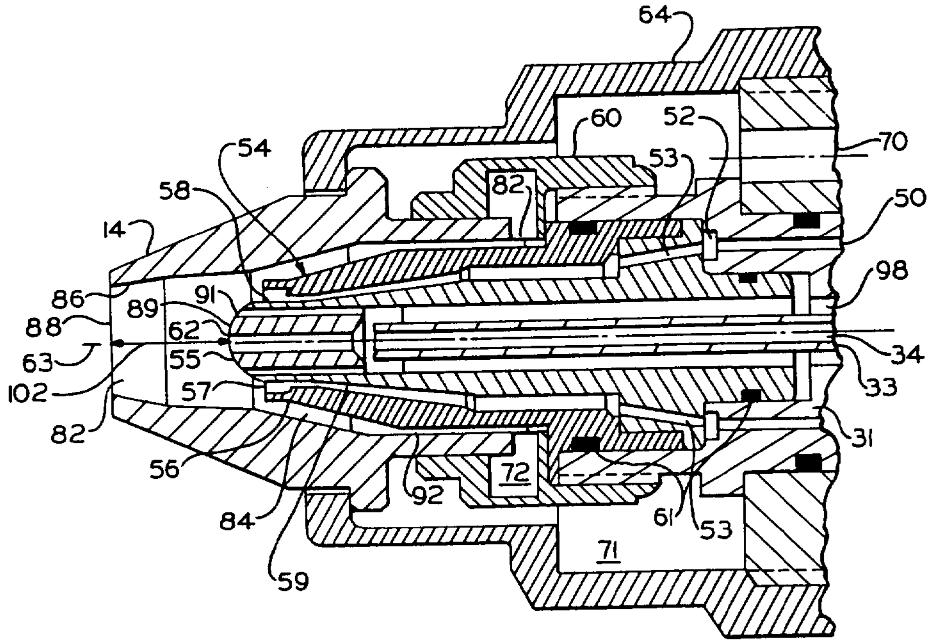

FIG.3

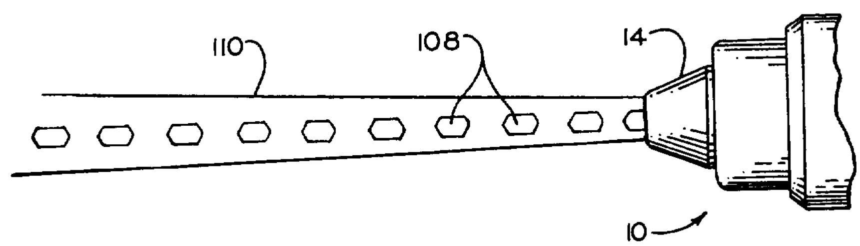

FIG.5

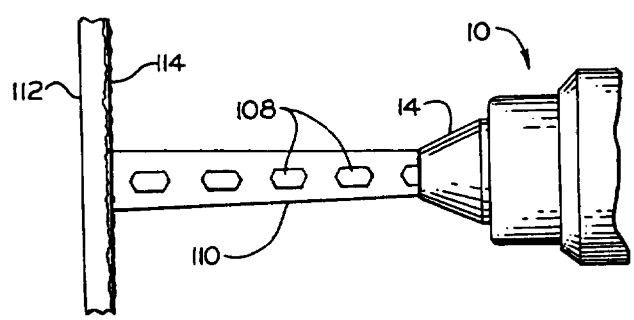

FIG.6