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[54] **VALVE TRAIN COMPONENTS HAVING AN OXIDATION AND CORROSION-RESISTANT THERMAL SPRAY COATING**

[75] Inventors: **Brad Beardsley**, Laura; **Christine K. Jones**, Peoria, both of Ill.; **Karen R. Raab**, Neuenhain, Germany

[73] Assignee: **Caterpillar Inc.**, Peoria, Ill.

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Primary Examiner—Harold J. Tudor
Attorney, Agent, or Firm—Husch & Eppenberger

[57] **ABSTRACT**

Today's engines are pushed to operate at higher temperatures, higher peak cylinder pressures, in more corrosive environments and with highly variable fuel types and qualities. A solution to guttering is an oxidation and corrosion-resistant coating with a general turn MCrAlY applied to the face of the engine valve train components by thermal spray coating.

20 Claims, 1 Drawing Sheet

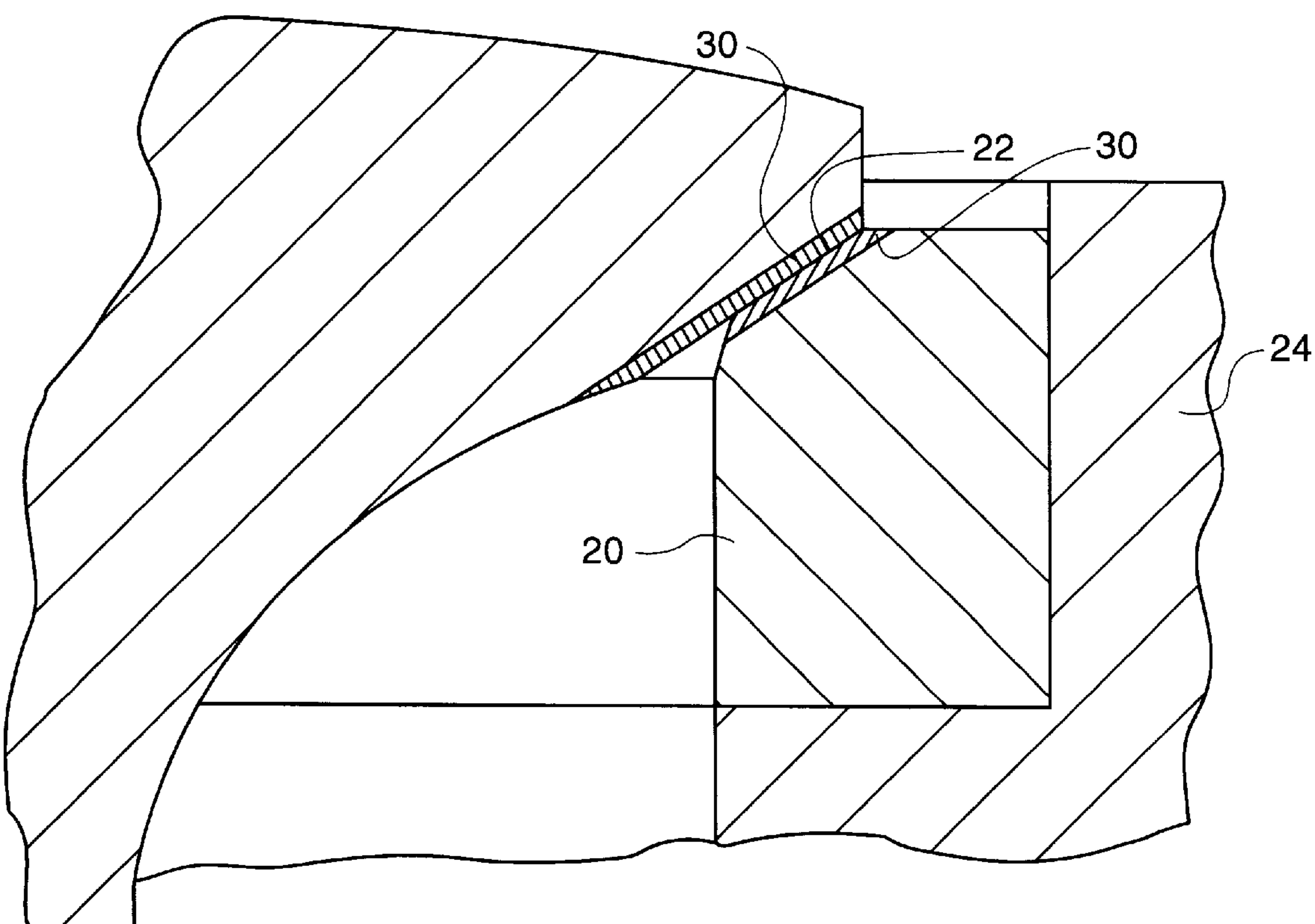


FIG. 1

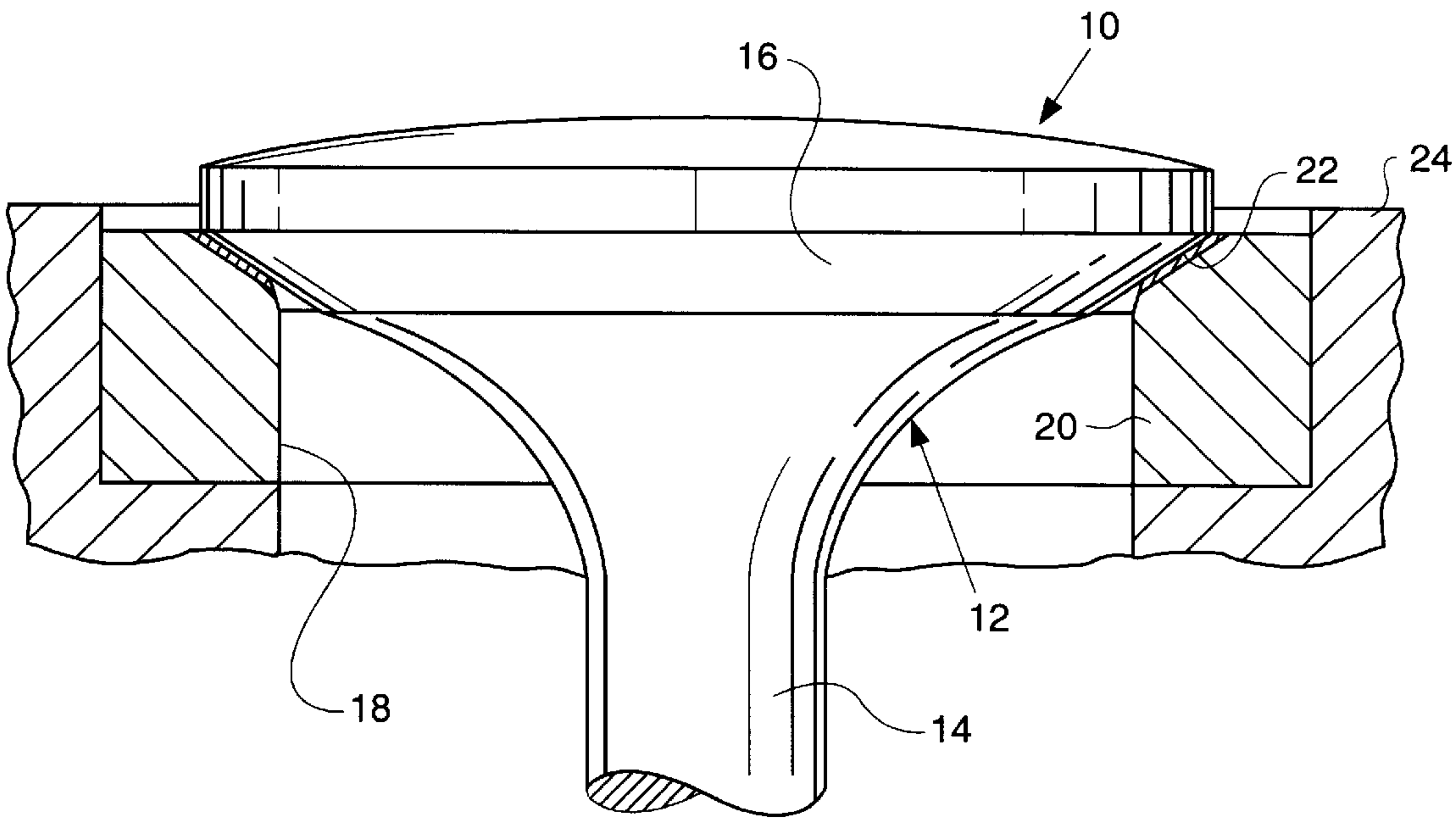
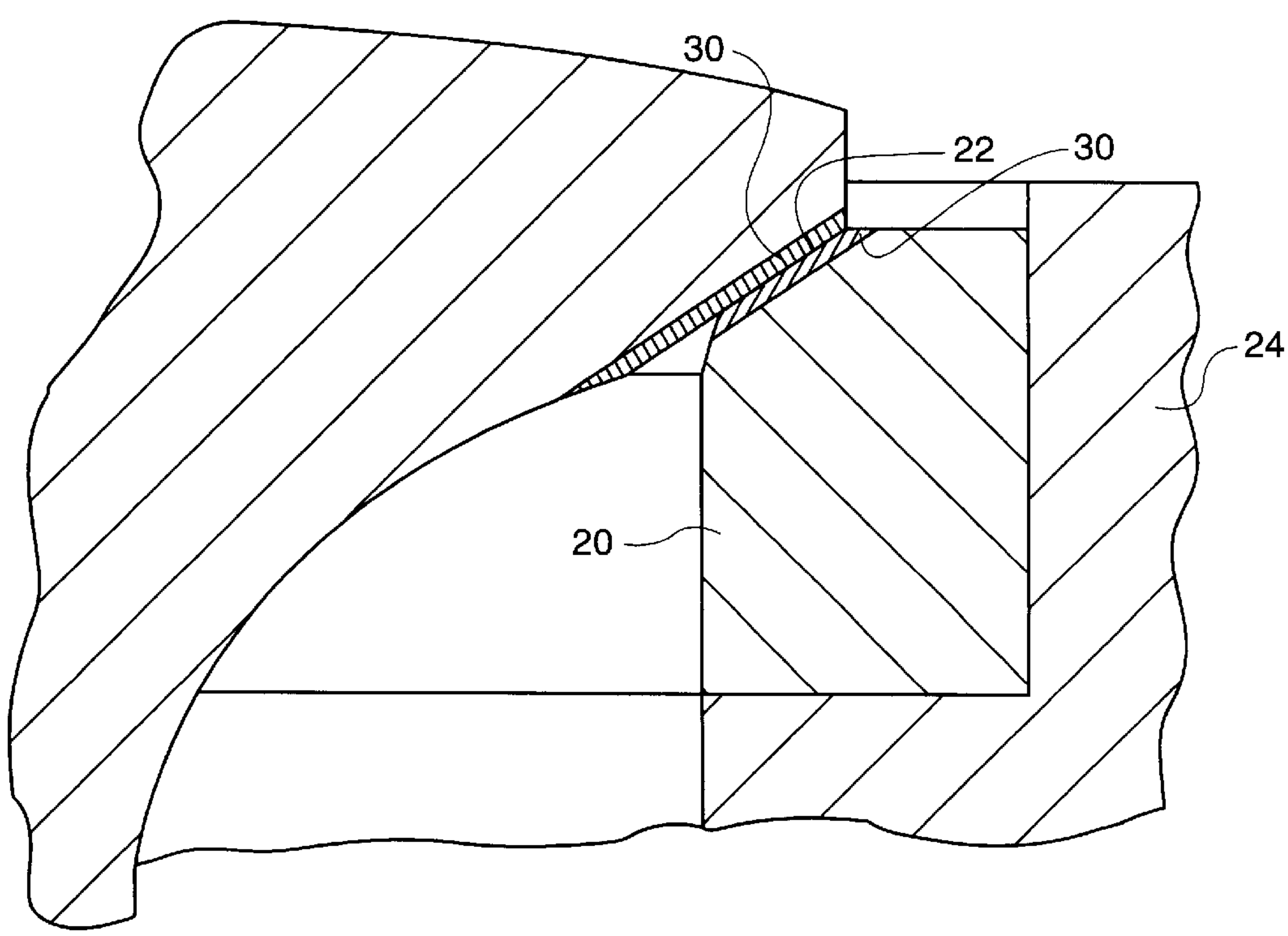


FIG. 2



VALVE TRAIN COMPONENTS HAVING AN OXIDATION AND CORROSION-RESISTANT THERMAL SPRAY COATING

TECHNICAL FIELD

This invention relates generally to the field of internal combustion engines, and more particularly to improved wear resistance of valve train components.

BACKGROUND ART

Engine exhaust valves control the intake of an air-fuel mixture and the discharge of spent gas in the combustion chamber. Each engine valve includes a valve head and a valve stem extending therefrom. The valve head is located within the combustion chamber. Cycles of tight engagement and separation are repeated between a valve seat insert snuggly fitted in a cylinder head and a contact face on the valve head. The engine valve is required to be resistant to heat, corrosion, and wear because it is exposed to elevated temperatures of 700° C. to 800° C. in a combustion chamber and subjected to repetitive collision against the valve seat insert. Furthermore, today's engines are pushed to operate at higher temperatures, higher peak cylinder pressures, more corrosive environments and highly variable fuel types and quality.

Observation of the failed valves has shown that failure appears to result from two separate and distinct modes: (i) corrosive attack that leads to guttering and (ii) radial cracking along the valve face. Guttering tends to predominate in engines burning diesel fuel; whereas radial cracking is generally observed in gas-burning engines, where engine temperatures are typically higher. Guttering in diesel engines is primarily an oxidation phenomenon along the contact face that is accelerated by the presence of deposits. These deposits, which strongly adhere to the contact face, are formed by the combustion of additives in a lubrication enhancing oil. The oxidized region is inherently brittle and erodes away during repeated cyclic loading during operation. The erosion process accelerates in an avalanche effect until engine performance degrades to the point of failure.

The root cause of radial cracking of valves in gas-burning engines appears to be related in part to the residual stresses associated with a hardfacing weldment. The higher the operating temperatures vis-à-vis diesel engines suggest that high-temperature fatigue initiating at the hardfacing/head interface could also play a role.

The wear resistance problems of engine exhaust valves described above may be addressed by hardfacing or manufacturing engine exhaust valves with a base material that is comprised of the components of the present invention. However, such alternatives would be very expensive.

The present invention is directed to overcoming one or more of the problems set forth above.

DISCLOSURE OF THE INVENTION

In accordance with the present invention there is provided a method of making an engine valve train component having a protective coating, comprising the steps of: grit blasting the face of the valve component; selecting an oxidation and corrosion-resistant coating material having the general formula MCrAlY; depositing the oxidation and corrosion-resistant coating material onto the face of the valve component; cooling the valve component during the deposition; thereafter grinding the face to finish dimensions; and thereby making an engine valve train component with an oxidation and corrosion-resistant coating on its face.

In accordance with another aspect of the invention there is provided an engine valve train component having a protective coating material including: an oxidation and corrosion-resistant, thermal spray deposited coating at the face of the valve component; and said coating having the general formula MCrAlY.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view, partly elevational and partly sectional, of an engine valve including a valve head seated in a valve seat; and

FIG. **2** is a fragmentary cross-section on a larger scale than FIG. **1** and showing the protective coating on a contact face and a valve seat face.

BEST MODE FOR CARRYING OUT THE INVENTION

An engine valve, generally designated **10**, includes a head **12** which has a stem **14** and a contact face **16**. A valve opening **18** is formed by a valve seat insert **20** fitted into the engine block **24**. The insert **20** has a valve seat face **22** against which the contact face **16** fits in gas-sealing engagement. A relatively thin protective coating **30** is on either face **16** or **22**, or both.

The protective coating **30** is an oxidation and corrosion-resistant coating. This coating is thermal spray deposited via a process of: degreasing the valve component **12** or **20**; grit blasting a face **16** or **22** at about 100 psi using aluminum oxide having a size less than about 1.7mm; subsequently degreasing the valve component; depositing an oxidation and corrosion-resistant coating **30** at least about 0.015" thick onto the face **16** or **22**; cooling the valve component **12** or **20** during the deposition using auxiliary air; thereafter finish grinding the coating **30** of the valve component to finish dimensions with about 0.010" coating thickness.

To achieve low porosity, the deposition is by a high particle velocity spray device. One such device is generically termed High Velocity Oxygen Fuel (HVOF). This is a combustion process where oxygen is mixed with a fuel gas in a specified ratio and ignited. In this embodiment, the exhaust gas is accelerated toward a substrate using a converging/diverging nozzle, achieving velocities of 4500 ft/s. Powder metals or cermets with a particle size distribution from about 11–44 μm are injected generally axially into the gas stream, become molten and are propelled toward the contact face **16** and/or the valve seat face **22**. Valve seat faces **22** are sprayed at around a 90 degree angle to a thickness of approximately 0.015–0.020". The high particle velocities contribute to the high mechanical bond strengths and high densities of HVOF coatings. During the process, the valve component **10** and/or **20** is cooled with auxiliary air, and thereafter the coating **30** is finish ground to print dimensions, with approximately 0.010" final coating thickness, as described above.

Table I indicates several applicable materials for coating **30**.

TABLE I

Material	Mftr Name	Fe	Ni	Cr	Ti	Al	C	Nb	Y	Co
NiCrAlY—B	Amdry 961	—	76.17	16.8	—	6.25	—	—	0.68	—
NiCrAlY—A	Amdry 964	—	56.69	31.07	—	11.26	0.01	—	0.71	—
CrC—NiCr	Diamaloy 3006	—	41	52	—	—	7	—	—	—
CrC—NiCr	Diamalloy 3007	—	16	74	—	—	10	—	—	—
TiAl	TiAl	—	—	2	49	47	—	2	—	—
FrCrAlY		70				4			1	25
CoCrAlY				18		8			0.5	73.5
NiCoCrAlY			46.2	18		12.5			0.3	23

HVOF processing parameters for Sulzer Metco HVOF equipment are included in Table II.

TABLE II

Material	Oxygen Pressure (PSI)	Oxygen Flow Rate (SCFH)	Propylene Presure (PSI)	Propylene Flow Rate (SCFH)	Air Pressure (PSI)	Air Flow Rate (SCFH)	Nitrogen Pressure (PSI)	Powder Feed Rate (3/min)
CrC—NiCr	150	606	100	167	75	805	175	38
NiCrAlY	150	577	100	167	75	631	175	70
TiAl	150	577	100	167	75	631	175	20

Table III indicates corrosion test results compared to current production valve materials.

TABLE III

Material	Thickness of Corroded Region
Nimonic 80A	100 μm
Eatonite 6	15 μm
CrC—NiCr (Diamalloy 3006)	100 μm
TiAl	coating spalled during cooling
NiCrAlY—A	no evidence of corrosion except small localized 10 μm region
NiCrAlY—B	no evidence of corrosion except small localized 10 μm regions
CrC—NiCr	entire thickness of coating - 350 μm

From the above results the material selected for the coating **30** has the general formula MCrAlY. In one composition the NiCrAlY-A, generally is about 76.17% by weight nickel; 16.80% by weight chromium; 6.25% by weight aluminum; and 0.68% by weight yttrium. In another composition, NiCrAlY-B generally is about 56.69% by weight nickel; 31.07% by weight chromium; 11.26% by weight aluminum; 0.01% by weight carbon; and 0.71% by weight yttrium. Of course, there may be trace elements.

Industrial Applicability

The above-described corrosion and oxidation-resistant coatings possess wear characteristics to withstand the demanding conditions present during engine operation. This precludes the guttering problem which is related to oxidation followed by micro cracking. While it is not known how guttering occurs, one possible explanation is that the exhaust gases erode the microcracks and form gas paths. Another possibility results from deposit formation on the face and subsequent spallation which removes some of the valve face material.

While preferred steps and materials have herein been described, this has been done by way of illustration and not limitation, and the invention should not be limited except as may be required by the scope of the appended claims.

What is claimed is:

1. A method of making an engine valve train component for an internal combustion engine, comprising the steps of:

grit blasting a face of the engine valve train component;

depositing an oxidation and corrosion-resistant coating material having the general form MCrAlY onto the face of the engine valve train component;

cooling the engine valve train component during the deposition;

grinding the face to finish dimensions.

2. The method of making an engine valve train component as set forth in claim **1**, wherein the step of depositing includes depositing said coating material having about 17–31% by weight chromium.

3. The method of making an engine valve train as set forth in claim **1**, wherein the step of depositing includes depositing said coating material having about 57–76% by weight nickel; about 17–31% by weight chromium; and the remainder aluminum, yttrium and trace elements.

4. The method of making an engine valve train component as set forth in claim **1**, wherein said coating is a material generally being by weight about 16–32% Cr, 4–13% Al, 0–1% Y, 0–70% Fe, 0–77% Ni, 0–74% Co and trace elements.

5. The method of making an engine valve train component as set forth in claim **1**, wherein the coating material generally being by weight about 31% Cr, 11% Al, 0.5% Y, and remainder nickel and trace elements.

6. A method of making an engine valve train component for an internal combustion engine, comprising the steps of:

grit blasting a face of the engine valve train component;

depositing an oxidation and corrosion-resistant coating material onto the face of the engine valve train component to a thickness of about 0.015";

cooling the engine valve train component during the deposition; and

grinding the face to finish dimensions with about 0.010" coating thickness.

7. The method of making an engine valve train component according to claim **6**, wherein said step of depositing an oxidation and corrosion-resistant coating material being depositing a material having a general form of MCrAlY.

8. The method of making an engine valve train component according to claim **6**, wherein said step of depositing being depositing said coating material having about 17–31% by weight chromium.

9. The method of making an engine valve train component according to claim **6**, wherein said step of depositing being depositing said coating material having about 57–76% by weight nickel; about 17–31% by weight chromium; and the remainder aluminum, yttrium and trace elements.

10. The method of making an engine valve train component according to claim **6**, wherein said step of depositing said coating material having generally by weight about 17% Cr, 6% Al, 0.5% Y and remainder being Ni and trace elements.

11. The method of making an engine valve train component according to claim **6**, wherein said step of depositing being depositing said coating material having generally by weight about 31% Cr, 11% Al, 0.5% Y, and remainder being Ni and trace elements.

12. The method of making an engine valve train component according to claim **6**, wherein said depositing step includes applying the coating by a high velocity particle spray process.

13. The method of making an engine valve train component according to claim **12**, wherein said high velocity particle spray process being a combustion process including mixing oxygen with a fuel gas stream, igniting said mixture, accelerating said mixture toward said face and injecting a powder of said coating material into said fuel gas stream.

14. The method of making an engine valve train component according to claim **13**, wherein the step of injecting said powder includes injecting cermets into said fuel gas stream, said cermets becoming molten and being propelled toward said face.

15. The method of making an engine valve train component according to claim **13**, wherein the step of accelerating being accelerating said mixture to a velocity of about 4500 feet per second.

16. The method of making an engine valve train component according to claim **13**, wherein said powder having a particle size between about 11 μm and 44 μm.

17. An engine valve train component for an internal combustion engine comprising:

a contact face; and

a coating being applied to said contact face, said coating being applied by a thermal spray process, said coating having general form MCrAlY.

18. The engine valve train component as set forth in claim **17**, wherein said coating having a thickness of about 0.010".

19. The engine valve train component according to claim **17**, wherein said coating having a composition by weight of about 17% Cr, 6% Al, 0.5% Y, and a remainder being Ni and trace elements.

20. The engine valve train component according to claim **17**, wherein said coating having a composition by weight of about 31% Cr, 11% Al, 0.5% Y and a remainder being Ni and trace elements.

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