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Zverev et al.

[11] **3,884,415**

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[54] **INSTALLATION FOR EXPLOSIVE DEPOSITION OF INORGANIC COATINGS**

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[52] **U.S. Cl.** **239/79**

[51] **Int. Cl.** **B05b 1/24**

[58] **Field of Search** 239/79-85; 117/105, 105.1

[56] **References Cited**

UNITED STATES PATENTS

3,150,828 9/1964 Pelton et al. 239/79

Primary Examiner—Lloyd L. King

Attorney, Agent, or Firm—Holman & Stern

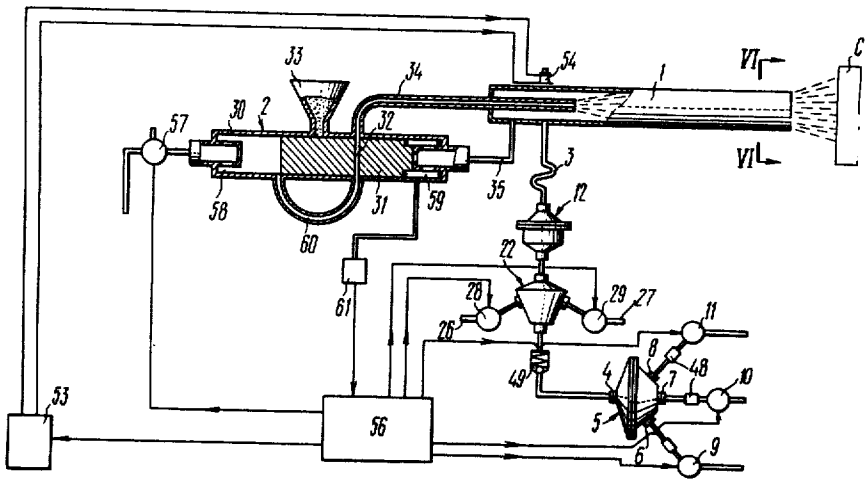
[57] **ABSTRACT**

The installation comprises the tubular-shaped combustion chamber closed at one end and communicated with the proportioner for batchwise feeding a powdered coating material thereinto and with the mixing chamber which feeds through its outlet sleeve and the safety coiler an explosive mixture into the combustion chamber, said explosive, mix, when made to explode, sets up a detonation wave in the combustion chamber to eject the coating material through the open end of said chamber onto the surface of the workpiece under treatment.

According to the invention, provided in between the safety coiler and the mixing chamber outlet sleeve is the backfire extinguishing device adapted to operate in case of blowbacks from the combustion chamber into the safety coiler. The device has a hollow housing wherein a porous refractory partition is provided.

Such an installation features safety and reliability in operation.

5 Claims, 10 Drawing Figures



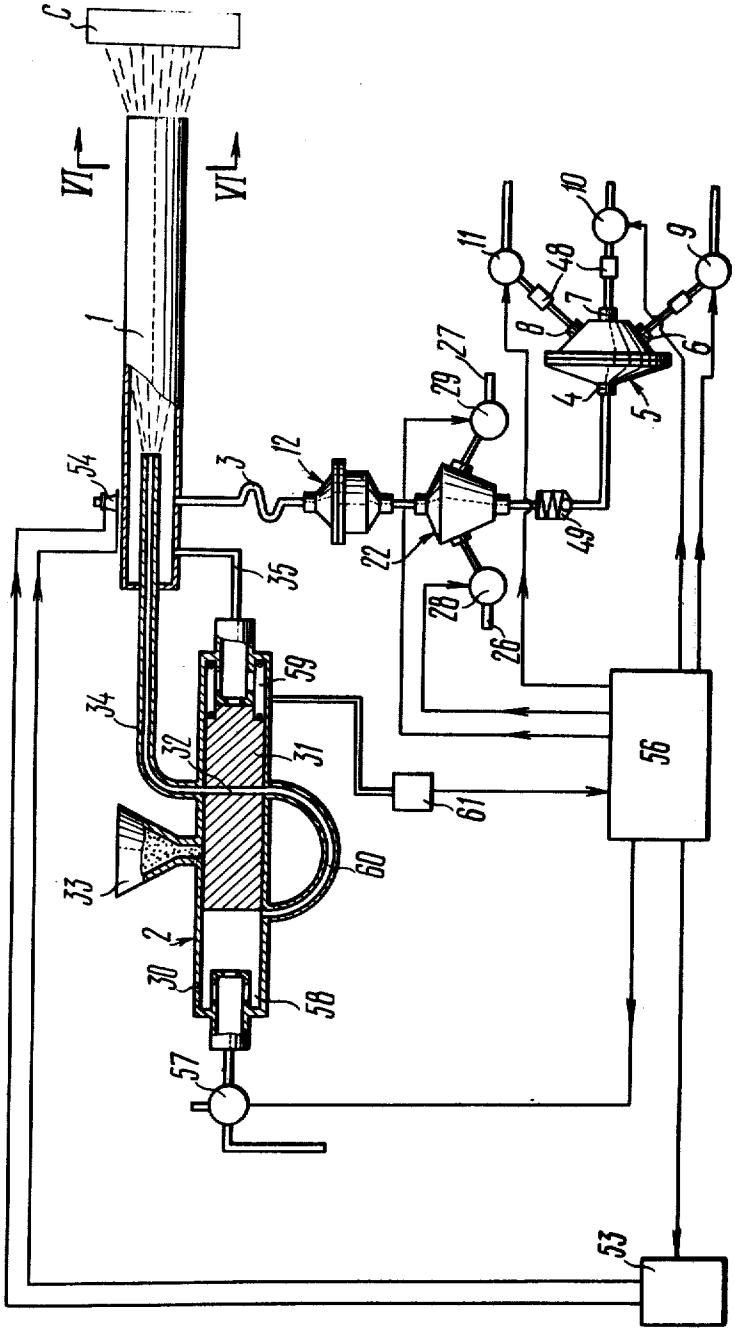

C
VI
VI
1
54
3
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35
59
34
32
31
61
56
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2
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11
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FIG. 1

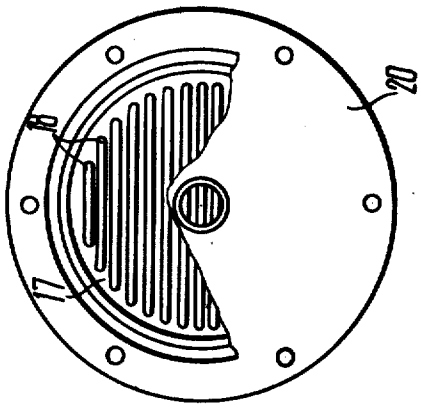


FIG. 3

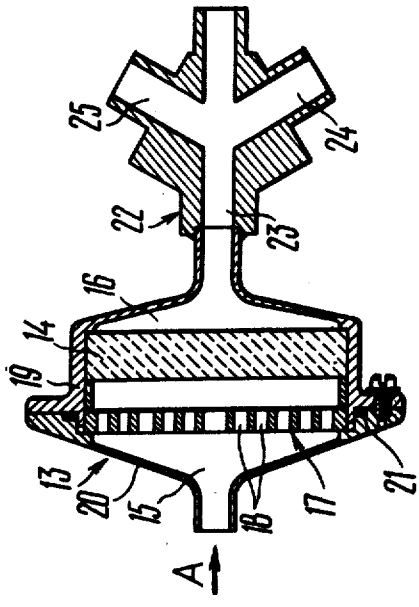


FIG. 2

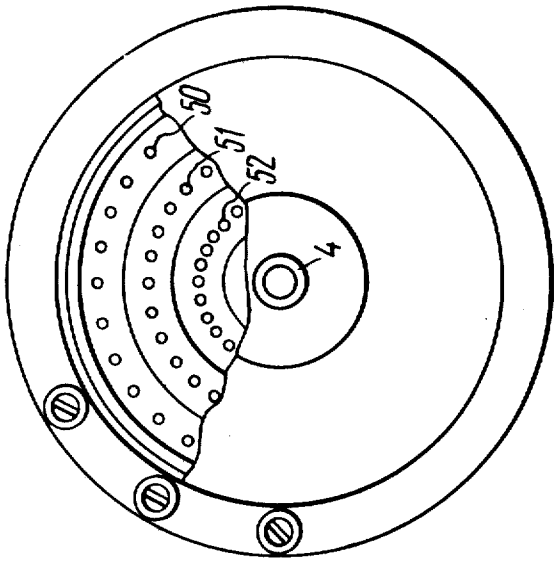


FIG. 5

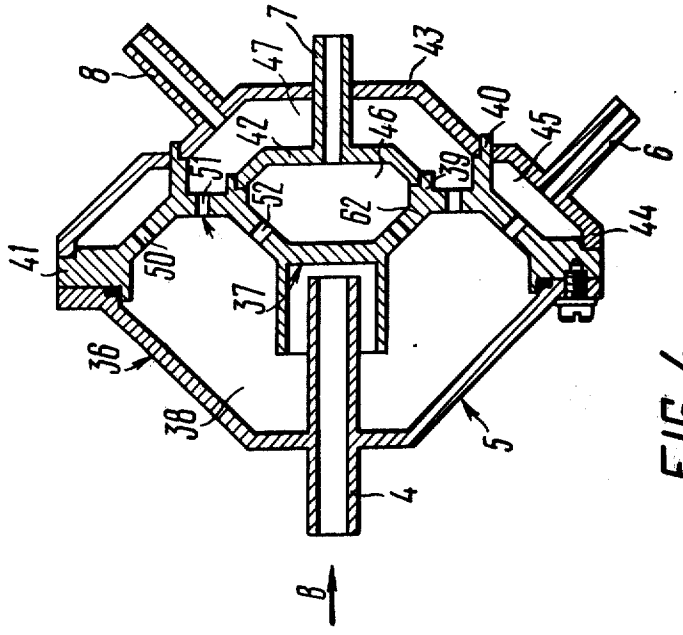


FIG. 4

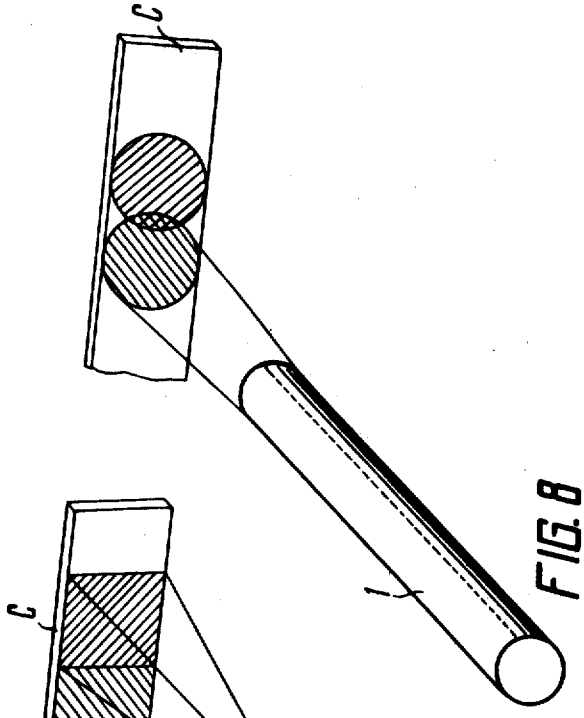


FIG. 8

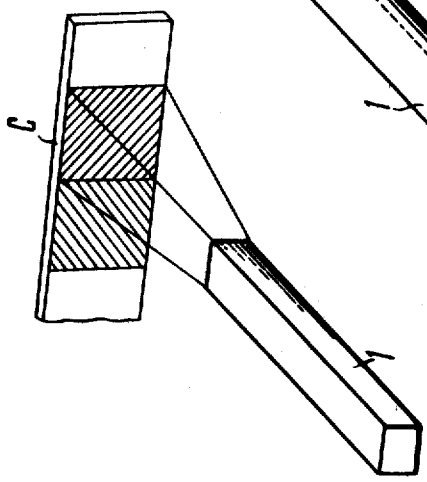


FIG. 7

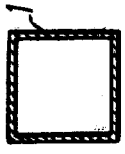


FIG. 6

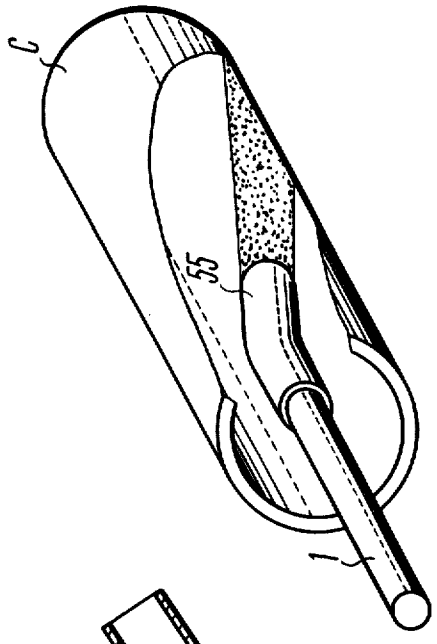


FIG. 10

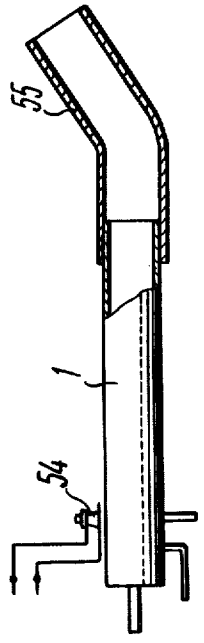


FIG. 9

INSTALLATION FOR EXPLOSIVE DEPOSITION OF INORGANIC COATINGS

This invention relates generally to devices based upon utilization of the detonation effect in gases for treatment of inorganic materials and is concerned more specifically with an installation for explosive deposition of inorganic coatings upon the surface of metallic or nonmetallic articles.

It is common knowledge that when a long tube is closed at one end and filled with an explosive mix, whereupon said mix is fired at the closed tube end, the flame front will propagate at an ever increasing velocity until a detonation wave sets up at a certain distance from the firing place.

Said detonation wave features high pressure and temperature and is liable to propagate at a constant velocity whose magnitude is maximum for the given explosive and environmental conditions, which is in the order of from 2 to 4 km/sec.

Detonation effect has found extensive application for stamping large-sized pieces, cleaning workpieces from scale after heat-treatment, as well as for pelletizing the particles of various loose powdery materials both refractory and low-melting.

The invention is applicable to best advantage for explosive deposition upon metallic or nonmetallic parts, of coatings from wear-, corrosion- or heat-resistant materials, such as nickel, cobalt or alloys thereof, as well as tungsten and titanium carbides.

One prior-art installation for explosive deposition of inorganic coatings is known to be disclosed in U.S. Pat. No. 3,150,828, and to comprise a tubular combustion chamber closed at one end, a proportioning feeder for batchwise feeding a powdered coating material into said chamber, and a mixing chamber which communicates through its inlet sleeves with the source of the components of an explosive mix and with that of an inactive gas and through its outlet sleeve and a safety coiler, with the combustion chamber so as to feed said mix thereinto, whereupon said mix is ignited to set up a detonation (explosion-shock) wave which expels the coating material through the open end of the chamber to deposit it upon the surface of the workpiece under treatment.

Solenoid-operated valves are provided in the pipes communicating the inlet sleeves of the mixing chamber with the source of an explosive mix (i.e., a combustible gas and oxygen) and with that of an inactive gas, adapted to operate in response to a command signal from a common control unit of the whole installation.

The installation operates as follows.

Upon receiving a command signal from the control unit, said valves open in a definite sequence to admit the components of an explosive mix to pass into the mixing chamber, where they are intermixed to form an explosive mix which is fed into the combustion chamber into which a powdery coating material is concurrently fed from a proportioner.

Upon feeding a definite batch of the mix the valves are closed and an inert gas is fed into the mixing chamber to scavenge the safety coiler, whereupon the explosive mix held in the combustion chamber is fired to detonate, whereby high pressure and temperature are set up inside the chamber.

Explosion products impart their energy to the particles of the coating material suspended in the gas stream, whereby said particles grow hot and escape at a great velocity from the combustion chamber through its open end, thus forming a coating on the surface of the workpiece under treatment.

Thereupon, the valve opens again to feed the inactive gas into the mixing chamber so as to perform general scavenging of the safety coiler and the combustion chamber.

Experience gained in operation of such installations has shown that upon firing the explosive mix in the combustion chamber a rarefaction occurs therein, whereby partial ingress of the remainder of the explosive mix from the mixing chamber into the safety coiler takes place. As a result, the explosive mix gets mixed with the in active gas filling the safety coiler and is liable to catch fire from hot detonation products when the latter rush from the combustion chamber into the safety coiler.

This phenomenon will hereinafter be referred to as a "blowback."

As a result of an incomplete combustion of said mix, soot is formed which then settles upon the inside surface of the mixing chamber and its valves, which is liable to cause their failure or premature wearout.

Moreover, blowbacks tell adversely on the quality of coatings thus obtained.

Among the disadvantages inherent in the known installations there shall be noted also the fact that scavenging of the safety coiler with an inactive gas upon feeding the explosive mix into the combustion chamber (before igniting said mix therein) and a complete scavenging of said coiler and the combustion chamber at the end of the cycle (upon ejection of the coating material from the combustion chamber) are effected from the same valve which feeds the inactive gas into the mixing chamber, the gas pressure being indentical in both cases.

However, a complete scavenging of the safety coiler and the combustion chamber involves much higher pressure pulse of the inactive gas than than that required for scavenging the safety coiler alone, since otherwise the explosive mix might be expelled from the combustion chamber rather than from the safety coiler alone.

All these disadvantages render the operation of the installation unstable and adversely affect the quality of the coatings produced.

It is a primary object of the present invention to provide an installation for explosive deposition of inorganic coatings that would be protected against blowbacks from the combustion chamber and, thereby be safe in operation.

It is another object of the invention to provide such an installation that would feature a clear-cut and steady operation of all the units thereof.

It is a further object of the present invention to provide an installation of the character set forth hereinbefore which would be instrumental in upgrading the quality of the coatings being applied.

It is one more object of the present invention to provide a highly-efficient installation of the character set forth hereinbefore.

Said and other objects are attained in an installation for explosive deposition of inorganic coatings, comprising a tubular-shaped combustion chamber closed at one end, a proportioner for batchwise feeding a powdered coating material thereinto, and a mixing cham-

ber which communicates through the inlet sleeves thereof with the source of the components of an explosive mix and with that of an inactive gas and through its outlet sleeve and a safety coiler, with the combustion chamber so as to feed said explosive mix thereinto, said mix when made to explode sets up a detonation (explosion-shock) wave which ejects the coating material through the open end of said chamber to deposit it upon the surface of the workpiece under treatment.

According to the invention, provided in between the safety coiler and the outlet sleeve of the mixing chamber is a device for extinguishing fire in case of blowbacks from the combustion chamber into the safety coiler, said device having a hollow housing provided with a partition made of a porous refractory material to divide the interior space of the housing into two chambers of which one is communicated with the safety coiler, while the other, with the outlet sleeves of the mixing chamber.

Such a constructional arrangement of the installation makes it possible to completely avoid backfires or inrush of hot detonation products from the combustion chamber into the mixing chamber and, thereby, to protect the latter and the pipings of the entire installation against blowbacks, which adds to safety of its operation and improves the quality of the coatings obtained.

It is expedient that provision be made in between the backfire extinguishing device and the outlet sleeve of the mixing chamber for a three-way connector having an axial open-end passage to communicate said device with said mixing chamber, and two side passages adapted to alternatively communicate in the course of installation working process, with the source of an inactive gas, for said gas to feed along one of said passages under a pressure high enough to scavenge the safety coiler upon feeding an explosive mix from the mixing into the combustion chamber and along the other passage to scavenge said coiler together with the combustion chamber upon ejection of the coating material therefrom.

Such a constructional arrangement enables an independent and effective scavenging with an inactive gas of both the safety coiler alone and a complete scavenging of it together with the combustion chamber at the end of the working cycle of the installation.

This ensures a steady and reliable operation of the installation as a whole and renders it more economic.

It is likewise reasonable that a flame splitter grate, spaced somewhat apart from the partition, be provided in the interior of the housing communicating with the safety coiler.

Such constructional feature enables the flame front to be split so as to abate it and then completely smother in the pores of the refractory partition.

The housing of the backfire extinguishing device may be cylinder-shaped, while the flame splitter grate may be made as a disk coaxial with said cylinder and having open-end calibrated apertures spread over the entire disk surface along its parallel chords spaced equidistantly from one another.

The partition in the housing of the backfire extinguishing device is preferably made of a porous cermet.

In what follows the invention is disclosed in a detailed description of one of the practicable embodiments thereof given by way of illustration with reference to the accompanying drawings, wherein:

FIG. 1 is a general schematic view of installation for explosive deposition of inorganic coatings, according to the invention, showing a fragmentarily cutaway view of the combustion chamber and proportioner;

FIG. 2 is a longitudinal section view of a backfire extinguishing device in assembly with a three-way connector, as shown in the installation of FIG. 1;

FIG. 3 is a view along the arrow "A" in FIG. 2;

FIG. 4 is a longitudinal section view of a mixing chamber assembly as shown in the installation of FIG. 1;

FIG. 5 is a view along the arrow "B" in FIG. 4 (with the cover partly out of position);

FIG. 6 is a section taken along the line VI—VI in FIG. 1;

FIG. 7 is coating pattern as produced with the use of a square-shaped combustion chamber;

FIG. 8 is the same in case of a circular combustion chamber;

FIG. 9 is a fragmentarily sectional view of a combustion chamber in assembly with a swivel nozzle; and

FIG. 10 is a partly outaway view of a coating pattern produced on the inside surface of the workpiece under treatment.

Now referring the accompanying drawings FIG. 1 illustrates an installation for explosive deposition of inorganic coatings, comprising a combustion chamber 1 shaped as a calibrated tube closed at one end, into which a powdered coating material and an explosive mix are fed.

The length of the chamber 1 and the diameter thereof are so selected that when the explosive mix therein is made to explode, a detonation (explosion-shock) wave sets up in the chamber to eject the explosion-heated powdered material through the open end of the combustion chamber 1 to get onto the surface of a workpiece "C" under treatment, thus establishing a strong coating thereon.

For batchwise feeding the powdery material, the combustion chamber 1 is connected with its closed end to a proportioner 2 and through a safety coiler 3, to an outlet sleeve 4 of a mixing chamber 5, wherein an explosive mix is prepared. Inlet sleeves 6 and 7 of the chamber 5 communicate through respective solenoid-operated valves 9 and 10 with the sources (not shown) of the components of said mix, while an inlet sleeve 8 of said chamber communicates through a solenoid-operated valve 11 with the source (not shown) of an inactive gas.

According to the invention, provided in between the safety coiler 3 and the outlet sleeve 4 of the mixing chamber 5 is a device 12 to extinguish backfire in case of blowbacks from the combustion chamber 1 into the safety coiler 3.

The device 12, according to the invention, has a hollow cylindrical housing 13 (FIG. 2) which accommodates a partition 14 made of a flame-retardant porous refractory material, such as cermet, to divide the cylindrical housing 13 into two chambers 15 and 16 of which the chamber 15 is communicated with the safety coiler 3 and accommodates a grate 17 spaced somewhat apart from the partition 14 and arranged in parallel thereto, adapted to split the flame whenever it rushes in the safety coiler during blowbacks from the combustion chamber 1, whereas the other chamber 16 of the housing 13 communicates with the outlet sleeve 4 of the mixing chamber 5.

The grate **17** is shaped as a disk coaxial with the housing **13** and provided with calibrated through apertures **18** (FIG. 3) spread over the entire disk surface along its parallel chords spaced equidistantly from one another.

The housing **13** of the device **12** is made of two elements, viz., a cylindrical shell **19** and a taper cover **20** interconnected through a separable joint which is hermetically sealed with a packing ring **21**.

According to the invention, a three-way connector **22** (FIG. 1) is interposed between the device **12** and the outlet sleeve **4** of the mixing chamber **5**, which connector has an axial through passage **23** (FIG. 2) to communicate said device with said sleeve, and two side passages **24** and **15** arranged at an angle to the axial passage **23** and communicated through respective pipes **26** (FIG. 1) and **27** with the source of an inactive gas, solenoid-operated valves **28** and **29** being provided in the pipes **26** and **27**, respectively.

The valves **28** and **29** are adapted, in the course of the installation working process, to alternatively communicate the side passages **24** and **25** with the source of an inactive gas in such a manner that, according to the invention said gas is fed along the side passage **24** under a pressure high enough to scavenge the safety coiler **3** (through the backfire extinguishing device **12**) upon feeding the explosive mix from the mixing chamber **5** to the combustion chamber **1**, whereas along the other side passage **25** of the three-way connector **22** said gas is fed to completely scavenge said coiler **3** and the combustion chamber **1** at the end of the installation working cycle, i.e., after the coating material has been ejected therefrom. A pressure differential between the passages **24** and **25** is attained due to a gas pressure reducer (not shown) of a conventional design.

The proportioner **2** for the powdered coating material has a hollow tubular casing **30** closed at both ends, inside which a sliding spool valve **31** with a metering chamber **32** is free to travel.

The interior space of the casing **30** of the proportioner **2** is communicated with a hopper **33** for a powdery coating material, and through an outlet sleeve **34** and a feedback sleeve **35** it communicates with the combustion chamber **1**.

The mixing chamber **5** has a pressure-tight shell **36** (FIG. 4) which accommodates a transverse partition **37** to divide the interior space of the chamber into a mixing compartment **38** and a discharge space which, in turn, is subdivided by three concentric partitions **39**, 40, 41 and respective ring-shaped covers **42, 43, 44** of the shell **36**, coaxial with the outlet sleeve **4** of the mixing chamber **5**, into three annular discharge chambers **45, 46, 47**. Said chambers are communicated by way of respective inlet sleeves **6, 7, 8** (FIG. 1) through the solenoid-operated valves **9, 10, 11** and feed pipings with filters **48**, with the source of one of the components of the explosive mix, viz., a combustible gas (acetylene), an oxidant (oxygen) or an inactive gas (nitrogen).

The mixing compartment **38** of the mixing chamber **3** communicates by way of the outlet sleeve **4** of the latter and the respective piping provided with a check valve **49**, with the axial passage **23** (FIG. 2) of the three-way connector **22**.

The transverse partition **37** in the shell **36** has in its central portion a projection shaped as a truncated cone and along the periphery, it has the shape of an inverted truncated cone, the walls of both cone frustums being provided with open-end calibrated apertures arranged in concentric rows coaxially with the outlet sleeve **4** and serving as spray orifices communicating the respective annular discharge chambers **47, 46, 45** with the mixing compartment **38**.

Apart from the afore-specified operative units, the installation comprises also a pulse generator **53** (FIG. 1) producing high voltage supplied to a spark plug **54** for the explosive mix in the combustion chamber **1** to explode.

Whenever necessary, use may be made of detachable combustion chambers **1** differing in the shape of their cross-sectional area, say, round, square, rectangular or any other. Thus, the use of a square-shaped combustion chamber (FIG. 6) enables the deposited material to be utilized more completely and efficiently and makes it possible to obtain a coating more uniform in thickness as compared to that obtained with the use of a round-shaped combustion chamber.

To illustrate this, FIGS. 7 and 8 are provided.

The combustion chamber **1** of the installation can be provided with changeable swivel nozzles **55** (FIGS. 9 and **10**) put onto its vacant end.

Such nozzles **55** can be curved at any angle which enables a coating to be applied to the inside surfaces of long-measured workpieces C (FIG. **10**).

The installation proposed herein operates as follows.

At the instant where the proportioner is charged with the powdered coating material the sliding spool valve **31** assumes an extreme left-hand position in the casing **30** (FIG. 1), so that its metering chamber **32** gets communicated with the feeding hopper **33** to be filled with the powder.

In response to a command signal produced by the control unit **56**, the solenoid-operated valves **9, 10, 11** are made to open and admit fuel, oxidant and inactive gas to pass into the discharge chambers **45** (FIG. 4), **46** and **47** of the mixing chamber **5**.

Using the valve **11** the explosive mix can be doped with different amounts of an inactive gas so as to modify the temperature, pressure and propagation velocity of the detonation wave within reasonably broad limits, thereby rapidly selecting the required operating conditions of the installation to suit a variety of coating materials used.

Besides, at operator's discretion, there can be fed concurrently an oxidant into the discharge chambers **45** and **46** and fuel gas into the chamber **47**, or vice versa, depending upon the viscosity of the components being fed, thereby ensuring homogeneity of the explosive mix which is of special importance when a liquid explosive is made use of as one of the components. This being the case, the inactive gas is fed from its own solenoid-operated valve (not shown).

From the discharge chambers **45, 46, 47** the components of the explosive mix are passed through the spray orifices **50, 51, 52** to get into the mixing compartment where they are intermixed to form a homogeneous explosive mix which is fed through the outlet sleeve **4** of the mixing chamber **5**, the check valve **49** (FIG. 1) and further on, along the axial passage **23** (FIG. 2) of the three-way connector **22** to get into the housing **13** of the device **12**, from whence the explosive mix is passed through its porous partition **14** and the calibrated apertures **18** of the grate **17** into the safety coiler **3** (FIG. 1) to fill the combustion chamber **1**.

Once the combustion chamber 1 has been filled with the explosive mix the valves 9, 10, 11 are closed and simultaneously opened are the valve 57 controlling the proportioner 2 and the valve 28 for prefire purging of the safety coiler 3.

Once the valve 57 has been opened, the actuating medium pressure in the left-hand (as in FIG. 1) chamber 58 of the casing 30 of the proportioner 2 starts rising to urge the sliding spool valve 31 to displace all the way to the right (as in FIG. 1) so as to expel the gas from the chamber 59 of the proportioner 2 through the feedback sleeve 35 into the combustion chamber 1.

Just as the sliding spool valve 31 assumes its extreme right-hand position in the casing 30, its metering chamber 32 is communicated with the outlet sleeve 34 of the proportioner 2, besides, when in the aforesaid position the sliding spool valve 31 clears the arc-shaped passage 60 and expels the powder from the metering chamber 32 into the combustion chamber 1.

The concurrently opening valve 28 feeds the inactive gas into the side passage 24 of the three-way connector 22 and further on, into the axial passage 23 thereof, wherefrom the gas is passed through the device 12 (i.e., through its partition 14 (FIG. 2) and the calibrated apertures 18 of the grate 17) to fill the safety coiler 3.

Thereupon all the valves are closed, and the pulse generator 52 produces a pulse to the spark plug 54 which ignites the expolsive mix in the combustion chamber. The resultant detonation wave ejects the powdered coating material through the open end of the chamber 1 onto the surface of the workpiece C positioned in front of the combustion chamber 1.

The transducer 61 responsive to a dynamic pressure exerted by the detonation wave, delivers a signal to the control unit 56 which, in turn, sends a signal for opening the valve 29 to completely scavenge the safety coiler 3 and the combustion chamber 1 with the inactive gas which is fed along the other side passage 25 of the three-way connector 22 into the chamber 16 in the housing 13 of the device 12 and further on, into the safety coiler 3 and the combustion chamber 1, thus expelling all combustion products therefrom.

Thereupon, the cycle described hereinbefore is repeated.

Application in the installation proposed in the invention of the backfire extinguishing device 12 ensures safety and reliability in operation of all its units and components, while independent scavenging of the safety coiler 3 and the combustion chamber 1 renders its operation more reliable and steady.

Besides, an advantageous feature of the installation, according to the invention, resides in the fact that the variation of the coating deposition conditions (schedule), increasing or decreasing of the proportion of a component of the explosive mix fed into the combustion chamber, extending or reducing the scavenging time, start and end of the deposition cycle, control of the retarding time of the mix ignition, raising or lowering of the firing rate, etc. are carried out remotely, i.e., from the control desk.

Maximum versatility of the installation, high reliability and safety of operation rendered thereby, as well as a relatively simple control of modification of its operating conditions for various coating materials, all this makes the installation convenient in service. Moreover, due to all said features the installation attendance does not require highly skilled service personnel.

Taking into consideration all the afore-discussed advantages of the herein-proposed installation, its industrial application makes it possible to save on the costs involved in the production of expensive equipment used in aircraft and rocketry production, space technology, and in some other industries.

What we claim is:

1. An installation for explosive deposition of inorganic coatings, comprising: a tubular-shaped combustion chamber closed at one end; a proportioner for batchwise feeding a powdered coating material into said combustion chamber; a mixing chamber having inlet sleeves and an outlet sleeve; a safety coiler; said mixing chamber communicated through its inlet sleeves with the sources of the components of an explosive mix and of an inactive gas and through its outlet sleeve and said safety coiler, with said combustion chamber so as to feed said mix thereinto, where the latter is made to explode and thus set up a detonation wave which ejects the coating material through the open end of said chamber onto the surface of the workpiece under treatment; a device for extinguishing the backfire resulting from blowbacks from said combustion chamber into said safety coiler, said device being located between said coiler and the outlet sleeve of said mixing chamber; a hollow housing of said device; a partition made of a porous refractory material and adapted to divide the interior space of said housing of said device into two chambers one of which communicates with said safety coiler and the other, with the outlet sleeve of said mixing chamber.

2. An installation as claimed in claim 1, wherein interposed between the backfire extinguishing device and the mixing chamber outlet sleeve is a three-way connector having an open-end axial passage intercommunicating said device with said sleeve and two side passages adapted to alternatively communicate with the source of an inactive gas in the course of installation working process, so as to enable said gas to feed along one of said passages under a pressure high enough to scavenge the safety coiler after said explosive mix has been fed from said mixing chamber into said combustion chamber, and along the other passage to scavenge said coiler together with the combustion chamber after the coating material has been ejected therefrom.

3. An installation as claimed in claim 1, wherein a flame splitter grate is provided in the housing chamber communicating with the safety coiler, spaced somewhat apart from the partition therein.

4. An installation as claimed in claim 3, wherein the housing is cylinder-shaped, while the grate is made as a disk coaxial thereto and provided with open-end calibrated apertures spread over the entire surface thereof along its chords parallel to and spaced equidistantly from one another.

5. An installation as claimed in claim 1, wherein said partition is made of a porous cermet material.

* * * * *