

Sept. 25, 1962

A. P. SHEPARD

3,055,591

HEAT-FUSIBLE MATERIAL SPRAY EQUIPMENT

Filed July 29, 1959

2 Sheets-Sheet 1

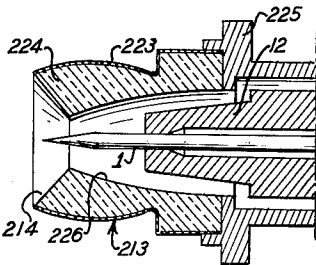


Fig. 2

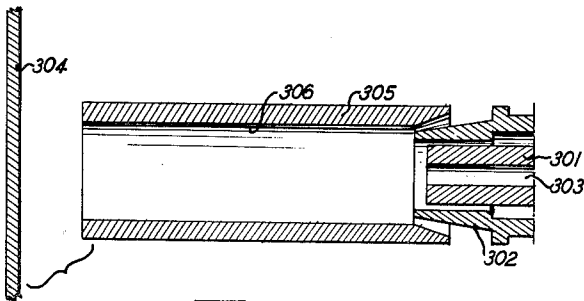


Fig. 3

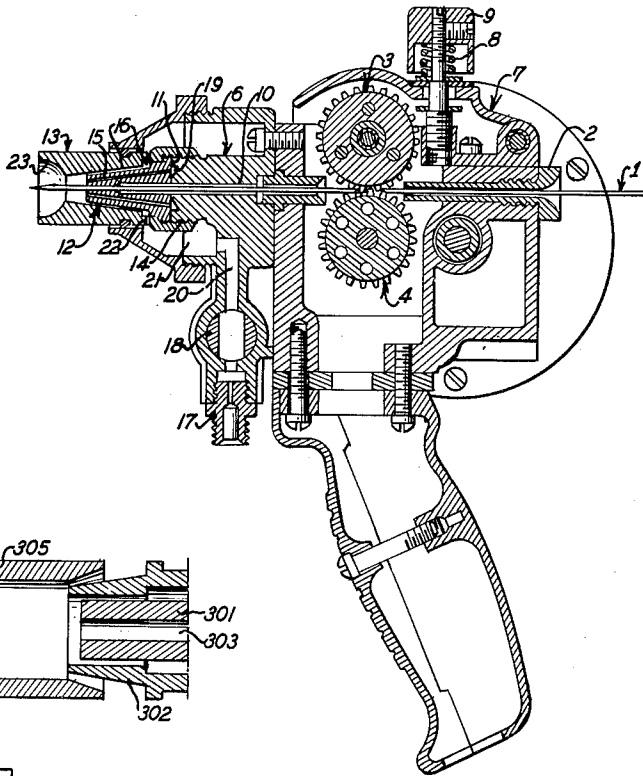


Fig. 1

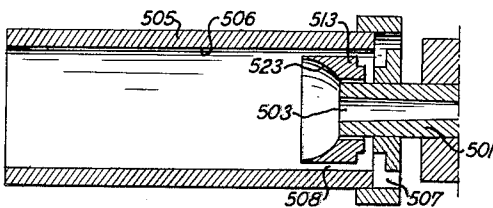


Fig. 5

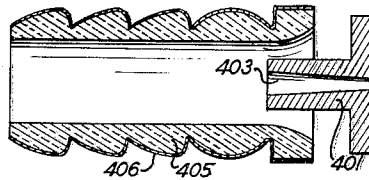


Fig. 4

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HEAT-FUSIBLE MATERIAL SPRAY EQUIPMENT

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2 Sheets-Sheet 2

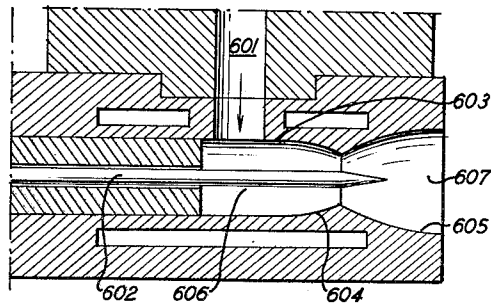


Fig. 6

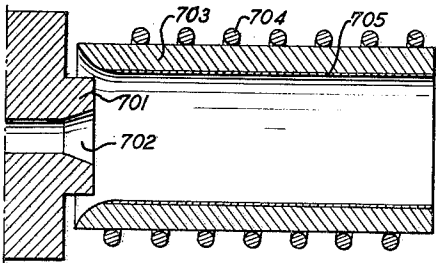


Fig. 7

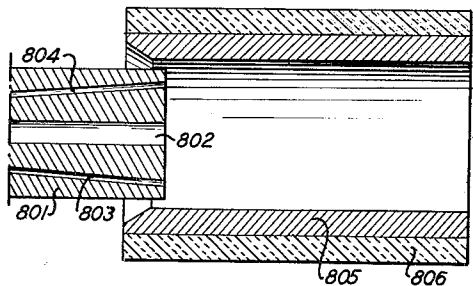


Fig. 8

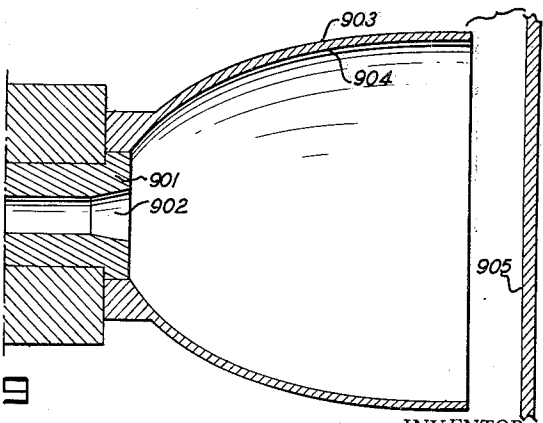


Fig. 9

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3,055,591

HEAT-FUSIBLE MATERIAL SPRAY EQUIPMENT
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 Inc., a corporation of New Jersey
 Filed July 29, 1959, Ser. No. 830,395
 17 Claims. (Cl. 239-13)

This invention relates to new and useful improvements in heat-fusible material spray equipment. The invention more particularly relates to a heat-fusible material spray gun and to a process for spraying heat-fusible material utilizing radiant heat energy.

Heat-fusible material spray guns are devices in which heat-fusible material is fed into a heating zone where the same is melted or at least heat-softened and then propelled from the heating zone in a finely divided form onto the surface to be coated. Such guns are generally constructed of either of two types, i.e., the wire type or powder type.

In the wire type heat-fusible material spray guns, the material to be sprayed is fed into the heating zone in the form of a rod or wire, where it is melted or heat-softened and atomized and propelled in finely divided form onto a surface to be coated. The atomization and propelling is usually effected by a blast gas.

In some cases it has been found convenient to provide a rod or wire for use in such guns by sintering together finely divided materials, or alternatively to bond together finely divided material by means of a plastic binder or other suitable binding material which disintegrates in the heat of the heating zone, thereby releasing the material to be sprayed in finely divided form.

In the powder type of heat-fusible material spray gun, the material to be sprayed is fed into the heating zone in the form of finely divided material, usually conveyed thereto by means of a carrier gas. In such guns the finely divided material is either melted or at least the surface of the grains of the material are heat-softened and the finely divided particles propelled onto a surface to provide a coating thereon. In powder spray guns where finely divided material is fed into the heating zone no energy may be required for "atomizing" the material but nevertheless it is sometimes the practice to supply a blast gas in addition to the combustion gases in order to aid in accelerating the particles and propelling them toward a surface to be coated.

Heat-fusible material spray guns of both the wire and powder type have been proposed in which combustible gases are allowed to burn in a confined zone having an elongated or throttle nozzle outlet passage, and emerge from this passage with a jet-like effect so that the same may serve the dual purpose of heating gas and blast gas requiring no or only a small amount of additional blast gas.

In the guns utilizing a blast gas, the blast gas sometimes serves an additional function, i.e., that of cooling the workpiece and the coating being formed thereon.

The most successful heat-fusible material spray guns commercially used are of the "combustion flame" type which utilize an ordinary combustion flame in order to heat the heat-fusible material. These guns therefore utilize the heat produced by a chemical reaction, such as the oxidation of various fuels as, for example, acetylene, propane, natural gas, or the like with air, oxygen enriched air, or pure oxygen.

The hottest known, readily available commercial flame is the oxy-acetylene flame which has a maximum temperature of about 5600° F. The ordinary flame type of spraying guns are therefore incapable of spraying some of the higher melting point materials which are becoming of increasing importance. The use of other fuels as, for example, cyanogen gas or exotic fuels, to produce a high-

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er flame temperature has not proven at all practical from a commercial standpoint.

The temperature limitations of the conventional flame type spray guns have, to a certain extent, been overcome by the more recently developed "plasma" flame spray guns. These spray guns utilize a plasma flame rather than a chemical flame in order to provide the heat for melting or softening these heat-fusible materials. The plasma is in an energy state of particle activity above the gaseous state, at least a portion of the atoms of the gas being stripped of one or more electrons which are also present in the free state. The plasma flame is usually generated by means of an electric arc with a gas being converted to a plasma by contact with such an arc, and most generally a constricted arc.

In co-pending application, Serial No. 745,680, filed June 30, 1958 a heat-fusible material spray gun is described which utilizes a free plasma stream in order to heat-condition and at least partially propel the heat-fusible material. This free plasma stream is a stream of plasma which is free of and does not constitute a direct part of an electric arc, i.e., does not contribute to current flow between electrodes. In accordance with the preferred embodiment of the said application, the free plasma stream is generated by passing a sheath of plasma-forming gas around an electric arc struck between a pencil and nozzle electrode so as to force the arc part way down the nozzle electrode, constricting the arc; the sheath of plasma-forming gas becoming a plasma and leaving the arc and nozzle as a free plasma jet or stream. The heat-fusible material is passed in contact with this free plasma stream, to be thermally conditioned thereby for spraying and propelled away from the gun.

In addition to the heat-fusible material spray gun of the combustion flame and plasma flame type as described above, heat-fusible material spray guns utilizing electrical heating means are known or have been proposed. Such heat-fusible material spray gun may utilize electrical resistance heating elements, induction heating elements, or arc heating elements in order to produce the heat in the heating zone by which the heat-fusible material is at least heat-softened.

The electric resistance heating has been conventionally used primarily in heat-fusible material spray guns of the crucible type, in which a heating zone is produced in a crucible by means of a conventional resistance heating element and the material is introduced into the crucible, heated to spraying temperature, and thereafter passed out of the crucible and projected toward the surface to be coated. Such guns have proven suitable only for relatively low melting materials, such as solder, lead and zinc.

In heat-fusible material spray guns utilizing induction heating, the heat-fusible material is heat-softened by electrical induction heating and thereafter sprayed by means of a blast gas. Guns operating on this principle have not been too successful in commercial operation due to the difficulty in concentrating the heat sufficiently.

In addition to the utilization of electric arcs, in order to produce a plasma as described above, electric arcs have also been used and proposed to directly heat the heat-fusible material in spray guns. In the usual construction of such guns two wires or rods are fed forward at a converging angle. The wires or rods are connected to a source of high-amperage, relatively low-voltage electric current, so that the converging wires will ultimately contact each other and strike an arc which represents the heating zone. The wires or rods melt in the arc and the molten metal is atomized by a blast of blast gas and thereby propelled toward the surface to be coated.

It has also been proposed to feed the powdered heat-fusible material directly through an electric arc as, for example, an arc formed between two separate electrodes,

such as carbon electrodes. It has also been proposed to vaporize the material to be sprayed in the arc rather than to merely melt or heat-soften the same.

In heat-fusible material spray guns of all the above mentioned types, the efficiency with respect to the actual theoretical maximum temperature which the heating means could achieve and the actual upper limit of the melting point of the material which could be sprayed, was not all that could be desired. Thus, the guns could generally not be satisfactorily used for spraying material having a melting point within the vicinity of the maximum theoretical temperature of the heating means. For example, spray guns of the flame type, utilizing acetylene and oxygen, and having a flame temperature of almost 6000° F. generally could not be too satisfactorily used for spraying zirconia which has a melting point of about 4700° F. Acetylene-oxygen guns have been successful to a limited extent in spraying zirconia, but their limitations are serious. Such guns spray very slowly and result in high cost of operation. Apparently the heat loss would be such that the zirconia would sometimes reach thermal equilibrium at a temperature below its melting point.

In connection with heat-fusible material spray guns, the problem of heating the heat-fusible material to the desired temperature is sometimes one of maintaining the heat-fusible material in the area of the desired temperature for a sufficient period of time. For certain temperatures this time period is often too long to be obtained practically.

In connection with the heat transfer from a heating fluid to the heat-fusible material in a spray gun, as for example in the case of a flame type gun, the relative movement between the heat-fusible material and the heating fluid has been given primary consideration. Thus, a high relative motion generally gives the most efficient transfer and rapid heating of the heat-fusible material. As the heat-fusible material particles are accelerated, however, this relative velocity necessarily decreases at a rapid rate proportional to the acceleration.

It has been observed that the particles of the heat-fusible material generally lose heat very rapidly in transit between the heating zone of the gun and the target or work surface.

This is true even though the stream of carrier gas used for propelling the particles is as hot or even hotter than the melting temperature of the material being sprayed. Here again it is a question of relative velocity and it appears that after the particles have obtained a velocity close to that of the flame, heat input by the flame falls off rapidly since the particle is surrounded by a gas envelope having low calorific value per unit of volume. In general a reduction of the distance between the heating zone and the target or surface has not proven a satisfactory solution to this problem. First, the high local heat which develops on the work surface can create high stresses in the work itself or even may destroy the work surface. Second, unless the coating material is fed through the flame at a very low rate, a high concentration of the material builds up in a very small area and the result is a very high stress condition as the coating material solidifies. Furthermore, it is often desirable to have a high relative temperature differential between the surface and the heat-fusible material particles, as a rapid quenching of the particle in certain cases produces superior coatings.

One object of this invention is to greatly increase the efficiency of heat-fusible material spray equipment and to allow the spraying of higher melting materials with a given type of equipment.

A further object of this invention is an improvement in heat-fusible material spray equipment which will permit higher spraying speeds, increased deposit efficiency, and an improved coating quality.

These and still further objects will become apparent

from the following description read in conjunction with the drawings in which:

FIG. 1 is a vertical cross-section of an embodiment of a heat-fusible material spray gun of the wire combustion flame type having an embodiment of the reflector in accordance with the invention;

FIG. 2 is a diagrammatic vertical section of a further embodiment of a reflector in accordance with the invention;

FIG. 3 is a diagrammatic vertical section of an embodiment of a shroud-type reflector in accordance with the invention;

FIG. 4 is a diagrammatic vertical section of a further embodiment of a shroud-type reflector in accordance with the invention;

FIG. 5 is a diagrammatic vertical section of a further embodiment of the invention utilizing a reflector positioned at the nozzle exit and a shroud-type reflector;

FIG. 6 is a diagrammatic vertical section of an embodiment of a plasma type heat-fusible material spray gun with a reflector in accordance with the invention;

FIG. 7 is a diagrammatic vertical section of a further embodiment of the invention utilizing a coil heated, shroud-type heat radiator;

FIG. 8 is a diagrammatic vertical section of an embodiment in accordance with the invention utilizing a flame heated, shroud-type heat radiator; and

FIG. 9 is a diagrammatic vertical section of a plasma torch nozzle utilizing a reflector in accordance with the invention.

In accordance with the invention, I have surprisingly discovered that the above mentioned disadvantages may be avoided and that the heat-fusible material spray gun may be used for spraying higher melting point materials; may be operated at higher spraying speeds; have an increased deposit efficiency and an improved coating quality if a radiant heat reflector is provided which is shaped and positioned in the path of radiant heat emitted by the heat-fusible material being sprayed, to redirect and focus said radiant heat back against the heat-fusible material.

While the above mentioned disadvantages have been encountered in the metallizing art for over thirty years, a proposal to use radiant heat as a solution has not been previously offered.

Furthermore, it should be noted that radiant energy was not included as one of the modes conventionally used for heating the heat-fusible material in heat-fusible material spray guns. It was never believed that this type of energy would be suitable to quickly and efficiently transfer the heat to the heat-fusible material in the manner necessary and desired.

While the improvement in accordance with the invention is broadly directed to and applicable in connection with any known or conventional heat-fusible material spray gun, including powder, wire and crucible guns, irrespective of the source of heat, i.e., combustion flame, induction heating, electrical resistant heating, arc guns, plasma guns, etc. the same is particularly applicable to and preferable with heat-fusible material spray guns of the flame type, including within this classification combustion flames and plasma flames.

The reflector may be positioned to reflect back the radiant energy to the heat-fusible material in the heating zone of the gun and/or along the path of travel of the heat-fusible material to the workpiece.

In connection with heat-fusible material spray guns having a blast gas nozzle or cap surrounding or adjacent to the heating zone, it has been found preferable to construct this blast gas nozzle as the reflector. Where the shape of the blast gas nozzle for optimum blast gas flow does not conform to the optimum shape of the reflector, the inner surface of the nozzle may be constructed of a material substantially transparent to the radiant energy as, for example, quartz glass or glass, and the reflector of the desired shape may be positioned outwardly of this

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transparent section as, for example, by providing the outer surface of the nozzle with a reflective coating.

Where the heat-fusible material spray gun is not provided with a blast gas nozzle of this type, a separate reflector may simply be positioned around and adjacent the outlet on the gun. Where in addition to, or in place of, redirecting the radiant heat energy to the heating zone of the gun, it is desirable to effect this redirecting in the path of travel of the heated particles to the workpiece, the path of travel between the outlet nozzle of the gun and workpiece or a portion of this path of travel may very simply be surrounded with a reflective shroud.

Referring to the embodiment shown in FIG. 1 of the drawing, a vertical cross-section of a conventional wire type metal spray gun, utilizing a combustion flame as a source of heat and provided with a reflector in accordance with the invention, is shown. The gun is used to spray heat-fusible material in the form of a rod or wire (generically referred to as a wire and designated in the drawing as 1). This wire may be any conventional metallizing wire though the improvement in accordance with the invention is most apparent when operating with higher melting point material as, for example, sintered zirconia rods and alumina rods, molybdenum wire, and other high melting point materials. The wire or rod is fed forward through the gun, through the after wire guide or bushing 2, the feed rollers 3, 4, the forward wire guide or bushing 5 and out through the gas head 6 and nozzle assembly.

The feed roller 3 is mounted in a hinged housing 7 which is pressed by a spring 8 so as to cause the feed roller 3 to engage the wire 1 and cause it to feed. A thumb screw 9 is arranged so as to adjustably compress the spring 8 and maintain the desired feed pressures between the rollers 3, 4. The feed rollers are driven in a conventional manner as, for example, by means of a gas turbine or an electric motor through a gear train (not shown). The gas head 6 is screwed to the after-portion of the gun provided with the wire feed mechanism and has the nozzle assembly. The gas head and nozzle assembly has a central axial bore 10 through which the rod or wire 1 extends. The nozzle proper 12 is mounted on the gas head at the seat 11 and held in place by means of the gas blast nozzle or air cap 13 which is screwed on to the gas head at 14. An annular groove 19 is provided at the seat 11. This annular groove forms a manifold leading to the combustible gas passages 15 in the nozzle 12. The inner surface of the gas blast nozzle 13 and outer surface of the nozzle 12 are so shaped as to provide an annular blast gas passage 16 therebetween. A connection 17 with a valve 18 is provided for the blast gas. This leads to a passage 20 which, in turn, leads to the space 21 and passage 22 into the annular passage 16. Similar connections are provided for fuel gas and the combustible gas which lead to the manifold 19. These connections, which are not shown, are parallel to the connection 17. The construction thus far described is conventional for metal spray guns and is, for example, essentially identical to that described in United States Patent 2,539,487.

Where the blast gas nozzle 13 extends in front of the nozzle 12 a combustion zone is formed which is the heating zone where the heat-fusible material to be sprayed is melted or at least heat-softened.

In accordance with the invention the inner surface of the forward end of the blast gas nozzle at 23 is shaped as a reflector and provided with a polished reflecting surface for radiant heat energy.

The reflector surface should be one which is tarnish-resistant and it has been found that a gold colored reflecting surface is more effective than the conventional silver colored reflecting surface. Thus, a surface of polished gold, brass, bronze or tarnish-resistant copper material is preferable. It is also possible, however, to use a polished aluminum or rhodium reflecting surface or more preferably a gold anodized aluminum reflector surface.

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In operation a blast gas, such as compressed air, is hooked up at 17, and a combustible gas and an oxidation gas as, for example, acetylene and oxygen, are hooked up to the other connections not shown. The wire is threaded through the gun in the conventional manner and the driving mechanism as, for example, the turbine or electric motor actuating rollers 3 and 4, is started so the wire will be fed forward. The combustible gas is mixed in the manifold 19 and passes out through the passages 15 and is ignited, for example, with a conventional spark or match at the outlet of the nozzle. The blast gas passes through the connection 17 and goes through the passage 16. The combustion in front of the nozzle 12 heats the tip of the wire, heat-softening and melting the same, and the stream of blast gas atomizes molten particles from the wire and propels the same toward a surface to be coated. In accordance with the invention, the radiant energy from the tip of the wire 1 and from the molten particles being atomized thereof and propelled by the blast gas, strikes the reflective surface 23 and is redirected and focused against these molten particles and the wire tip.

In all other respects the operation and construction of the gun is identical to that described in the said Patent No. 2,539,487.

However, conventional spray guns are constructed to give a fuel-rich mixture when lighting in order to obtain a softer and less violent lighting effect. This has been done by constructing the valves so that a rich fuel mixture flows through until after lighting, at which time the proportion of the oxygen is increased.

In accordance with the invention, however, it has been found that starting a gun in this manner tends to soot and soil the reflective surface 23, interfering with its operation. It has, therefore, been found preferable to effect the lighting with a relatively oxygen-rich mixture which avoids this disadvantage.

In certain cases the shape of the reflective surface 23 is not the optimum shape for gas flow through the blast gas nozzle. In such instances, it is possible by having at least a portion of the nozzle transparent to the radiant heat energy, to provide both the optimum reflective shape and optimum shape for gas flow.

Such an embodiment is shown in FIG. 2. In this embodiment the blast gas nozzle or air cap 213 is formed of a material which is transparent to at least a major portion of the radiant heat energy, as for example being formed of fused quartz or glass. The shape of the inner surface of this nozzle 226 is designed solely from the standpoint of gas flow characteristics in the manner of a conventional blast gas cap. The outer surface 223, however, is shaped so as to provide the optimum shape for a reflector for redirecting and focusing the radiant heat energy from the heat-fusible material back to this material. The outer surface 223 of the cap 213 is plated with a reflective plating as, for example, a gold plating. The outer reflective coating will therefore act as an optimum reflector for the radiant heat energy, the shape of which does not detrimentally affect the gas flow characteristics through the nozzle. The transparent portion 224 of the cap 213 is connected to a metal base portion 225 which is joined to the gun in the identical manner as shown in FIG. 1. In all other respects the embodiment is identical to the embodiment shown in FIG. 1.

While the embodiments as shown in FIGS. 1 and 2 are shown in connection with a wire combustion flame-type gun, the same are equally applicable to other type guns. In this connection, for example, the nozzle 12 may be considered a powder nozzle wherein, in place of the wire or rod 1, powdered heat-fusible material is passed through the central bore, entrained in a carrier gas. Additionally, the same may be considered analogous to a crucible gun wherein melted material from the crucible is passed through the orifice where the wire 1 is shown.

While in the embodiments shown in FIGS. 1 and 2

the radiant energy is redirected and concentrated in the areas adjacent the heating zone and in the heating zone itself, it is also possible to reflect and focus this radiant energy along the path of travel of the heated heat-fusible material to the work surface. Such an embodiment is shown in FIG. 3. In this embodiment 301 represents the outlet nozzle of any conventional heat-fusible material spray gun as, for example, a powder or wire gun operating with any conventional source of heat, such as combustion flame, plasma flame, electrical heating or the like, which may or may not be provided with a blast gas cap 302. The heated and at least softened particles of heat-fusible material being sprayed emerge from the outlet 303 of the nozzle and travel along a path substantially coaxial with the axis of the nozzle to a surface being coated as, for example, the steel surface 304.

In accordance with the invention a cylindrical shroud 305 is positioned coaxially with the nozzle, in front of the nozzle, so that the same surrounds at least a portion of the path of travel of the heated particles to the surface 304. The inner surface of the shroud 305 is polished at 306 and is preferably polished brass or gold-plated with a polish so as to provide a reflector. The radiant energy from the particles of the heat-fusible material traveling to the surface strikes this reflective surface and is redirected and reflected back to the particles.

It has been found that the hot particles being sprayed lose heat rapidly by radiation as they travel from the gun to the work surface. As the heat input from the heating fluid depends upon a high velocity of this fluid across the surface of the material, this heat input also falls off rapidly as and after the particles have been accelerated to their spraying velocity. In accordance with the invention the reflection and focusing of the radiant heat energy back into the particles substantially prevents this heat loss, so that the particles will arrive at the target, i.e., the surface being sprayed, at a much higher temperature. This allows the use of conventional or even larger spraying distances so the work surfaces may be maintained cool, which prevents an unduly high concentration of material build-up and high stress conditions when the material solidifies at the work surface. Furthermore, the temperature differential between the particles and the surface is much higher, so that the particles are more rapidly quenched, which often enhances the quality of the coating produced as, for example, by optimum crystal-structure formation. Thus, for example, the crystal-structure or allotropic form of some materials is affected by the rapidity of the quench. If molten alumina is cooled relatively slowly, crystal structures known as alpha are formed. If, however, the quench is rapid, the gamma and eta forms occur. In accordance with the invention, it is therefore possible to obtain a much higher concentration of the gamma and eta forms due to the more sudden quench which is possible.

In the embodiment as shown in FIG. 4 the cylindrical shroud 405 surrounding at least a portion of the path of particle travel from the nozzle 403 is constructed of a material which is substantially transparent to the radiant heat energy as, for example, fused quartz or glass. The outer surface has a reflective coating 406 as, for example, gold or even silver-plate. The shape of this outer reflective surface is such as to more accurately and concentratedly focus the radiant energy in a number of zones along the path. The purpose of having the smooth inner surface wall of the quartz or glass is to prevent turbulent or eddy flow patterns which might interfere with the spraying. In all other respects the embodiment is identical to that shown in FIG. 3 except that the outlet nozzle of the heat-fusible material spray gun 401 is shown without a blast air cap.

The embodiments shown in FIGS. 3 and 4 may, of course, also be used in combination with the embodiments shown in FIGS. 1 and/or 2.

FIG. 5 shows an embodiment in which the reflected

redirected radiant energy is utilized immediately in front of the nozzle of the gun and along the portion of the path of travel of the heat-fusible material to the target. In this embodiment 501 represents the nozzle outlet of any conventional heat-fusible material spray gun corresponding, for example, to the nozzle 301 in FIG. 3. Surrounding this nozzle is a parabolic reflector 513 with the reflective surface 523. This reflective surface is preferably of polished brass, gold-plate, rhodium, or the like. Surrounding the nozzle and extending along the path of travel of the heat-fusible material leaving the nozzle, is the cylindrical shroud 505 with the inner cylindrical polished surface 506 of, for example, the same material as the surface 523. Additionally the shroud 505 forms an auxiliary blast cap with the air inlet 507 and passage 508 through which a blast gas is passed. The surface 523 reflects and focuses the radiant energy from the heat-fusible material just as the same leaves the nozzle, forming an auxiliary heating zone immediately adjacent the nozzle. The reflective surface 506 reflects and redirects the radiant heat energy of the particles as the same travel from the nozzle to the target.

In the embodiment as shown in FIG. 6, 601 represents the outlet for the hot plasma fluid from a plasma flame generator as, for example, is described in application Serial No. 745,681, now Patent No. 2,960,594 filed June 30, 1958, and Serial No. 745,680, filed June 30, 1958. A spray head is positioned at right angles to this plasma outlet. This spray head has a feed device for feeding the heat-fusible material rod 602, as for example a conventional metallizing rod or wire, through the zone 606 and out through the outlet 607. In accordance with the invention the inner surface 603 and 604, of the main heating and melting zone for the wire, is in the form of a polished reflective surface, as for example polished brass, which is so shaped as to redirect radiant energy from the heat-fusible material and from the plasma flame itself back to the heat-fusible material. The surface 605 of the outlet is also polished, as for example of polished brass and shaped so as to redirect the radiant energy from the atomized heat-fusible material leaving the tip of the wire 606 and redirecting and focusing the same back to this heat-fusible material.

In operation the hot effluent plasma, preferably a free plasma stream from the generator, passes through nozzle 601 into the space defined by 603 and 604, where the same heats the wire or rod 602 and passes along the wire into the outlet 607 and out of the device. As the plasma stream passes through the outlet 607, past the tip of the rod, the same further heats the rod and acts as a blast gas atomizing molten material from this rod and propelling the same toward the surface to be coated. The radiant energy from the heated rod in the zone 606, and from the plasma itself, is reflected by the surfaces 603 and 604 back to the rod. The radiant energy from the molten particles in the outlet 607 is reflected by the surface 605 and focused back on particles being atomized from the rod tip.

With the use of the radiant heat reflector focusing means in accordance with the invention, it becomes possible to spray materials having a melting point very close to the maximum temperature obtainable with the heating means of the particular heat-fusible material flame gun as, for example, the maximum flame temperature. Additionally, as mentioned, the invention allows a substantial increase in spraying speeds, increased deposit efficiency and an improved coating quality.

The following examples are given by way of illustration and not limitation:

Example 1

The metal spray gun used in this example was similar to the one shown in United States Patent 2,593,487 and is commercially sold by the Metallizing Engineering Co. Inc., Westbury, Long Island, as a Type K gun.

Operating the gun with acetylene at 15 lbs. p.s.i. and oxygen at 39 lbs. p.s.i. and air at 70 lbs. p.s.i., maximum spraying speeds obtainable were as follows:

For a $\frac{3}{16}$ " zirconia rod, 3" a minute
For a $\frac{3}{16}$ " alumina rod, 8" a minute.

In the case of the zirconia rod the atomization was coarse, even at this low spraying speed, and the coating quality could not be considered satisfactory.

When using the gun to spray molybdenum at an acetylene pressure of 15 lbs. p.s.i., oxygen 36 lbs. p.s.i. and air at 40 lbs. p.s.i., the maximum speed obtained with a $\frac{3}{16}$ " fire was 10.4" per minute.

Example 2

Example 1 was repeated except that the air cap is replaced with an air cap having a gold-plated reflecting inner surface as, for example, corresponding to the reflector shown in FIG. 1. Under the same conditions the $\frac{3}{16}$ " zirconia rod will spray at $6\frac{1}{2}$ " a minute, the $\frac{3}{16}$ " alumina rod at 10.5" a minute, and the $\frac{3}{16}$ " molybdenum wire at 11.8" per minute. In the case of zirconia much better atomization is obtained and the coating formed, as for example on a steel plate, is of much higher quality.

Example 3

A powder type metallizing gun, as for example described in U.S. Patent 2,820,670, was used. The gun is commercially sold by the Metallizing Engineering Co. Inc., Westbury, Long Island, as a Thermospray Type P gun. The gun was operated with oxygen and acetylene, using an oxygen pressure of 14 lbs. p.s.i. and an acetylene pressure of 12 lbs. p.s.i. Zirconia powder having a particle size of minus 325 mesh was sprayed onto a steel plate. The deposit efficiency (percentage of powder used which is deposited on the work surface) was 82% at a powder feed rate of 2.3 lbs. of powder per hour.

Example 4

Example 3 was repeated except that the gun was provided with a reflector shroud as shown in FIG. 3 having an inner surface of polished brass. The deposit efficiency increased to 93%.

A comparable improvement in spraying results is obtained when using the invention in connection with other heat-fusible materials of any conventional type, including powder guns, guns operated with plasma and the like.

While, as mentioned, radiant heat has never been successfully utilized in the spraying of heat-fusible material and while there is a substantial difference in utilizing radiant heat per se and the reflected-back radiant heat as described above, nevertheless the success in the use of the reflected-back radiant heat as described suggests the utilization of radiant heat per se in heat-fusible material spray guns. I have furthermore discovered that radiant heat from a hot body radiator may be used in connection with heat-fusible material spray guns in addition to the reflected-back radiant heat described above or in place thereof, as an auxiliary heating means or even as the primary heating means, the latter particularly in the case of spraying lower melting point materials, such as zinc, silver, lead, and the like.

In accordance with this embodiment of the invention a hot body radiator is positioned for emitting and directing radiant heat energy toward the heat-fusible material to be sprayed, in addition or in place of the normal heating means.

In the embodiment as shown in FIG. 7, 701 represents the nozzle outlet of the conventional heat-fusible material spray gun of the type described above. The pre-softened particles of heat-fusible material emerge from the outlet 702. A cylindrical shroud 703 of, for example, ceramic material or metal surrounds at least a portion of the path of travel of these materials to the

surface. This shroud is provided with a wire coil 704, either of the electrical resistance heating type or induction heating type, so that the shroud 703 will be heated to a high temperature radiating radiant heat which will effect an auxiliary heating of the particles along their path of travel. Where coil 704 represents an inductive heating coil the shroud 703 should be of a conductive metal or ceramic material which is readily heated by the induction currents. The inner surface of the shroud 703 should be chosen from materials with high emissivity which will readily radiate radiant heat energy, as for example copper and iron. The shroud 703 may, in addition, be provided with a reflective surface so that the radiant energy from the particles is at least partially reflected back and focused. For this purpose materials should be chosen which will both emit when heated and reflect the desired radiation, as for example copper and brass. It is advantageous to provide an insulating coating over the outside of the shroud 703 and outside of the coil 704 to prevent heat loss.

Materials may also be chosen in any of the preceding embodiments which will absorb a portion of the spectrum band, thereby becoming heated and thus radiating, and which in addition reflect another portion of the spectrum band to reflect back radiant energy, as for example titania and alumina. In any case, however, the reflectivity and emissivity of the material should be chosen with respect to the operating temperature of the device.

In the embodiment as shown in FIG. 8, 801 represents a nozzle for a heat-fusible material spray gun of the type described above in connection with which pre-softened, heat-fusible material is propelled from the nozzle outlet 802. A shroud in the form of a cylindrical sleeve 803 surrounds the outlet path from the nozzle. A ring of gas jets 803, 804, is directed against this shroud and a combustible gas mixture is passed through these gas jets and ignited, so that the same strikes the shroud, heating the same. The shroud is thus heated to a high temperature and constructed of a material which is well suited to emit radiant energy at the heated temperature in question. Heat-fusible material emitted from the nozzle 802 is additionally heated by this radiant energy. An insulation sleeve 806 surrounds the shroud 805 to prevent external heat loss. Additionally and particularly in connection with low melting material, powdered material in an unmelted and unheated condition in a gas stream may be passed out through the nozzle 802, and the radiant energy from the heated emitter 805 may solely be used for heat-softening the heat-fusible material being sprayed. This embodiment, however, is merely intended for lower melting point materials, as for example zinc, silver, lead or the like. The surface of the shroud 805 may additionally be reflective as described previously.

The problems encountered in the heating of heat-fusible material in the spraying art are sui generis and the teaching in the other heating arts is generally not relevant. Nevertheless, the reflecting and focusing of the radiant heat from the heat-fusible material in accordance with the above, has suggested the utilization of this principle in the other heating arts.

In accordance with a further embodiment of my invention I have discovered that in connection with plasma flame heating, the radiation losses are particularly great and the heating effect may be substantially improved along with the economy if the radiant energy from the object being heated by the plasma flame is reflected back to this object. Furthermore, the radiant energy from the flame itself may be reflected and focused on the object. In this connection the source of the plasma flame is not at all critical and any conventional or known plasma flame or plasma arc generator may be used, including the free plasma flame as described in co-pending application Serial No. 745,681, filed June 30, 1958.

In the embodiment as shown in FIG. 9, 901 represents the nozzle of any conventional plasma flame generator,

as for example a plasma torch described in application Serial No. 745,681, filed June 30, 1958. The plasma flame is emitted from the opening of the nozzle 902 and directed against the surface 905 for any conventional purpose, as for example heating, melting, cutting, welding, annealing or the like. In accordance with the invention an elliptical reflector 903 with a polished radiant heat-reflecting surface 904 is provided. As the surface 905 is heated up, the radiant energy therefrom strikes the polished surface 904 of the reflector and is reflected back and focused on the work, thus substantially increasing the heating effect and efficiency.

Furthermore, the radiant energy from the plasma flame itself emitting from 902, is reflected and focused against the surface.

It has also been advantageous to construct at least a portion of the inner surface of the nozzle electrode of the plasma generator as, for example, of the type shown in application Serial No. 745,681, as a reflector, such as by constructing the same of polished reflective materials.

The shape of the reflecting and/or radiating surfaces in accordance with the invention described above depends upon the individual uses for which the same are intended. Thus, if the heat is to be distributed over a fairly wide area, it may be desirable to focus the radiant energy over such a wide area. Conversely, if it is desired to concentrate the heat at a small area, the surface should be so arranged to focus the heat at this area. The shapes of the various reflecting surfaces, in order to achieve this function, are of course within the skill of the artisan.

The above description of the invention has been given for purposes of illustration and not limitation. Various changes and modifications which fall within the spirit of the invention and scope of the appended claims will become apparent to the skilled artisan. The invention is therefore only intended to be limited by the scope of the claims or their equivalent wherein I have endeavored to claim all inherent novelty.

I claim:

1. In a heat-fusible material spray gun having means for heating heat-fusible material to be sprayed and for propelling the heated material in at least heat-softened condition away from the gun, the improvement which comprises a radiant heat reflector shaped and positioned in the path of radiant heat emitted by the heated heat-fusible material being sprayed to redirect and focus said radiant heat back against said heat-fusible material.

2. Improvement according to claim 1 in which said means for propelling the heat-fusible material includes a blast gas nozzle and in which said blast gas nozzle defines said reflector.

3. Improvement according to claim 2 in which said blast gas nozzle has an inner surface of radiant heat transparent material, with said reflector defined outwardly thereof.

4. Improvement according to claim 3 in which said reflector is in the form of a reflecting plating on the outer surface of said nozzle.

5. Improvement according to claim 1 in which said reflector has a substantially circular, cross-sectional shape and is positioned coaxially with a nozzle outlet provided on the heat-fusible spray gun.

6. Improvement according to claim 1 in which at least a portion of said reflector is in the form of a shroud surrounding at least a portion of the path of travel of sprayed heat-fusible material from the gun.

7. Improvement according to claim 1 in which said

reflector has a substantially gold-colored reflecting surface of a tarnish-resisting material.

8. Improvement according to claim 1 in which said gun has a heating zone for at least heat-softening the heat-fusible material, said reflector surrounding said heating zone.

9. Improvement according to claim 8 in which said reflector is defined by a polished wall defining at least a portion of said heating zone.

10. Improvement according to claim 1 in which said heat-fusible material spray gun is provided with an exit nozzle from which the heat-fusible material is sprayed, and in which said reflector is defined by a polished wall of at least the outlet end portion of said nozzle.

11. Improvement according to claim 1 in which said heat-fusible material spray gun is provided with an outlet nozzle, and in which at least a portion of the wall of said nozzle is polished to form said reflector and including an additional reflector positioned in front of said nozzle.

12. In a heat-fusible material spray gun having means defining a heating zone, means for passing a combustible gas and a combustion supporting gas for flame combustion into said heating zone, means for passing the heat-fusible material through said heating zone for at least the heat-softening thereof, and means for propelling the heat-softened, heat-fusible material away from the gun for spraying, the improvement which comprises a reflector shaped and positioned in the path of radiant heat emitted by the heated heat-fusible material being sprayed to redirect and focus said radiant heat back against said heat-fusible material.

13. Improvement according to claim 12 in which said means for propelling the heat-fusible material includes a blast gas cap at least partially surrounding said heating zone and means for passing a blast gas through said blast gas cap, and in which said reflector is defined by at least a portion of said blast gas cap.

14. In the method for spraying heat-fusible material in which the heat-fusible material is heated to at least heat-softened condition and propelled, the improvement which comprises reflecting back radiant heat energy from the heated heat-fusible material against the said material.

15. In a plasma torch, the improvement which comprises a radiant heat reflector shaped and positioned in the path of radiant heat emitted by the material being heated by the torch to redirect and focus said radiant heat back against the material.

16. In a plasma torch, the improvement which comprises a radiant heat reflector positioned in the path of radiant heat emitted by the torch to direct and focus said radiant heat against material being heated by the torch.

17. In the method of heating objects with a plasma flame in which the plasma flame is directed against the object being heated, the improvement which comprises reflecting radiant energy from at least one of the plasma flame and the material being heated in focus against the object being heated.

References Cited in the file of this patent

UNITED STATES PATENTS

2,673,121	Brennan	Mar. 23, 1954
2,794,677	Collardin et al.	June 4, 1957
2,858,411	Gage	Oct. 28, 1958
2,874,265	Reed et al.	Feb. 17, 1959
2,960,594	Thorpe	Nov. 15, 1960

FOREIGN PATENTS

1,087,688	France	Nov. 20, 1953
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