June 26, 1962 C. G. A. ROSEN ET AL 3,041,194

METHOD AND APPARATUS FOR METALLIZING

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Fig. 1.

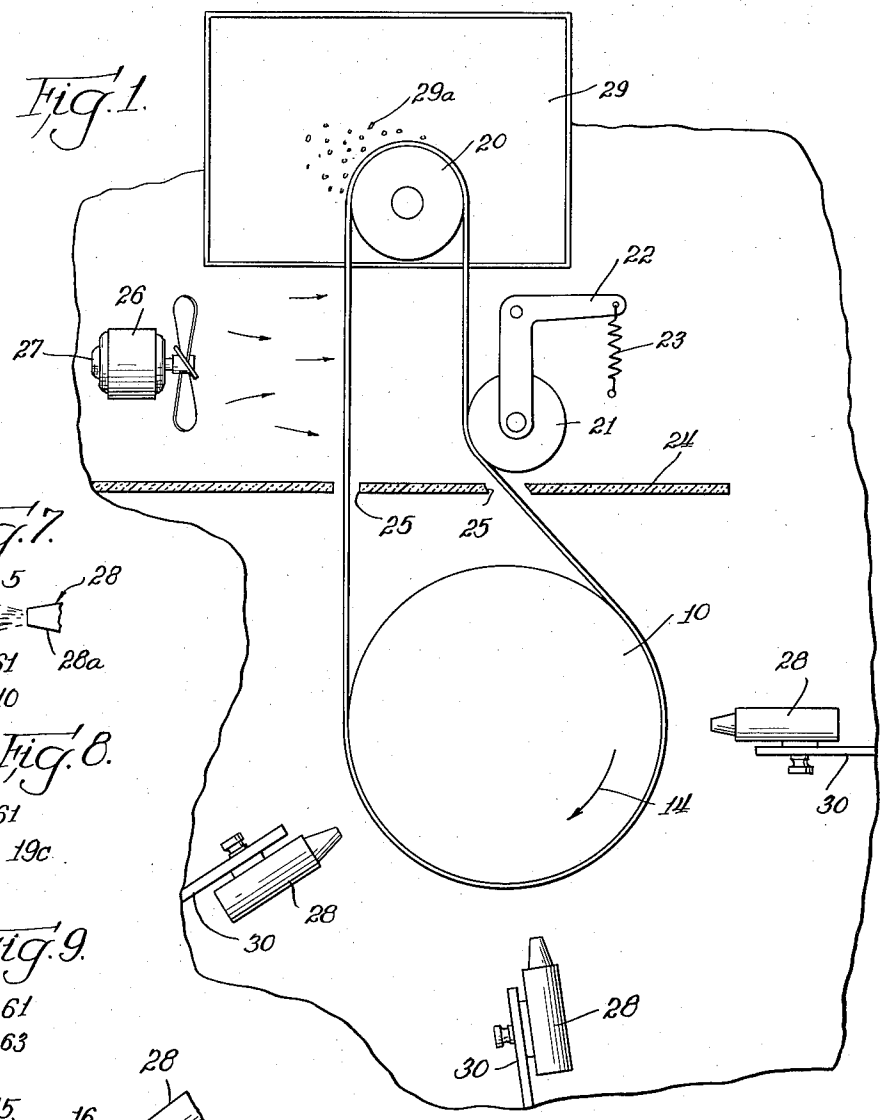


Fig. 7.

Fig. 8.

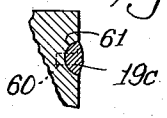
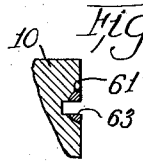


Fig. 9.



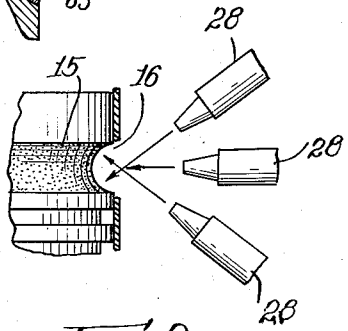


Fig. 2.

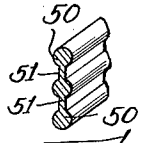


Fig. 4.

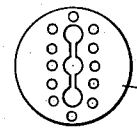


Fig. 3.

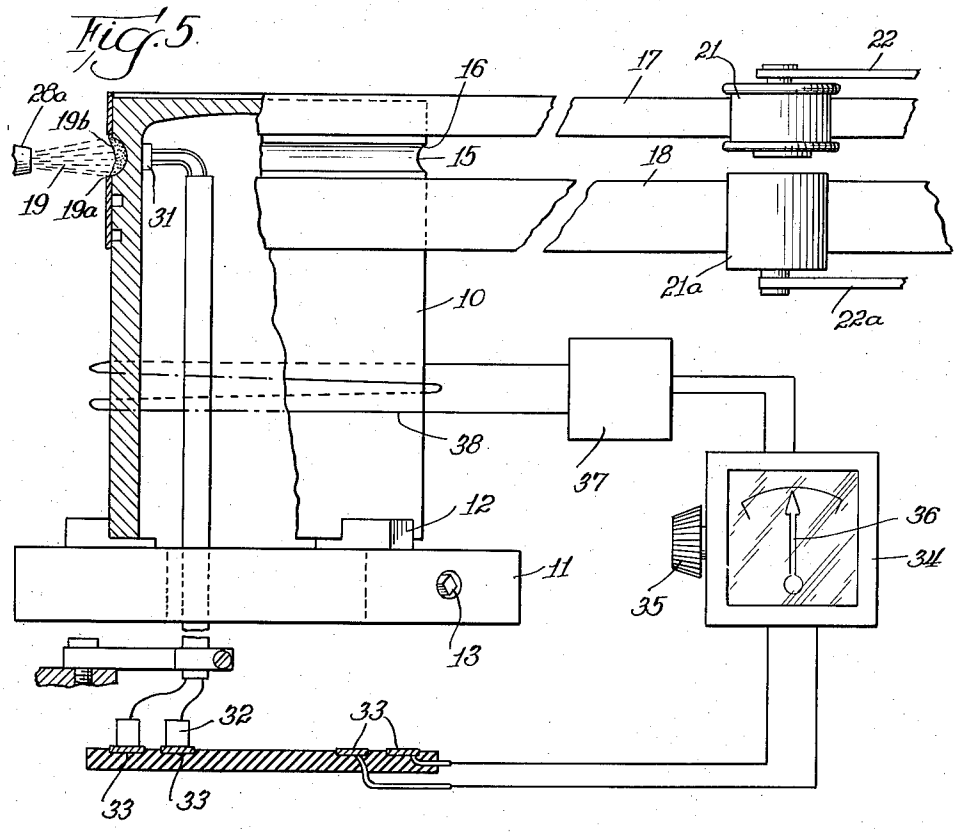
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Fig. 5.



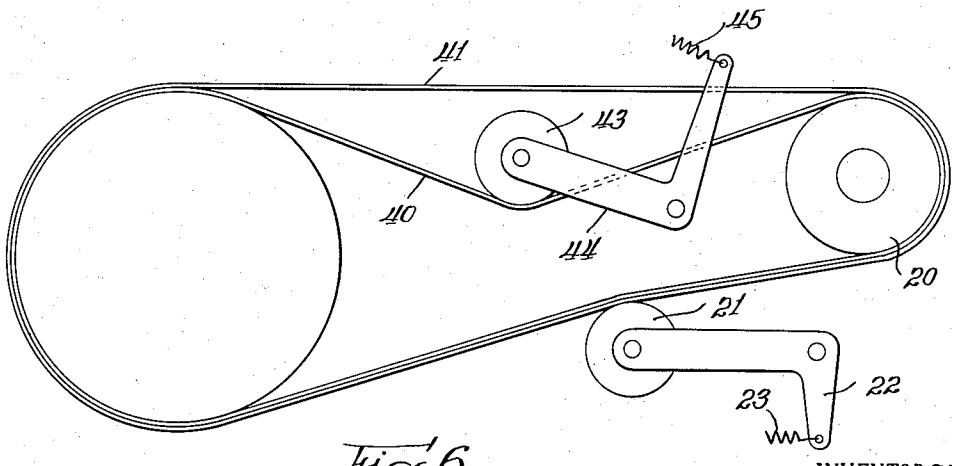


Fig. 6.

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METHOD AND APPARATUS FOR METALLIZING

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The present invention relates to a process and apparatus for metallizing articles and, more particularly, to the spraying of molten metal upon moving surfaces over limited areas.

When spraying molten metal at high velocity on a limited area to fill up or build up the area, there occurs a scattered deposit of metal or overspary where it is not wanted on adjacent areas. This requires extra machining time to remove the excess represented by the overspray and entails a large waste of material. Moreover, depositing molten metal by spray in large quantities raises the temperature of the receiving body unduly and prevents uniform conditions being maintained for predictable results.

One of the objects of the present invention is to provide a process and apparatus wherein the temperature of a body being sprayed is maintained at a predetermined level regardless of the quantity of molten metal being applied.

Another object of the invention is to provide an improved contour for receiving the spray with minimum lateral and thickness overspray.

A further object of the invention is to mask in an improved way areas bordering an area being metallized and recover the waste spray as chips uncontaminated by machining oil and debris which occurs when waste is removed as by machining.

The invention is further characterized by a self-cleaning mask for metallizing spray which serves as a constant thickness depth indicator for the amount of metal applied on an adjacent working area.

The invention also contemplates an improved metallizing technique wherein greater quantities of molten metal can be applied in a short time without overheating the work piece.

A further object of the invention is to provide an improved temperature control for temperatures of work pieces being metallized with a metal of a much higher melting point temperature.

These being among the objects of the invention, other and further objects will be apparent from the description and the drawings, in which:

FIG. 1 is a plan view in schematic representation showing one form of the invention;

FIG. 2 is a side view in schematic representation of the relative position of some of the parts shown in FIG. 1;

FIG. 3 is a front end view of a metallizing gun flame head showing a preferred form of the invention;

FIG. 4 is a perspective view, partly in section, showing the preferred form of spray gun wire;

FIG. 5 is a side elevational view of an apparatus schematically showing an embodiment of the invention;

FIG. 6 is a plan view in schematic representation similar to FIG. 1 showing a modification of the invention, and

FIGS. 7, 8 and 9 are sectional views showing another embodiment of the ring groove in various stages of its formation.

As described in application Serial No. 435,696, now Patent Number 2,833,668, reference to which is hereby made, an improved method of bonding two metal masses to each other comprises spraying one metal against another wherein the melting point of the metal sprayed is preferably above the boiling point of the other metal.

Thereafter, if desired, other layers of the same metal or of a different metal can be added in light or heavy layers, in small or large quantities within a given time.

In the practice of such a process, if the metal of the lower melting point is heated to a temperature just below its melting point, the heat that must be supplied by the sprayed metal as the latent heat of vaporization to vaporize a thin surface layer of the other metal is much less than would otherwise be required. Such permits metals to be used where the melting temperature of the higher temperature metal can be comparatively close to the boiling point of the lower temperature metal. Consequently, the heat required is barely a little more than the difference between the sensible heat of the lower temperature metal and the melting point of the higher temperature metal, plus the heat units required for the latent heat of vaporization of the lower temperature metal.

Then, too, whether the sprayed metal is applied very thinly or very thickly, its application should be confined to the area desired so that any machining required afterwards is not confronted with the removal of a lot of overspray metal.

In the present invention, as embodied in a method and apparatus for molecularly bonding molybdenum and stainless steel to an aluminum piston body to provide a compression ring groove that withstands long periods of hard usage, the piston is heated and rotated about a predetermined axis with spaced stainless steel or polished aluminum bands or belts running with and against it as marginally located to border an improved groove shape. Molten metal is sprayed into the groove and against the piston body between the bands. The overspray lands on the bands and is carried thereby to a place remote from the piston where a sharp flexing of the bands causes the overspray to chip off and collect in a clean pile of metal.

The bands also serve as coolant controls for the piston because they can be controlled with respect to the amount of heat which they dissipate between the time they leave contact with the piston and again come into contact with the piston to pick up more heat.

In FIG. 1, an aluminum piston is identified at **10** as clamped upon a spindle or turntable **11** (FIG. 5) by centering clamps **12** tightened through individual clamp screws **13**. In the embodiment shown, the turntable is rotated in the direction indicated by the arrow **14** and the cooperating parts are arranged accordingly. As shown in FIGS. 2 and 5, the upper or compression ring groove **15** is machined to the shape shown in which its sectional contour is part of a circle or ellipse with diverging side walls **16**. Two spaced bands **17** and **18** are located so that their adjacent marginal edges are disposed close to the outer edges of the side walls **16**.

The two bands **17** and **18** are continuous and each runs over two flat pulleys, one a pulley **20** of small diameter journalled to rotate on a fixed axis and the other a lag pulley **21** carried by a lever **22** urged by spring **23** to take up the slack in the band. A barrier **24** having suitable apertures **25** for the passage of the bands is disposed behind the piston and a fan **26** drives cooling air over the bands at a rate determined by the conventional speed governor and control knob **27**. A catch pan **29** is located below the pulley **20** to receive the chips **29a** of overspray broken from the bands.

Metallizing spray guns **28** such as those sold commercially under the trademark Mogulectric are located at spaced points around the piston as slidably mounted upon radially disposed tracks **30** that are also adjustable in a vertical plane. As shown in FIG. 2, the three guns can be disposed with different pitches to direct their spray along different paths to strike different portions of the

groove, preferably with each disposed in alignment with a radius of the groove's sectional contour.

The turntable is also equipped with a thermocouple which internally engages the body of the piston, and, through brushes 32 and rings 33 the thermocouple actuates a switch 34 at a predetermined temperature that is set by the hand knob 35. The thermostat preferably has a temperature indicating hand 36. An induction heater 37 and coil 38 is controlled by the switch to bring the piston quickly up to the working temperature before the metallizing guns are brought into operation. The quick heat conductivity enables rapid normalization in this respect. It will be appreciated that where the piston is made of a metal of high heat conductivity such as aluminum, the thermocouple could be located elsewhere if desired. However, the location indicated in the drawings is preferred because ring carrier units that are later installed on piston bodies can be handled by the apparatus shown with suitable extensions on the clamps.

Once the metallizing guns are turned on, molten metal 19 is driven against the piston in the ring grooves as the piston is rotated, leaving a fill 19*b*, and some spray 19*a* falls on the bands 17 and 18. As the bands run around the piston and pulleys, the sharp turn or flexing induced by the small pulley 20 cracks the overspray from the band to drop it into the catch pan 29. The bands absorb heat from the piston through their contact with it and this heat is carried away towards the pulley 20. Leaving the pulley 20 the band returns to working contact again with the piston to repeat its function.

Depending upon the temperature indicator hand 36, the bands are cooled by the air from the blower or fan 26 to dissipate the acquired heat to a predetermined degree, as set by the fan speed governor 27. In performing their best control function it is seen that the bands are located where the highest heat input to the piston occurs, namely, where the spray is striking the piston, and thereby provide the best heat control possible where it is most important.

As shown in FIG. 6, if desired each band may be in two parts, superposed on each other with the inner one 40 made of aluminum or copper for quick heat pickup and the outer one 41 of steel to withstand the impact of the molten metal spray of high heats such as that involved with molybdenum. Preferably in this embodiment the inner band is the longer band so that it can be run out of contact with the outer band over a portion of their paths and air can contact both sides of both bands. This separation is accomplished by another lag pulley 43 suitably mounted on a lever 44 actuated by a spring 45.

It is further preferred to employ a novel form of wire for the metallizing guns, converting them to have a nozzle as shown in FIG. 3 to take the wire form shown in FIG. 4. In this way, more than three times the amount of metal can be sprayed without altering the flame ports of the gun. In the wire form shown, the greatest area for uniform flame-heat absorption is presented to the flames.

The form is one in which circular wire shapes 50 are joined by webs 51 to provide a unitary ribbon or wire form in which there is no thickness greater than the radius of the wire with respect to the heat load carried by each flame. Where the wires are located, flames are on directly opposite sides and the webs are narrow enough that their metal content is melted from the flame edges simultaneously and economically with the wire portions. Thus an integral wire ribbon which will melt throughout its transverse section substantially simultaneously is provided which also fans out the molten spray enough to be more than the equivalent of three guns. If the groove is wide, the major sectional dimension of the ribbon is disposed crosswise of the groove. With narrower grooves the ribbon is canted to concentrate the spray in the groove. The same feed rate is used with suitable increase in flame heat input, and one gun can do the work of three conventional guns, and three guns the work of nine conventional guns or more without overheating the workpiece. Thereby the metallizing time is cut as much as nine-tenths for the same volume of metal. The round groove is preferred since it mates most naturally with the cones of conventional guns or the elliptical cones of the improved wire form with minimum lateral of thickness overspray.

In this connection, referring now to FIGS. 7, 8 and 9, it is not necessary as a matter of economy to have the groove 15 and the spray fill 19*b* extend the full depth required for a ring groove. The hammering action of the compression ring in the ring groove need only be opposed by a wall of stainless steel or other hard metal over the wall area of the ring that contacts the walls of the ring groove.

With the molecular bond provided as described herein and in said application, the heat conducting aluminum body of the piston can be exposed at the bottom of the ring groove to the piston ring and any expansion springs that may be present behind it. This heat conductivity at this point prevents any possible build up of heat in the ring and the supporting spring, thereby increasing its effective life and assuring uniform perforance.

As shown in FIGS. 7 and 8, the ultimate expected ring groove contour is indicated by the broken line 60. The preliminary groove cut in the wall of the cylinder is indicated at 61 and as shown in FIG. 7, the gun 28 with the nozzle 28*a* is located square with the piston. The spray pattern of the gun is determined and the groove is cut to meet the spray pattern so that the center and sides fill up proportionately and the fill 19*c* comes out even with the surface over its whole surface when the level of the piston wall is reached.

Thereafter as shown in FIG. 9, the ring groove 63 is cut through the fill 19*c* and down into the aluminum body of the piston. Thus once the proportion is computed with respect to the spray pattern, a round nose tool is contoured accordingly to make the initial cut to form the groove 61 in a one-step operation. The gun can be located square to the piston wall and left there until the fill is made. The hot metal particles impact the surface of the groove and are not subject to eddy currents which otherwise chill the particles, prevent them bonding in the fill and make of them undesirable waste metal dust.

Thus knowing what the wear surface is that is required on the walls of the groove and the pattern of the spray, the depth and arc of the initial groove can be determined so that overspray is minimized and the groove is solidly filled.

In operation, it is preferred to raise the temperature of the aluminum to 450° F., or more, so that it is above the "shine" point of the metal. Then one of the guns is turned on to spray a thin layer of molybdenum in the groove where it vaporizes and disperses the oxidized surface of the aluminum so that molybdenum molecularly bonds with the pure aluminum. The molybdenum gun is turned off and stainless steel is sprayed from one or more of the other guns shown (more than two could be used if desired) until a predetermined depth is attained. The overspray, or side spill, from the guns is carried away by the bands and dropped in the catch pan, and being clean as they engage the piston, the thickness of the bands serves as a thickness gauge for the applied spray depth.

If the temperature at the groove increases from the heat input of the spray, the bands can be cooled to any degree desired to carry away the surplus heat.

Having thus described the invention and the preferred forms thereof, it will be appreciated how the objects are attained and how various and other changes, alterations or adjustments can be made without departing from the spirit of the invention, the scope of which is commensurate with the appended claims.

What is claimed is:

1. The method of metallizing a work piece of high heat conductive material comprising rotating the work piece, spraying molten metal against the work piece layer upon layer in overlapping relationship at a temperature above the boiling point of said material and thereby adding heat to said work piece, simultaneously shielding portions of the work piece in the path of the spray of the molten metal from the spray with a heat absorbing material in heat exchange contact with the work piece and thereby cooling the work piece continuously by conducting heat from the shielded portion through the shielding material to maintain the work piece at a temperature below its melting point.

2. The method of metallizing a work piece comprising rotating the work piece in heat exchange contact progressively with a shield of heat absorbing material, cooling the shield at a point remote from the work piece, spraying molten metal at a temperature above the boiling point of the material of the work piece in an elliptical cone into a sectionally rounded groove bordered by the shield and thereby simultaneously catching the overspray and cooling the work piece immediately adjacent to the spray area progressively by transporting the shield away from the work piece to carry heat units absorbed thereby away from the work piece along with the overspray and the heat thereof to maintain the work piece at a predetermined temperature below its melting point.

3. The method of metallizing a work piece comprising heating a work piece to a temperature just below its melting point and moving the work piece progressively past an area of metal spray application into heat exchange contact with a shield of heat absorbing material, cooling the shield at a point remote from the work piece, spraying molten metal against the work piece at a temperature above the point of boiling the surface material of the work piece, simultaneously catching the overspray and absorbing from the work piece heat units derived from the molten spray at the spray area, and by the shield carrying away from the work piece said heat units and the overspray caught by shield to maintain the work piece at a predetermined temperature below the point of melting the work piece.

4. An apparatus for metallizing a work piece comprising a metallizing gun, means for moving the gun and work piece with respect to each other including a metal band masking means of good heat conductivity having a length greater than the periphery of the work piece, said band being convexly flexed around said work piece defining a predetermined area to be metallized and disposed in heat exchange relationship therewith where it receives overspray, means for moving said masking means lengthwise with respect to said gun to catch overspray progressively from the gun where the band is convexly flexed, and means for removing said overspray progressively from said masking means including a flattened area of the band and an element convexly flexing the masking means in a direction away from the spray exposed surface at a point spaced from the work piece.

5. The combination called for in claim 4 in which said masking means includes two layers of metal, an inner one of high heat conductivity and an outer one containing a ferrous metal of high impact resistivity.

6. The combination of a turntable, a metallizing gun spaced therefrom, means for mounting a work piece upon the turntable, a masking band of good heat conductivity convexly flexed about and in heat exchange relationship with the work piece where it receives the overspray at a point proximate to the gun, said band extending away from the work piece and gun along a portion of a path that is straight to a point remote from the gun, means for flexing said band at said remote point to clean and break off the overspray from the band.

7. The combination called for in claim 6 including a thermostat carried by said turntable and having a thermocouple engaging the work piece, and heat induction means proximate to said work piece controlled by said thermostat.

8. The combination called for in claim 6 including means for cooling said band at said point remote from said gun.

9. The method of forming a piston ring groove in a piston body containing aluminum and having a predetermined boiling point comprising the steps of applying successive layers of molten metal against the piston at a temperature above said boiling point in an elliptical cone into a circumferential, concave groove defined in the piston body, simultaneously shielding and cooling the piston adjacent to the groove progressively by heat conduction from the piston body to a masking band in heat exchange contact with said piston and cutting a groove through the central portion of the fill thus formed into the substrate material of the piston to expose the substrate material of the piston body to heat exchange contact with a piston ring supported between the side portions of the fill.

10. The method of metallizing a metal work piece of high heat conductivity comprising heating the work piece to a temperature just below its melting point and moving the work piece progressively past an area of spray application, spraying molten metal against the work piece over a predetermined area at said point of application and at a temperature above the point of boiling the surface material of the work piece, shielding and progressively removing from said work piece through said shielding on the same side of the work piece solely over an area laterally adjacent to and spaced from said spray area heat units derived from the molten spray to cool the work piece and maintain the work piece in said spray area at a predetermined temperature below the point of melting the work piece.

References Cited in the file of this patent

UNITED STATES PATENTS

1,256,599	Schoop	Feb. 19, 1918
1,865,445	Rutkoskie	July 5, 1932
1,947,493	Rose et al.	Feb. 20, 1934
2,207,765	Stevens	July 16, 1940
2,231,247	Bleakley	Feb. 11, 1941
2,340,903	Shepard	Feb. 8, 1944
2,410,405	Cornelius	Nov. 5, 1946
2,559,351	Drake et al.	July 3, 1951
2,590,557	Melsheimer	Mar. 25, 1952
2,639,490	Brennan	May 26, 1953
2,666,678	Carney	Jan. 19, 1954
2,833,668	Dailey et al.	May 6, 1958