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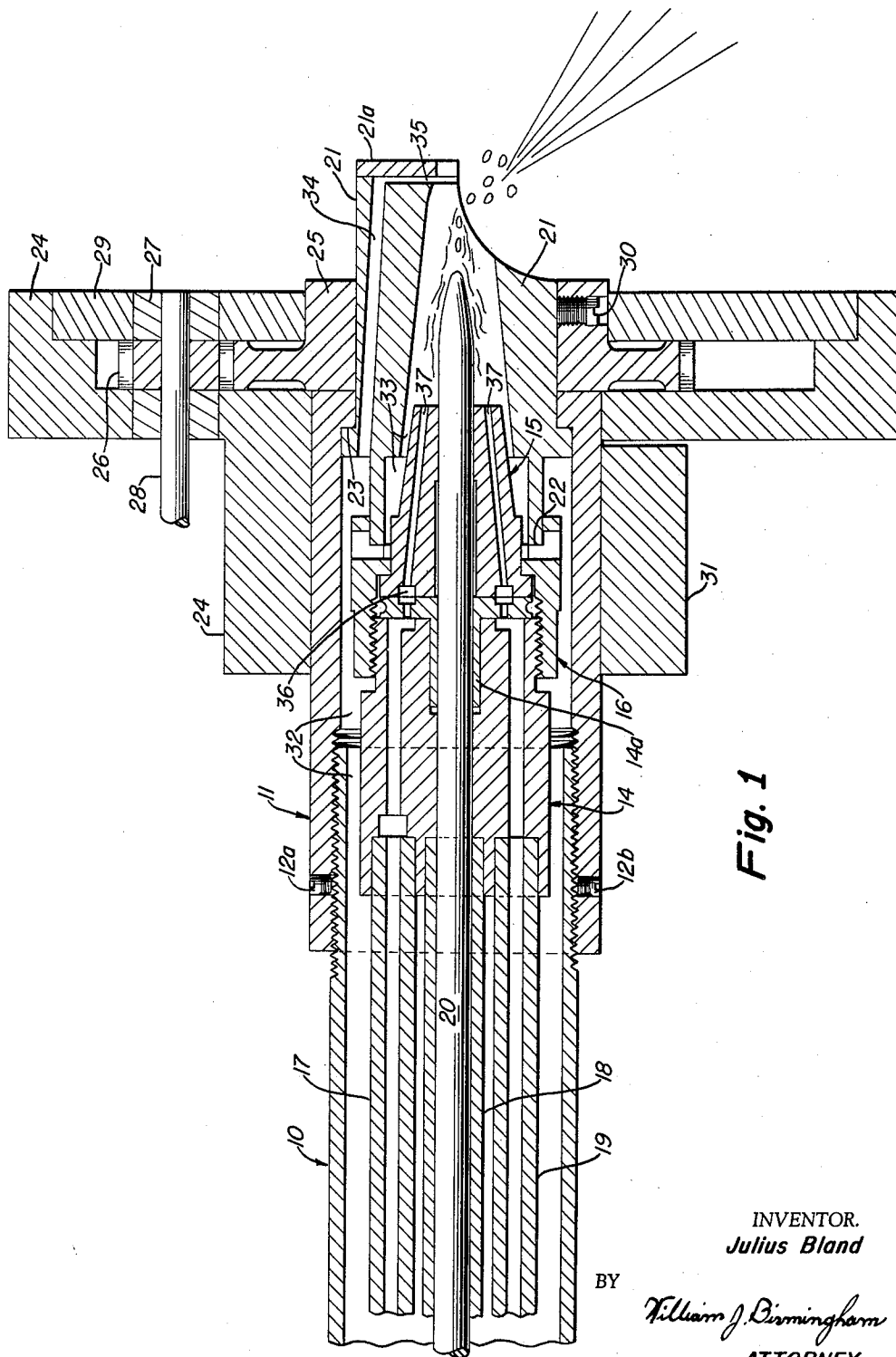
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3,013,528

METALLIZING GUN FOR INTERNAL SURFACES

Filed Sept. 30, 1957

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

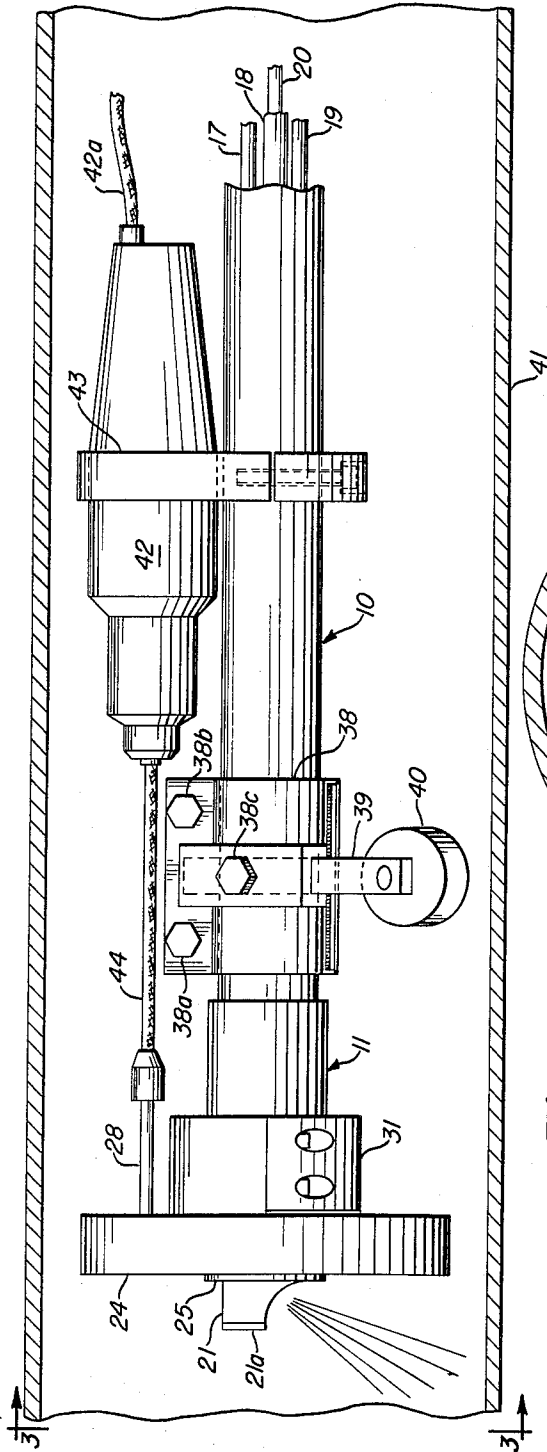


Fig. 2

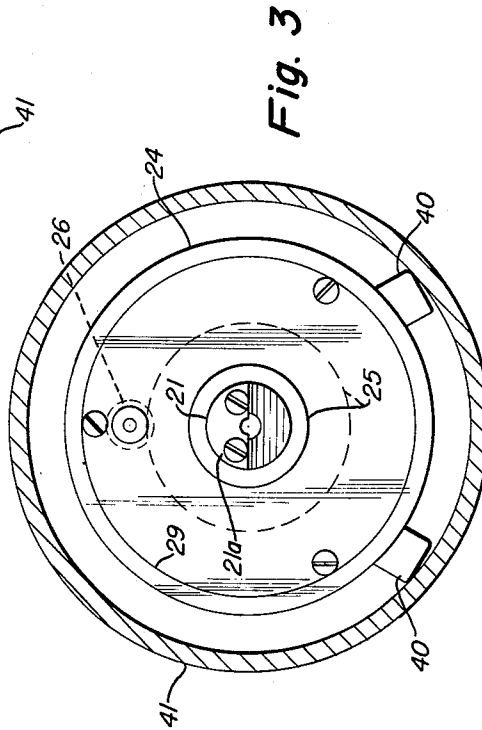


Fig. 3

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3,013,528

METALLIZING GUN FOR INTERNAL SURFACES

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This invention relates to a device for applying sprayed metal to interior surfaces and, specifically, to a metallizing spray gun for applying sprayed molten metal uniformly to the internal surfaces of non-rotatable cylindrical bodies, such as conduits, tubes, pipes, and the like.

One of the most successful and economical methods for minimizing corrosion of conduits used for conveying corrosive gases or liquids without resorting to expensive alloys is to coat the internal surfaces with a protective coating of material of substantially greater corrosion resistance. For many types of service, e.g., reformer furnace tubes subject to the corrosive action of high-temperature hydrogen sulfide or mixtures of hydrogen and hydrogen sulfide, and often alternate oxidizing and reducing atmospheres, it has been found particularly advantageous to coat the internal tube surfaces with aluminum. Such coatings are conveniently applied by dipping the tube in, or otherwise filling the tube with, the protective metal in molten form. Alternatively, the internal surfaces may be spray coated, or damaged protective coatings may be repaired, by use of commercially-available spray metallizing guns. Such guns are capable of supplying a relatively-fine spray of molten metal droplets. The gun is mounted within the tube with the narrow spray of molten metal directed at the surface. The tube is continuously rotated about its axis at a controlled rate so that the spray covers a complete arc of 360°. Simultaneously, the gun is moved at a controlled rate parallel to the axis of the tube so that the tube may be coated throughout its length.

In many cases, however, such as in the case of furnace tubes already installed, it is not feasible to rotate the tubes. Furthermore, efforts to deflect a fine spray of molten aluminum outwards through a continuous arc of 360° and still obtain the desired metallic bonding have been unsuccessful. Thus, prior art techniques such as conical diffusion discs and other solid or gaseous peripheral deflecting means which have proved successful when spraying, for example, paints, resins, plastics and the like are inoperative with fine particles of molten metal. Such devices or techniques cause plugging, non-uniformity and/or non-continuity of the coating, poor bonding and the like.

It is therefore an object of the present invention to provide an apparatus for applying sprayed metal uniformly to the internal surfaces of non-rotatable, cylindrical conduits, particularly tubes and pipes. Another object is to provide a simple device for spray metallizing internal surfaces of conduits throughout their length and which may be readily adapted to pipes of varying diameters. Another object is to provide a metallizing spray gun for uniformly coating the internal surfaces of non-rotatable tubes which is actuated by pressured gases. These and other objects of the present invention will be apparent as the detailed description of the apparatus proceeds.

The invention resides in the discovery of a particular combination of apparatus elements which successfully overcomes the many problems inherent in the molten spray metallization of non-rotatable tube internals. The device comprises, in a simple embodiment, cylindrical nozzle means, said nozzle means containing a plurality of passages therethrough for a continuously-fed rod of solid

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spray material and for combustible gases whereby said solid spray material may be melted when said combustible gases are ignited adjacent to said nozzle means; a heat-conductive rotatable air cap concentric with and extending beyond said nozzles means and positioned with respect to said nozzle means so as to form an annular passage for channeling a first air blast toward the ignited gases and resulting melted spray of said melted spray material, said rotatable air cap also containing an air outlet for a second air blast positioned so as to deflect said fine spray of said melted spray material away from the axis of said nozzle means; means for rotating said rotatable air cap at constant speed about the axis of said nozzle whereby said fine spray of said melted spray material may be deflected continuously through an arc of 360°; and movable support means whereby said metallizing spray gun may be moved with respect to said non-rotatable cylindrical tube and in such a direction that the axis of said spray nozzle and said non-rotatable cylindrical tube are coincident.

The means for rotating the air cap is, conveniently, a driven gear, the axis of which is coincident with the axis of said rotatable air cap and the hub of which forms a collar around and is removably securable to at least a portion of said rotatable air cap, and said driven gear is rotated by motor means, such as a compressed-air-actuated motor, which is mounted on the movable support means and which is suitably coupled to the driven gear. The coupling means may include flexible and/or rigid shafting pinion-coupled to said driven gear.

The movable support means may comprise a hollow body member which is affixed at one of its extremities to the nozzle means and which has a plurality of extendable support legs adjustably attached at their inner ends to the body member and which have wheels, or other rotatable means, mounted at the outer ends in rolling contact with the inner surface of the tube to be sprayed. The plane of the wheels is, of course, parallel to the axis of the nozzle means. By adjusting the length of the extendable legs the metallizing spray gun is so positioned within the tube that the axes of the nozzle means and the tube coincide.

Combustible gases for melting the rod or wire of solid spray material include mixtures of oxygen and acetylene, propane, natural gas, or manufactured gas. In general, mixtures of oxygen and acetylene or propane are preferred because of the higher heat contents. Ratio of oxygen to the other gas depends on a host of variables including composition of the other gas, type of spray metal, rate of feed of the continuously-fed spray metal, hardness of metal coating desired and the like. As pointed out above, air may be used for restricting the resulting flame, for producing a fine spray of molten metal, and for deflecting the resulting spray towards the side of the tube. It should be understood, however, that the use of air is, in part, a matter of convenience and that other "inert" gases may also be used, e.g. nitrogen. In some instances, oxygen-free gases are preferred to minimize undesired oxidation of the spray material. The air or other inert gas also serves to cool the various parts of the spray gun and also the surface being sprayed, thus minimizing any undesired heat up.

The solid spray material may be any metal available in rod or wire form, including aluminum, lead, zinc, bronze, brass, stainless steel, carbon steel, chromium steels, molybdenum, and the like. Selection of the proper spray material depends upon material of the tube being sprayed, type of protection desired, and the like.

A more detailed embodiment of the present invention is illustrated in the accompanying drawings wherein;

FIGURE 1 is a view in longitudinal section of a pre-

ferred form of my spraying device showing details of the spray nozzle, rotatable air cap and means for rotating the air cap.

FIGURE 2 shows additional details of the device including other accessory equipment and the relationship of the assembled parts to each other and to the tube being spray metallized; and

FIGURE 3 is an end view of the device, taken along line 3—3.

Referring to FIGURE 1, hollow body member 10 and body cap 11 with set screws 12a and 12b comprise part of the movable support means shown in further detail in FIGURE 2. Interior, and concentric with, said hollow body member 10 and body cap 11 is the nozzle means comprising nozzle body 14 with insertable nozzle body adapter plate 41a, nozzle head 15, and nozzle clamp 16 which secures nozzle head 15 to nozzle body 14.

Combustible gas tubes 17 and 19 and rigid tube 18 for the rod or wire of spray metal extend the length of body member 10 and are connected to said nozzle body 14. Combustible gas tubes 17 and 19 are connected to a combustible gas supply to the left (not shown). Rigid spray metal feed tube 18 connects with a feeding means (not shown) which feeds a rod or wire of spray metal 20 through tube 18 and through said nozzle body 14 and nozzle head 15. Rotatable air cap 21 (with front cover plate 21a removably secured thereto) abuts against nozzle clamp 16 at surface 22 so that it may be rotated around its common axis with nozzle head 15. Rotatable air cap 21 is held in place by means of body cap 11 which forms a bearing surface with a flanged portion of said rotatable air cap at bearing surface 23. Body cap 11 is screwed down on body member 10 until rotatable air cap 21 is held snugly in position but still has sufficient clearance to rotate smoothly without binding or chattering. Set screws 12a and 12b in body cap 11 fix the position of the body cap and permit adjustments for wear of the bearing surfaces.

The means for rotating air cap 21 comprise housing 24, gear 25, pinion 26, bushing 27, drive shaft 28, and housing cover plate 29. Pinion 26 is rotated by drive shaft 28 which is flexibly coupled to a compressed-air-actuated motor, which is shown in FIGURE 2. Gear 25, the axis of which is coincident with the axis of rotatable air cap 21 and the hub of which forms a collar around and is removably securable to said rotatable air cap by means of set screw 30, meshes with and is driven by pinion 26. Thus, when pinion 26 rotates, gear 25 turns rotatable air cap 21. Housing 24 is removably affixed to body cap 11 by means of housing clamp 31, which is tightened around body cap 11 by means of set screws shown in FIGURE 2.

Hollow body member 10 contains compressed air, at elevated pressure, e.g., 50 to 150 p.s.i.g., which passes into annular space 32 surrounding the nozzle means. This compressed air serves a number of purposes. It passes from annular space 32 into the annular space 33 and thus forms an annular air blast which converges towards the center line of the rod of spray metal which extends to the right of nozzle head 15. This air blast restricts the flame and produces a fine spray of molten metal. Another portion of the compressed air passes through passageway 34 in the upper part of the rotatable air cap 21 and exhausts through an air outlet at 35 which is positioned so as to deflect the fine spray of melted spray material away from the axis of nozzle head 15, e.g., at an angle of 45°. The air blast from both annular space 33 and from air outlet 35 also cools the surface being sprayed so that undue heating does not occur. The compressed air also forces the flange of rotatable air cap 21 against body cap 11 at bearing surface 23, thereby preventing any substantial escape of compressed air.

Contact at bearing surface 23 should, of course, be be-

tween non-scoring bearing metals which have a low coefficient of sliding friction. At the same time, rotatable air cap 21 and metals in contact therewith should have sufficient thermal conductivity to prevent overheating. To obtain a low coefficient of sliding friction at bearing surface 23, metals of dissimilar hardness are used for body cap 11 and rotatable air cap 21. In general, a wide difference in hardness is preferred, limited, of course, by the ability of the two metals to withstand the required loading. To assure rotation of air cap 21 with respect to body cap 11, outside diameter of the flange on air cap 21 must be less than the inside diameter of body cap 11 into which the flange fits, at all temperatures encountered during the spraying operation. To assure such clearance without excessive spacing the coefficient of thermal expansion of the metals should not be greatly dissimilar. In practice we have found a rotatable air cap of bronze and a body cap of steel to be a satisfactory combination. Typically, the nozzle means, gear 25, pinion 26, and bushing 27 may be brass, and housing 24, housing cover plate 29, and housing clamp 31 may be aluminum, thereby minimizing weight and deflection of the apparatus.

During operation of the spray metallizing apparatus a rod or wire of spray material 20 is continuously fed through tube 18, nozzle body 14 and nozzle head 15, and is rapidly melted as it leaves nozzle head 15 by the intense heat of combustion of combustible gases which enter the nozzle means via tubes 17 and 19, are mixed in annular space 36, and are discharged from nozzle head 15 at multiple outlets 37 spaced evenly around nozzle head 15. Typically, one of tubes 17 and 19 contains oxygen at pressure while the other tube contains acetylene or propane gas. The resulting molten metal is formed into a spray of finely-divided droplets, e.g., 50 to 500 microns, by the air blast from annular space 33. The finely-divided droplets are then deflected to the surface of the conduit being sprayed by the compressed air exhausting from air outlet 35.

The rate of rotation of rotatable air cap 21, the feed rate of the rod or wire of spray metal, the selection of combustible gases and the like depend upon a host of variables, such as the size of the wire, the melting rate of the wire, the thickness of the coating to be applied, and the like. For orientation, typical values when spray aluminizing internal surfaces of steel furnace tubes, are a spray metal wire diameter of about $\frac{1}{16}$ to $\frac{1}{4}$ inch. This wire may be substantially-pure extruded aluminum which is fed at the rate of about 25 to 500 feet per minute, e.g., 150 feet per minute. As pointed out hereinabove, the resulting molten aluminum particles may range in size from about 50-500 microns, e.g., 200 microns. Rotatable air cap 21 may be rotated at a rate up to about 120 revolutions per minute, e.g., about 35 revolutions per minute. The spray apparatus may be moved along the axis of the tube being sprayed at a rate of about .1 to 10 feet per minute, e.g. 1 foot per minute. The thickness of the resulting coating is typically in the range of about 0.005 to 0.05 inch, e.g., 0.015 inch.

FIGURE 2 shows additional details with respect to the present invention and how it would appear within conduit 41 which is being spray metallized. Specifically, FIGURE 2 shows further details of the movable support means which comprises hollow body member 10, body cap 11, and body bracket 38, which is bolted by bolts 38a and 38b, or otherwise fixedly secured, to body member 10 and on which is mounted a plurality of extendable supporting legs 39 adjustably secured near their inner end to body bracket 38, and thus to body member 10. Wheels 40 are mounted near the outer end of extendable legs 39 and are in rolling contact with the inner surface of conduit 41, as also shown in FIGURE 3. Length of the extendable legs 39 can be adjusted by loosening bolt 38c so that extendable legs 39 may be slid in or out of a slot in an upraised portion of bracket 38. By this means

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the center line of the nozzle means and rotatable air cap are made to coincide with that of conduit 41. While in the present example only one body bracket with extendable supporting legs is shown, it should be understood that the metallizing spray gun may use a series of such movable support means attached at convenient intervals along the length of the body member 10.

FIGURE 2 also shows the compressed-air-actuated motor 42 with compressed air supply 42a mounted on body member 10 by means of motor bracket 43. This motor drives shaft 28 by means of flexible coupling 44. As pointed out in connection with FIGURE 1, shaft 28 drives a pinion within housing 24, which pinion in turn rotates gear 25 and thus rotatable air cap 21. While a flexible coupling 44, i.e., a wound-wire flexible shaft, is used to couple motor 42 and shaft 28, it should be understood that coupling 44 may, if the axes of motor 42 and shaft 28 coincide, be a rigid shaft.

No novelty is claimed in the means, per se, for feeding the wire of spray metal 20 through tube 18 within body member 10 to the nozzle means, and thus such means is not shown in FIGURE 2. Such devices are available commercially (e.g., from the Metallizing Engineering Co., Inc., Long Island City, New York) and can be obtained by consulting the appropriate equipment catalogs. Likewise, no novelty is claimed in the means for moving the spray metallizing apparatus of the present invention at a constant rate along the axis of the conduit being sprayed and thus such means is also not shown in FIGURE 2. Such latter means could include a support for the means for feeding the wire of the spray material, exterior of the conduit being sprayed, said support being moved at a constant speed by means of chain or worm drive in a direction paralleling the axis of the conduit. Preferably, both the means for feeding the wire and the means for moving the unit along the length of the conduit are compressed-gas actuated, e.g., turbine motors driven by compressed air. Thus, the entire apparatus may be mechanically operated by the energy of compressed gas. This avoids the necessity, and possible danger, of having another energy source, e.g., electricity, and other motive means, e.g., electric-driven motors, present which would complicate the present apparatus.

In the case of compressed-air-actuated motor 42, the air exhausting from said motor solves a problem heretofore unappreciated in the spray aluminizing of tubes, particularly small diameter tubes. During such operation, the gun is withdrawn at a constant rate in a direction to the right of FIGURE 2, as rotatable air cap deflects the sprayed metal continuously through a 360° arc. Because of the confined space within the tube the dust inevitably stirred up by the spray metallizing operation, i.e., by impingement of the sprayed metal and gases, would coat surfaces not yet metallized. In the present apparatus, however, the air exhaust from motor 42 forms a zone of positive pressure which tends to force the dust in a direction away from the spray nozzle, that is, to the left of FIGURE 2. Thus, as a spray apparatus is moved progressively to the right of FIGURE 2, any loosened dust or dirt is forced to the left and away from the surface not yet metallized.

FIGURE 3 shows in better perspective how wheels 40 support the apparatus such that the centerline of tube 41 and rotatable air cap 21 are coincident. For tubes of larger diameter, the extendable legs containing wheels 40 would, of course, be lengthened. In like fashion, for small diameter tubes, the extendable legs would be shortened. The outer screw heads in FIGURE 3 are the means for fastening housing cover plate 29 to housing 24. The inner screw heads in FIGURE 3 are the means for fastening the front cover plate of rotatable air cap 21. The dotted lines in FIGURE 3 illustrate how the hidden teeth of gear 29 mesh with the teeth of hidden pinion 26.

Prior to and/or spray metallizing internal tube surfaces, other preparatory and/or finishing treatments

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might be used. For example, oil, grease and scale may be removed by pickling, flaming, sandblasting and the like. The surfaces may then also be roughened by such techniques as grit blasting and the like. Welding grooves, flange facings and other surfaces which must not be aluminized may be masked. Information with respect to such surface preparation may be obtained from standard metallizing handbooks. After the surface has been metallized, additional treatments may also be employed, such as application of sealing materials, e.g., hydrolized ethyl silicate, aluminum pigmented bitumastic or silicone vehicles, and the like. In the case of spray aluminizing, an additional heat treatment to diffuse the aluminum into the ferrous surface has been found to be advantageous. Such treatment might consist of heating the sprayed tube to a temperature of about 1275 to 1300° F. for a period of about ½ hour. The sprayed surfaces may then also be brushed and air dusted.

While in describing the invention I have referred in detail to the form, arrangement and construction of parts, this is to be considered only in the illustrative sense and I do not wish to be limited thereto, except as may be specifically set forth in the appended claims.

Having described my invention, I claim:

1. In a metallizing spray gun having nozzle means, said nozzle means having a plurality of passages therethrough for a continuously-fed rod of solid spray material and for combustible gases whereby said solid spray material may be melted when said combustible gases are ignited adjacent to said nozzle means, a heat-conductive rotatable air cap concentric with and extending beyond said nozzle means and positioned with respect to said nozzle means to form an annular passage for channeling an air blast toward the ignited gases and resulting melted spray material and to produce thereby a fine spray of said melted spray material, said rotatable air cap also having an air outlet means positioned to deflect said fine spray of melted spray material away from the axis of said nozzle means and onto a tube surface; the improvement enabling said metallizing spray gun to apply sprayed metal uniformly to the internal surfaces of a non-rotatable cylindrical tube which comprises means insertable within said cylindrical tube for rotating said rotatable air cap at constant speed about the axis of said non-rotatable cylindrical tube whereby said fine spray of said melted spray material may be deflected continuously through an arc of 360°, said means comprising a motor means and a gear driven by said motor means, the axis of said gear being coincident with the axis of said rotatable air cap and the hub of said gear forming a collar around and being removably securable to at least a portion of said rotatable air cap, and adjustable support means whereby said metallizing spray gun may be moved axially with respect to said non-rotatable cylindrical tube and in such a direction that the axis of said rotatable air cap and said non-rotatable cylindrical tube are coincident.

2. The metallizing spray gun of claim 1 wherein said motor means is a compressed-gas-actuated motor mounted on said adjustable support means and flexibly coupled to said driven gear.

3. In a metallizing spray gun having nozzle means, said nozzle means having a plurality of passages therethrough for a continuously-fed rod of solid spray material and for combustible gases whereby said solid spray material may be melted when said combustible gases are ignited adjacent to said nozzle means, a heat-conductive rotatable air cap concentric with and extending beyond said nozzle means and positioned with respect to said nozzle means to form an annular passage for channeling an air blast toward the ignited gases and resulting melted spray material and to produce thereby a fine spray of said melted spray material, said rotatable air cap also having an air outlet means positioned to deflect said fine spray of melted spray material away from the axis of said nozzle

means and onto a tube surface; the improvement enabling said metallizing spray gun to apply sprayed metal uniformly to the internal surfaces of a non-rotatable cylindrical tube which comprises means insertable within said cylindrical tube for rotating said rotatable air cap at constant speed about the axis of said non-rotatable cylindrical tube whereby said fine spray of said melted spray material may be deflected continuously through an arc of 360°; and adjustable support means whereby said metallizing spray gun may be moved axially with respect to said non-rotatable cylindrical tube and in such a direction that the axis of said rotatable air cap and said non-rotatable cylindrical tube are coincident, said adjustable support means comprising a hollow body member affixed at one extremity to said nozzle means, extendable legs adjustably attached at their inner ends to said body member and having wheels mounted at their outer ends in rolling contact with the inner surface of said non-rotatable cylindrical tube whereby adjustments to the length of said extendable legs position said metallizing spray gun within said non-rotatable cylindrical tube so that the axes of said rotatable air cap and said non-rotatable cylindrical tube coincide.

4. In a metallizing spray gun for applying sprayed metal uniformly to the internal surfaces of a non-rotatable cylindrical tube which comprises in combination a hollow body member wholly insertable in said non-rotatable cylindrical tube, the hollow interior of said body member providing passages for compressed air, for a continuously-fed rod of solid spray material, and for at least one conduit containing combustible gases capable of melting said solid spray material when ignited; nozzle means at one extremity of said hollow body member and having a common axis therewith, said nozzle means containing a plurality of passages therethrough for said continuously-fed rod of solid spray material and for said combustible gases whereby said solid spray material may be melted when said combustible gases are ignited adjacent to said nozzle means; and a heat conductive rotatable air cap concentric with and extending beyond said nozzle means in a direction away from said body member and positioned with respect to said nozzle means to form an annular passage for channeling an air blast toward the ignited gases and resulting melted spray material and to produce thereby a fine spray of said melted spray material, said rotatable air cap also having an air outlet positioned to deflect said fine spray of melted spray material away from the axis of said nozzle means and onto the surface of the non-rotatable cylindrical tube, said rotatable air cap also having an external cylindrical flange held in bearing contact with said body member by the pressure of said compressed air in said body member; the improvement comprising a plurality of extendible supporting legs adjustably secured near their inner end to said body member and having wheels mounted near their outer end in rolling relationship with the interior surface of said non-rotatable cylindrical tube, and motor means carried by said body member and connected by coupling means to said rotatable air cap to rotate said rotatable air cap at a constant rate around the common axis of said nozzle means and said rotatable air cap.

5. The metallizing spray gun of claim 4 wherein said motor means is a compressed-air-actuated motor.

6. The metallizing spray gun of claim 4 wherein at least the metals of said rotatable air cap and said body member which are in bearing contact are non-scoring bearing metals.

7. In a metallizing apparatus for uniformly applying a spray of finely divided molten aluminum to the internal surface of a non-rotatable cylindrical tube which comprises in combination a hollow cylindrical body member, the hollow interior of said body member providing a passage for compressed air, for a plurality of conduits containing combustible gases capable of melting aluminum when ignited, and for a conduit adapted to receive aluminum wire, said aluminum wire being continuously fed by a first compressed-air-actuated driving means exterior of said tube; cylindrical nozzle means at one extremity of said hollow body member and having a common axis therewith, said nozzle means having a plurality of passages therethrough for said aluminum wire and for said combustible gases whereby said aluminum wire may be melted when said combustible gases are mixed and ignited adjacent to said nozzle means; and a heat-conductive rotatable air cap concentric with and extending beyond said nozzle means in a direction away from said body member and positioned with respect to said nozzle means to form an annular passage for channeling a first air blast toward the ignited gases and the resulting molten aluminum and to produce thereby a spray of finely divided molten aluminum, said rotatable air cap also having an air outlet for a second air blast positioned to deflect said fine spray of finely-divided molten aluminum away from and at a preselected angle to the axis of said nozzle means and onto the surface of the non-rotatable cylindrical tube, said rotatable air cap also having an external cylindrical flange held in bearing contact with said body member by the pressure of said compressed air in said body member, whereby said rotatable air cap may rotate with respect to said body member without substantial leakage of said compressed air at the bearing contact surfaces; the improvement comprising a plurality of extendible supporting legs adjustably secured near their inner ends to the exterior of said body member and having wheels mounted near their outer ends in rolling contact with said internal surface of said non-rotatable cylindrical tube, and a second compressed-air-actuated motor fixedly mounted on said body member adjacent to said nozzle means and connected by coupling and gear means to said rotatable air cap to rotate said rotatable air cap at a constant rate around the common axis of said nozzle means and said rotatable air cap, said second compressed-air-actuated motor being insertable in the non-rotatable cylindrical tube.

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