May 17, 1966 W. H. EBURN, JR., ET AL 3,251,341

FLAME SPRAY METALLIZING APPARATUS

Filed March 7, 1963 4 Sheets-Sheet 1

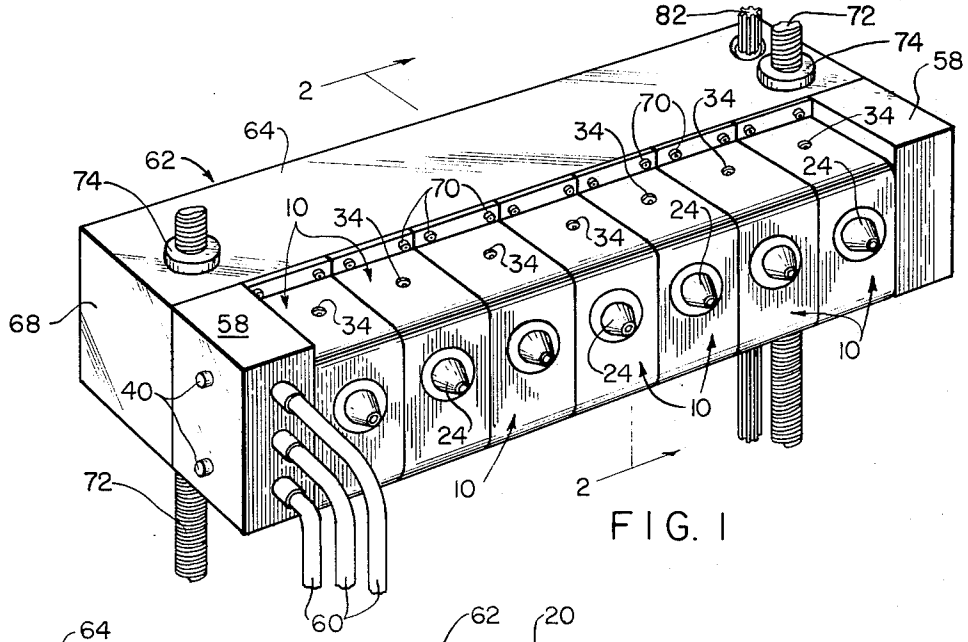


FIG. 1

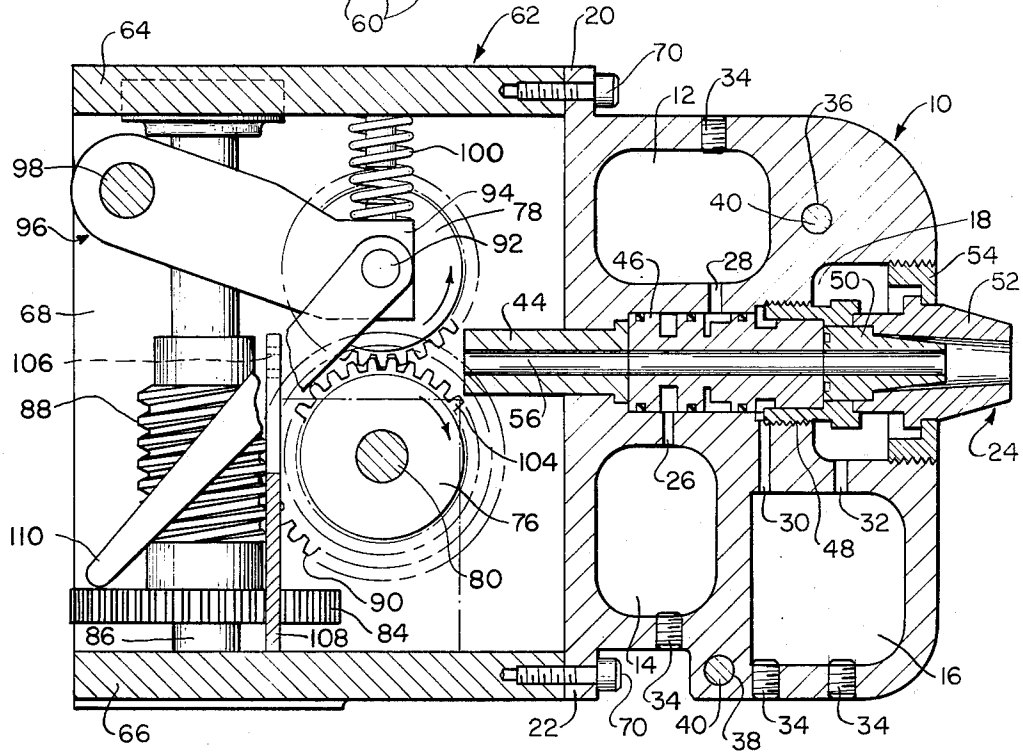


FIG. 2

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FLAME SPRAY METALLIZING APPARATUS

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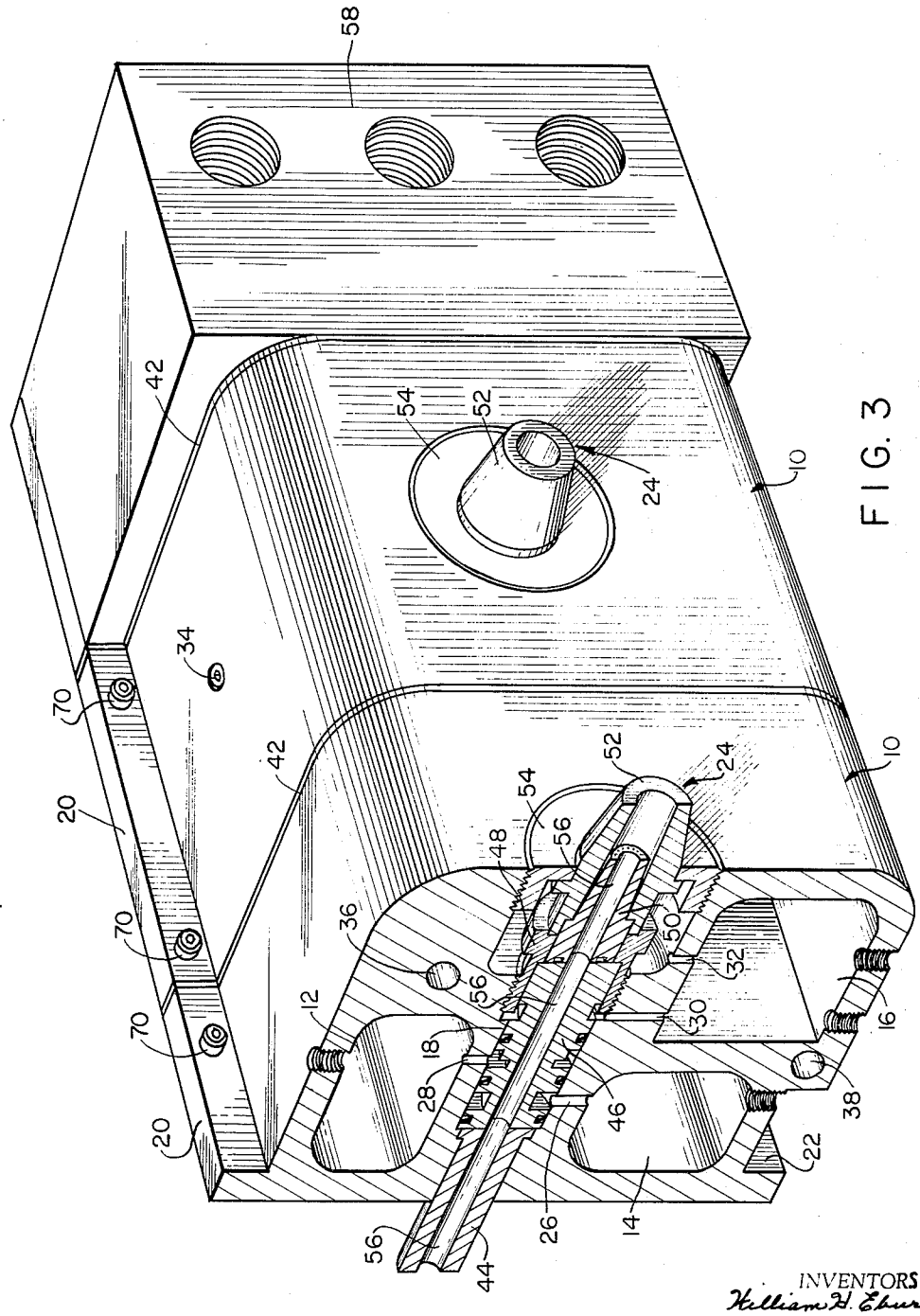


FIG. 3

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FLAME SPRAY METALLIZING APPARATUS

Filed March 7, 1963 4 Sheets-Sheet 3

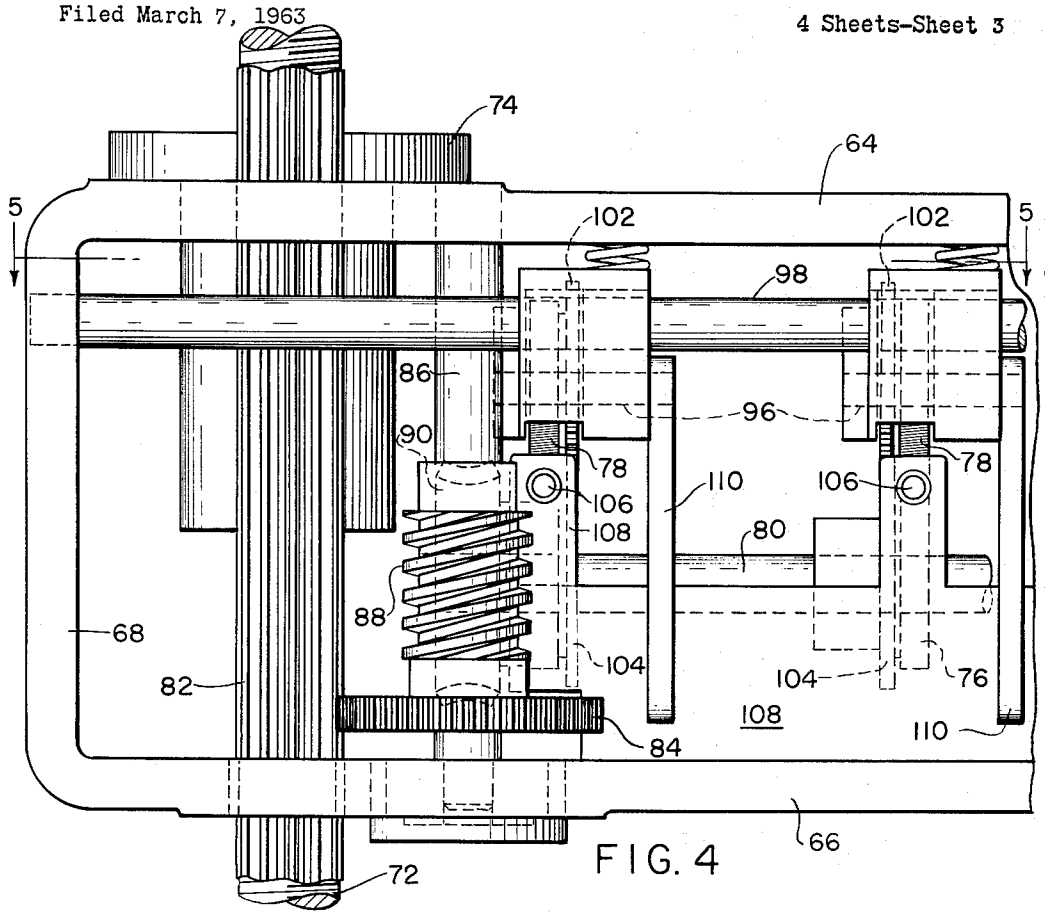


FIG. 4

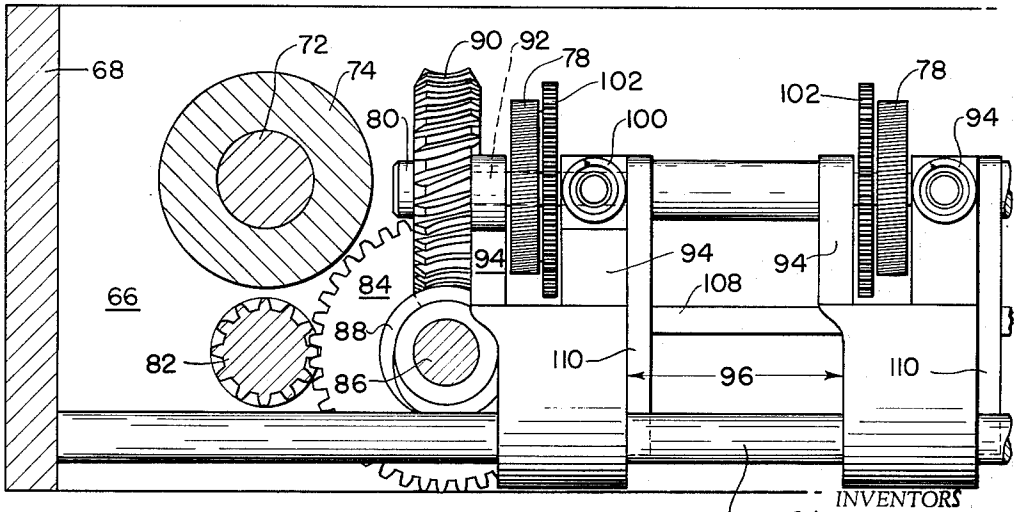


FIG. 5

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FLAME SPRAY METALLIZING APPARATUS

Filed March 7, 1963 4 Sheets-Sheet 4

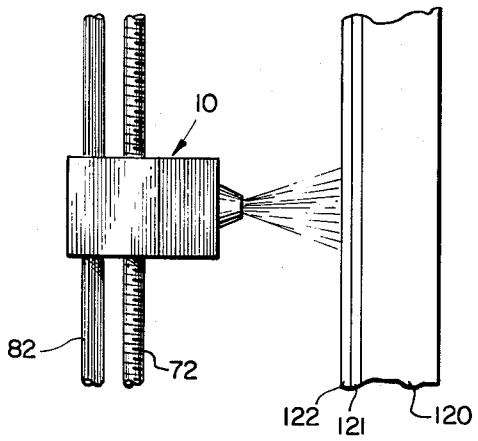


FIG. 6

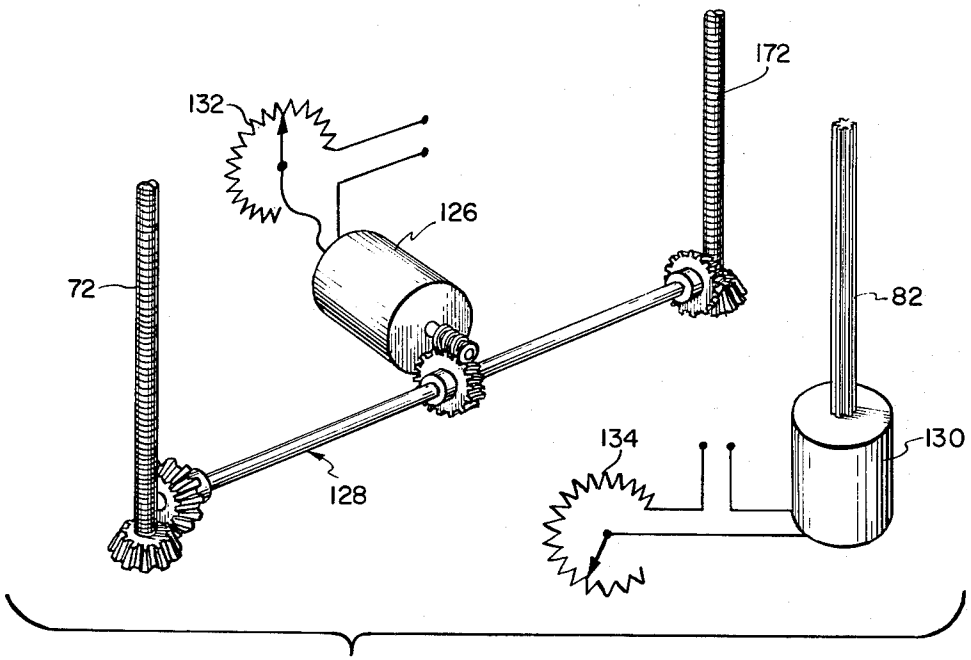


FIG. 7

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3,251,341

FLAME SPRAY METALLIZING APPARATUS

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Filed Mar. 7, 1963, Ser. No. 263,592
17 Claims. (Cl. 118—302)

This invention relates to flame spray metallizing apparatus and particularly to metallizing apparatus including a plurality of spray heads.

Currently available multiple head spray metallizing apparatus is designed and intended for coating objects, usually cylindrical or circular which are usually turned relative to the spray heads during the coating operation; and include complex (electronic) controls for insuring uniform coatings. Flame spray metallizing of plane surfaces, particularly rectangular surfaces of work which is large or difficult to handle, is usually performed manually with a single spray head and represents an expensive, tedious and time consuming process, with no assurance of uniform result.

An object of the present invention is to provide novel and improved multiple head flame spray metallizing apparatus for applying substantially uniform coatings to substantially plane surfaces.

Another object of the invention is to provide apparatus of the foregoing type having a simple and inexpensive construction which makes complex controls unnecessary, and is designed for substantially automatic operation particularly in a production process in which a succession of plane surfaces are metallized rapidly and uniformly in a minimum time and at little expense.

A further object of the invention is to provide flame spray metallizing apparatus of the foregoing type having a modular design which permits the apparatus to be assembled readily and easily with the number of spray heads desired, and with said heads disposed closer together than has been possible heretofore, thereby providing uniform coating of a desired depth on a rectangular surface in a single, rapid operation.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the apparatus possessing the construction, combination of elements and arrangement of parts which are examplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

FIGURE 1 is a front perspective view of multiple head flame spray metallizing apparatus embodying the invention;

FIG. 2 is a sectional view of the apparatus taken along the line 2—2 of FIGURE 1;

FIG. 3 is a perspective view, partially in section, of the apparatus of FIGURE 1;

FIG. 4 is a rear elevation view of a portion of the apparatus;

FIG. 5 is a sectional view taken along the line 5—5 of FIG. 4;

FIG. 6 is a fragmentary elevational view of the apparatus; and FIG. 7 is a partially schematic, perspective view of the apparatus.

The flame spray metallizing apparatus of the invention is designed for incorporation in automated production machinery in which a succession of plane (usually) surfaces, particularly the surface of rectangular panels, are sprayed with metal to form substantially uniform coatings of predetermined thickness thereon. The metal coatings may be applied to cover each surface completely, or through a mask or stencil to selected portions of the surface in order to protect the surface, achieve a decorative effect or, for example, provide a circuit pattern of electrically conductive elements. However, whatever the product ultimately produced, it is desirable that the spray metallizing operation be performed rapidly, automatically and is a single operation, and that there be reasonable assurance that uniform metal coatings of predetermined thickness will be produced. These requirements indicate the use of a multiplicity of spray heads operating in synchronism to deposit equal quantities of metal on equal areas of the surface of the work, with the heads being arranged adjacent one another so as to deposit metal over an aggregate area at least equal to one dimension of the surface; and including means for moving, or traversing, the plurality of heads together relative to the surface to completely coat the entire surface in a single movement or traversal. Because the metal deposited by each head may vary from a maximum near the center of the area (circular or eliptical) of deposit, it is preferable to arrange the heads with the centers thereof in a line and spaced so that the area of the surface of the work coated by each head overlaps adjacent areas, usually by about one-third of the area width.

As previously noted, a need has long existed for multiple head flame spray metallizing apparatus capable of depositing continuous, uniform coatings of predetermined thickness on generally plane surfaces of workpieces such as panels and the like, which are inconvenient or impractical to move with respect to stationary spray heads, and are rectangular rather than circular; and metallizing each panel rapidly and in a single operation. Moreover, the answer to this need, which is supplied by the present invention, also includes a multiple head flame spray metallizing apparatus which does not require for its operation, expensive electrical and electronic controls which heretofore have become more complex with each additional head. The apparatus of the invention is substantially more flexible since the controls for assuring uniform, coordinated operation of the multiple spray heads are simple, yet reliable, being largely mechanical; and the construction of the apparatus is modular so that any reasonable number of spray heads may be incorporated in the apparatus easily and without adding to the complexity of the controls involved. Moreover, the spacing between spray heads may be varied easily and, more importantly, may be substantially less than is possible with existing apparatus thereby making multiple overlapping passes or traversals by each individual head unnecessary.

The invention is particularly designed for incorporation in automated apparatus for producing printed wiring panels in which a succession of panels are conveyed to a spray station in which each panel is supported while a mask is located over the panel and metal is deposited through the mask to form a circuit pattern of conducting

elements on the panel. The panels or at least the areas thereof to be metallized are preferably rectangular in shape so that a plurality of spray heads can be moved with respect to the panel to completely coat the desired area to the proper depth, preferably in a single movement in one direction or at most, during the return movement of the spray heads to their original position. The panels are preferably suspended near their upper edges from a conveyor so that the surfaces to be coated are substantially vertical. A convenient system for masking each panel during metallizing is illustrated in FIG. 6 as including an electromagnet **120** behind the panel, designated **121** and an iron mask **122** which is attracted to the panel by the magnet. This system is particularly advantageous when the panel is of a material which is not magnetic, such as a non-ferrous metal or a plastic, as the mask and magnet cooperate to assure proper positioning of each panel during metallizing.

The basic components of a flame spray metallizing device are a spray head or nozzle for mixing a fuel gas with oxygen, burning the mixture to produce a flame for melting a metal wire, and directing a propellant gas, such as air, so as to atomize the molten metal and propel the atomized metal in a spray against the surface being metallized; means for conducting the gases to the spray head; and means for feeding the wire to the spray head at a predetermined controlled rate. The factors which largely control the amount of metal deposited by a spray head include the rate (i.e., pressure) at which the gases are supplied to the spray head and the rate at which the wire is fed to the spray head, so that when several spray heads are employed simultaneously, the gas supply and wire feed for the various heads must be substantially uniform if the metal deposited on a surface is to be of uniform depth. In addition to these factors, proper spacing of the spray heads is important in providing for an overlapping of deposits from adjacent spray heads to insure a uniform deposit of predetermined depth. Other factors such as the particular gas pressures, rate of wire feed, the spacing between nozzles and the work surface, and the rate of movement of the nozzles with respect to the work surface will depend upon the type of metal and the fuel gas used, as well as the desired depth of metal deposit. However, these latter factors will be substantially the same for each of the plurality of nozzles.

The multiple head flame spray metallizing apparatus of the invention is constructed in modular units each including a spray head or nozzle and means for supplying the three gases to the nozzle at the requisite pressures. Any reasonable number of the modular units may be joined easily and readily, and these are, in turn, coupled with means for feeding wires to the nozzles at the same rate and moving the nozzles in unison relative to the work surface being metallized. Each modular unit, as shown in FIGS. 1 through 3, comprises a manifold block **10** designed to be fabricated inexpensively, for example, by casting, and requiring a minimum of comparatively simple machining operations. Manifold block **10** is in the general form of a parallelepipedon and is initially formed, as by casting, with three manifold passages designed **12**, **14** and **16** extending through the block from side to side thereof and a centerally located bore roughly approximating bore **18** extending through the block from front to rear thereof.

Manifold passage **12** is located in the upper rear portion of the block above bore **18** and manifolds **14** and **16** are located in the lower portion of the block with manifold **14** located to the rear of manifold **16**. All three of the manifold passages are generally rectangular in cross section, the latter being substantially uniform throughout the length of each manifold. The manifold block is provided with a flange **20** at the upper rear corner thereof and a flange **22** at the lower rear corner thereof thus providing for the mounting of the block in a manner to be described hereinafter.

Bore **18** is designed to accommodate a flame spray head or nozzle generally designated **24**, and manifolds **12**, **14** and **16** are designed to conduct, respectively, oxygen, fuel gas, and air for the spray head. The machining operations required to complete the fabrication of each manifold block are few and are limited, essentially, to finishing bore **18** so that it will accept the spray head, providing connecting holes or conduits between the manifold passages and bore **18** and drilling holes through the flanges for mounting the block and through the block for securing the block to another block. Four connecting conduits or holes designated **26**, **28**, **30** and **32** are provided for connecting the manifolds with bore **18**, hole **26** being the rearmost and opening into manifold **14**, hole **28** opening into manifold **12**, and holes **30** and **32** opening into manifold **16**. Each of holes **26**, **28**, **30** and **32** is formed simply and easily by drilling from the outside of the block, and the holes thus formed between the exterior of the block and the manifold passages are tapped and filled with threaded plugs **34**. A hole **36** is drilled through the upper forward portion of the block and another hole **38** is drilled through the lower medial portion of the block, both from side to side of the block, for accommodating elongated tie bolts **40** provided to clamp two or more manifold blocks together. Gaskets **42**, each formed with openings corresponding with manifold passages **12**, **14** and **16** and holes **36** and **38** are provided between adjacent manifold blocks to prevent gas leakage.

Spray head or nozzle **24** is of a conventional type, the particular head shown by way of example being of the type manufactured and sold by Metco, Inc. as a part of their Type K metallizing machine. The spray head comprises (from rear to front) a wire guide or bushing **44** secured in a narrow section of bore **18**; a so-called siphon plug **46** formed with three peripheral gas conducting grooves aligned with holes **26**, **28** and **30** and separated by O rings engaged in grooves in siphon plug **46**; a threaded insert or nut **48** for retaining the siphon plug in place; a flame nozzle **50** engaged in nut **48** in an enlarged section of bore **18**; and an air cap **52** supported by a threaded insert **54** in closing relation in the open end of bore **18**. Wire guide **44**, siphon plug **46** and flame nozzle **50** are each formed with an axial bore **56** having a diameter slightly greater than the diameter of the wire and through which the wire is fed forwardly into air cap **52**. The siphon plug includes radial and axial bores (not shown) connected to the grooves for conducting the oxygen and fuel gas to convergent axial bores in the flame nozzle to form a flame within the air cap. Other bores are provided in the spihon plug for conducting air from hole **30** into bore **56** so that the air may circulate around the wire within the forward end of the siphon plug and the flame nozzle to prevent overheating of the flame nozzle. The air cap includes holes for conducting air from bore **18** around the forward end of the flame nozzle in order to atomize and propel the metal as it is melted by the flame within the air cap.

The several manifold blocks **10** are substantially identical in construction and are secured together so that the manifold passages through the blocks join to form three substantially continuous manifolds for conducting the three gases to each of the spray heads as substantially the same pressure, the manifolds being of sufficient size to insure transmission of the gases without any significant drop in pressure between manifold blocks. The modular units, each comprising a manifold block and spray head, are secured between a pair of end blocks **58** having holes aligned with holes **36** and **38** through which tie bolts **40** pass. One or both of the end blocks is provided with passages for conducting oxygen, fuel gas and air to the appropriate manifolds, the gases being conducted to the end block by such means as flexible hoses **60**.

The apparatus includes a drive and support assembly the function of which is to support and move the flame

spray heads relative to the work surface to be metallized, and feed wires to the flame spray heads at a predetermined rate. This drive and support assembly includes a support member designated **62**, in the form shown, comprising elongated, parallel upper and lower walls **64** and **66** connected by end walls **68**. The support member is at least equal in length to the assembly of manifold and end blocks, and the manifold blocks are secured to the forward edges of upper and lower walls **64** and **66** by bolts **70** extending through holes in flanges **20** and **22**.

Support member **62** is mounted for movement, in a plane parallel with the plane of the work surface to be metallized, on a pair of threaded lead screws **72**, in turn mounted with their axes in a plane parallel with the plane of the work surface and perpendicular to the axes of the spray heads. The lead screws are engaged in threaded bushings or nuts **74** secured against rotation on upper wall **64** near the ends thereof and extend through both the upper and lower walls, the lower wall being provided with guide bushings (not shown) through which the lead screws are free to slide axially. As shown in FIG. 7, means such as an electric motor **126** and a transmission **128** are provided for rotating the lead screws simultaneously and at the same speed for moving the support assembly (up and down).

Means are provided on the support assembly for feeding and guiding wires to the spray heads at the same rate in order to insure uniform metal deposits by the spray heads. These means include a pair of feed rolls **76** and **78** for each spray head mounted in juxtaposition, one (**78**) above the other (**76**), behind and closely adjacent each wire guide **44** with the surface of lower feed roll substantially tangent to a wire extending through bore **56** of the wire guide. The surfaces of the rolls may be knurled or serrated to promote gripping of the wire therebetween. Rolls **76** are mounted on and keyed to an elongated drive shaft **80** extending longitudinally of the support assembly below the axis of the spray heads, parallel with the upper and lower walls of the assembly and journalled in supports (not shown) mounted on lower wall **6**. For rotating the drive shaft, there are provided a pinion shaft **82** mounted for rotation with its axis substantially parallel with lead screws **72** adjacent one of the lead screws, and means such as an electric motor **130** for rotating the pinion shaft at a predetermined speed. The pinion shaft extends through openings on the upper and lower walls of the support members and meshes with a spur gear **84** keyed to an idler shaft **86** engaged between the upper and lower walls with its axis substantially parallel with the pinion shaft so that the drive and support assembly is free to move up and down with respect to the pinion shaft with gear **84** meshed with the pinion shaft. Power is transferred from pinion shaft **82** to drive shaft **80** by a worm **88** keyed to idler shaft **86** and a worn gear **90** keyed to drive shaft **80** and meshed with worm **88**.

Each of feed rolls **78** is mounted for rotation on a short shaft **92** mounted between a pair of arms **94** at the end of a support member **96**, in turn pivotally mounted near its other end on an elongated support shaft **93** extending from end to end of the support assembly. Rolls **78** are thus free to move toward and away from rolls **76** and are biased toward rolls **76** by coil springs **100** each engaged between support member **96** and upper wall **64**. Rolls **78** are driven individually, but in unison, by spur gears **102** each mounted on a shaft **92** together with a roll **78** and meshed with a similar spur gear **104** keyed to drive shaft **80**. The teeth on gears **102** and **104** may be made extra long so that they will mesh even though wires of diameters larger than a predetermined minimum are employed. A plurality of bushings **106** are provided mounted on a support member **108** with the bore of each of the bushings aligned with the bore of a wire guide **44** for guiding a wire into the bite of a pair of feed rolls **76** and **78**. An elongated lever **110** is provided on each support member **96** to facilitate the rotation (counterclockwise viewing FIG. 2) of each support member to space feed rolls apart so that a wire may be introduced therebetween into guide **44**.

The controls for the flame spray metallizing apparatus of the invention are relatively simple, comprising means for controlling the pressure of each of the three gases (fuel, oxygen and air) supplied to the three manifolds, motor **126** for driving lead screws **72** at a predetermined speed and motor **130** for driving pinion shaft **82** at a predetermined speed. The motors are preferably of the variable speed type and means, such as rheostats **132** and **134** are provided for controlling the speed, respectively, of electric motors **126** and **130**. The entire assembly including the drives may be mounted so that the spacing between the spray heads and the work surface may be adjusted, but once set, this position remains constant through successive metallizing operations. The operation of the apparatus is quite simple requiring that each spray head or nozzle be lighted with the gas pressure sufficient to at least maintain a pilot flame. A work piece is positioned in front of the spray assembly with an upper or lower edge of the area to be metallized disposed opposite the nozzles. The gas pressures are then increased to operative pressure while simultaneously lead screws **72** and drive pinion **82** are rotated to feed wire to the spray heads and move the spray heads with respect to the work surface toward alignment with the opposite edge thereof. If metallizing is to be performed in a single (preferably downward) traversal of the spray heads, the wire feed is discontinued and the gas pressure reduced when coating is complete at the end of the traversal, and the direction of rotation of the lead screws is reversed to return the support assembly to its original position; or if desired, metallizing of the same or another workpiece may be performed during the return movement of the assembly by continuing or recommencing the wire and gas feed. Spraying is preferably performed only on the downward traversal, since the wires are usually applied in large quantity on spools which, naturally, have considerable mass and resist uncoiling, so that uncoiling is accomplished during the upward traversal and the uncoiled lengths of wire are fed into the spray heads during the downward traversal. When it is desired to employ fewer spray heads, tie bolts **40** are removed, one or more of the end manifold blocks are removed from the support assembly, the desired number of spray heads is removed, and the tie bolts are reassembled to retain the end blocks in place and compress the gaskets between adjacent blocks.

Since certain changes may be made in the above apparatus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. Multiple head flame spray metallizing apparatus for applying a uniform metal coating to a substantially plane surface of a workpiece, said apparatus comprising, in combination:

a manifold block formed with three manifolds extending lengthwise within said block for carrying gases under pressure;

said block being formed with a plurality of transverse bores extending therethrough with the axes of said bores substantially parallel, and each of said transverse bores connected to said manifolds through connecting bores;

a flame spray head secured in each of said transverse bores and including means for mixing a fuel gas with oxygen, a combustion chamber for containing a flame when the mixture is ignited, said flame being adapted to melt a metal wire and means for directing a propellant gas so as to atomize the molten metal

and propel said molten, atomized metal in a divergent spray from said head against an area of said surface of said workpiece;

means for supporting said workpiece with said surface facing said spray heads;

a drive and support assembly for supporting and moving said manifold block and said spray heads mounted therein relative to said surface, generally parallel therewith and transversely of said manifolds;

wire feeding means mounted on said assembly adjacent each of said transverse bores for advancing a wire into and through each of said spray heads; and

a common drive for operating said wire feeding means to feed said wires into said spray heads at the same rate and thereby insure spraying of substantially the same amount of metal by each of said spray heads.

2. The flame spray metallizing apparatus of claim **1** in which said manifold block comprises a plurality of substantially identical segments each including a section of each of said manifolds and one of said transverse bores connected to said sections of said manifolds, said segments being secured together with said sections in alignment.

3. The flame spray metallizing apparatus of claim **2** in which said manifold block includes a pair of end members secured to the segments at the ends of said block for closing the ends of said manifolds, at least one of said members including three bores each connected with one of said manifolds and with a conduit for conducting a gas from said conduit to said manifold.

4. The flame spray metallizing apparatus of claim **1** in which said flame spray heads are positioned for directing said molten, atomized metal over a linear array of substantially identical areas of said surface of said workpiece, each of said areas overlapping adjacent areas by substantially one-half the width thereof.

5. The flame spray metallizing apparatus of claim **1** in which said wire feeding means for each of said spray heads is driven from a common drive shaft in turn driven by a pinion shaft mounted for rotation with its axis substantially parallel with the direction of movement of said manifold block relative to said workpiece.

6. The flame spray metallizing apparatus of claim **5** in which said wire feeding means for each of said spray heads comprise a driving roll mounted on said common drive shaft and a backing roll mounted in juxtaposition with said driving roll and resiliently biased toward said driving roll to grip a wire therebetween.

7. The flame spray metallizing apparatus of claim **1** in which said drive and support assembly includes a support member secured to said manifold block; a pair of lead screws mounted in spaced relation with their axes substantially in a plane parallel with said surface, said lead screws being engaged with said support member; and means for rotating said lead screws to move said support member substantially in said plane.

8. The flame spray metallizing apparatus of claim **7** in which said wire feeding means comprise an elongated shaft mounted on said support member; a plurality of drive rolls mounted on said shaft and each located in alignment with an axis of one of said transverse bores; a pinion shaft mounted adjacent and in generally parallel relation with one of said lead screws and coupled with said elongated shaft so as to rotate the latter; means for driving said pinion shaft; a plurality of backing rolls each mounted for rotation in juxtaposition with one of said drive rolls; and means for urging each of said backing rolls toward the adjacent drive roll to grip a wire therebetween.

9. The flame spray metallizing apparatus of claim **1** in which said common drive includes a variable speed motor for feeding said wires, and means for controlling the speed of said motor.

10. The flame spray metallizing apparatus of claim **1** in which said drive and support assembly includes a variable speed motor for moving said manifold block relative to said surface, and means for varying the speed of said motor.

11. Multiple head flame spray metallizing apparatus for applying a uniform metal coating to a substantially plane surface of a workpiece, said apparatus comprising, in combination:

means for supporting a workpiece in a stationary position;

a supporting assembly including a support member and means for moving said support member in a plane substantially parallel with said surface of said workpiece;

a manifold block comprising a plurality of similar segments joined to one another and mounted on said support member, each of said segments including portions of three manifolds extending lengthwise of said block and a transverse bore extending through said block with the axis of said bore substantially perpendicular to said plane and connected with each of said manifolds;

a flame spray head secured in each of said bores and including means for mixing a fuel gas with oxygen, a combustion chamber for containing a flame when said mixture is ignited, said flame being adapted to melt a metal wire extending through said head and means for directing a propellant gas so as to atomize the molten metal and propel said molten, atomized metal in a divergent spray from said head against an area of said surface of said workpiece;

said flame spray heads being arranged for directing said molten, atomized metal over a linear array of substantially identical areas of said surface, said areas being at least contiguous with one another;

wire feeding means including an elongated drive shaft and a plurality of wire feed rolls mounted on said shaft, each of said feed rolls being located adjacent one of said bores in alignment with said axis thereof for engaging and advancing one of said wires into and through one of said spray heads;

an elongated pinion mounted for rotation with its axis substantially parallel with the direction of movement of said support member and coupled with said drive shaft for rotating the latter; and

drive means for rotating said pinion.

12. The flame spray metallizing apparatus of claim **11** in which said workpiece is supported with said surface in a substantially vertical plane.

13. The flame spray metallizing apparatus of claim **11** in which said means for moving said support member include a pair of lead screws mounted with their axes parallel with each other and said axis of said pinion, and thread engaging means mounted near the ends of said support member and engaged with the threads of said lead screw.

14. The flame spray metallizing apparatus of claim **11** in which each of said spray heads is constructed and positioned with respect to said means for holding a workpiece for directing said molten, atomized metal over an area of said surface overlapping adjacent areas by approximiately one-half the width thereof.

15. The flame spray metallizing apparatus of claim **11** in which each of said segments of said manifold block comprises a casting through which holes have been drilled substantially perpendicular to said manifolds and the axis of said transverse bore to form connecting bores between said manifolds and said transverse bore, each of said holes is drilled through the outer wall of each of said manifolds and the holes in said outer walls are closed with plugs.

16. Flame spray metallizing apparatus as defined in claim **11** in which end members are secured to the ends of a plurality of said segments, and at least one of said

end members includes conduits for conducting gas to each of said manifolds.

17. Flame spray metallizing apparatus as defined in claim 11 in which each of said segments comprises a block mounted on said support member, gaskets are provided between adjacent blocks and include openings corresponding to said manifolds, and said blocks and gaskets are retained together by tie bolts extending lengthwise through said manifold blocks and gaskets within aligned holes through said blocks and said gaskets.

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DANIEL BLUM, *Primary Examiner.*