APPARATUS FOR COATING ARTICLES WITH REFRACTORY OXIDES AND THE LIKE


Application June 29, 1954, Serial No. 440,052

14 Claims. (Cl. 299—23,8)

This invention relates to the coating of metals and other materials, such as graphite, with oxide such as alumina, and more particularly to apparatus for fusing coating oxides and for applying such fused oxide to metal or other parts to coat them.

One of the objects of this invention is to provide a dependable and efficient apparatus for high-temperature fusing and atomizing, in reliable continuity, coating oxides and the like which, for effecting dependable coating, have to be provided in especially fabricated rod forms which are inflexible and breakable so that they cannot be reeled or coiled and have to be made up in relatively short lengths. Another object is to provide a practical and easily controlled apparatus for effecting and in controllable continuity bringing such rod-like oxide forms into contact with a high-temperature flame for fusion and an air blast for directing fused particles onto the surface to be coated, in a manner to utilize, to full advantage, the structural characteristics provided in the refractory oxide rod structures; more particularly, it is another object to provide for efficient consumption of the oxide rod forms, to reduce wastage thereof, and to facilitate long-continued coating production free from frequent or detrimental interruptions for replenishment of oxide coating material.

Another object is to provide an apparatus of the above mentioned character with ease and convenience of control of its operating characteristics so as to facilitate manual manipulation of the apparatus by the operator according to the requirements and conditions, including peculiarities of configuration, met with in the part to be coated. Another object is to provide an apparatus of the above mentioned character constructed for ease and dependable handling of operating or manipulating by the operator, adapted for facility of rearrangement according to various or varying requirements met with in practice.

Another object is to provide an improved apparatus for effecting coating of high melting point rod-like forms of oxides into strong, long lasting, and virtually integral coatings on metal parts, graphite parts, and other.

Another object is to provide such apparatus that is durable against the abrasion-like surface characteristics of such rods as the latter are singly or in succession fed to the high-temperature flame and applying air blast. Other objects are to provide dependable feed of such rods to the flame; to provide an apparatus dependably adapted to handle oxide rods of different thicknesses or diameters; to provide for maximum utilization for fusion and coating-application of the trailing end of the oxide rod; to protect rod-controlling means closely adjacent to the flame-producing end of the apparatus, against detrimental temperature effects thereon and against detrimental wear; to make practicable the utilization of short lengths of such oxide rods, even broken-off pieces thereof and to provide for the practical and reliable supply, in succession, of such lengths or pieces of oxide rods for efficient consumption thereof by fusion and coating-application, free from time-consuming or otherwise detrimental interruptions.

Other objects will be in part obvious or in part pointed out hereinafter.

In the accompanying drawings, in which is shown an illustrative embodiment of the invention and in which similar reference characters refer to similar parts throughout the several views,

Figure 1 is a small-scale side elevation of our apparatus for fusing and spraying refractory oxides and the like, the view showing diagrammatically, in broken lines, a long or deep article with the apparatus related thereto for coating it interiorly;

Figure 2 is an elevation, on the same scale as that of Figure 1, showing a number of refractory or like oxide rods in the relationship they bear in the apparatus of Figure 1;

Figure 3 is an end elevation as seen from the left in Figure 1;

Figure 4 is a simplified electrical diagram illustrating a preferred drive and speed control for certain parts of the apparatus;

Figure 5 is a large-scale side elevation of the apparatus, certain parts being broken away to shorten the view, the right-hand part being shown substantially in central vertical section and the left-hand part being shown in section as seen on the line 5—5 of Figure 3;

Figure 6 is a transverse vertical sectional view, on a larger scale, as seen along the line 6—6 of Figure 5, showing details of a gripper device and certain parts coating therewith;

Figure 7 is a detached plan view, as seen from above in Figure 5, of a combined gripper-element carrier and coupling, and

Figure 8 is a detached enlarged perspective view of side part of the gripper device shown in Figures 5 and 6.

Referring first to Figure 1, we have there shown, in simplified side elevation and approximately to scale, an illustrative form of our apparatus for fusing and spraying, for example, onto the surfaces of metal, graphite, or other substances, a wear-resistant, heat-resistant material, such as a refractory oxide of which alumina is a good illustration, to form thereon a coating that is lastingly joined to the surface, becoming virtually integral therewith. Alumina fuses at about 2,000° C; zirconia, which fuses at about 2,700° C, is another example and others are mentioned later.

Parts fabricated of metal, graphite, or other materials, when provided with such a coating, can be given many valuable attributes and thereby many practical advantages can be gained. For example, the coating gives the part protection against oxidation and other chemical reaction; it is electrically non-conductive and provides an insulating coating; it is highly resistant to wear; being refractory, it is also heat-resistant. There are many uses for parts so coated. Also, dependability and durability, as in gas turbines, jet engines, and rocket nozzles and chambers, where parts are subjected to high-temperature gases or hot flame or other bad effects of combustion, can be materially increased. For a full discussion of coating articles with oxide reference may be made to U. S. Patent No. 2,707,691, patented May 3, 1955, on application of the applicant Wheldon of this case which was copending here-with.

An oxyacetylene flame, though an oxyhydrogen or other high-temperature producing flame may be employed, serves as a suitably concentrated heat source, as an equivalent an applicating air blast, and to the flame is fed the high-fusion-point refractory oxide in the form of a straight solid rod that comprises fine particles of the oxide rigidly massed or boned together by sintering, the rod being hard, rigid, and unbendable without breaking, whereby, as it endwise enters the hot flame, its end portion is raised in temperature to fuse it and the sintered-together particles
move the device as a whole to bring and direct the spraying action as needed; at its right-hand end the apparatus comprises a compact casting shaped and machined to form a casing or housing 11 provided, as at its underside, with a handle or handgrip 18 and having extending from its front end (the left-hand end in Figures 1 and 5) a tube-like barrel structure, generally indicated by the reference character 13, and comprising preferably a number of successively and detachably coupled parts, later described, of which the endmost part is a nozzle structure NS for the emission of a mixture of combustible gases and for the emission of the air blast as well as for coactingly relating thereto the end of an oxide rod of the kind above described. The tube-like barrel structure 13 is of composite construction and, for various reasons, is preferably of substantial length and, moreover, it is so constructed that, according to certain conditions met with in practice, its over-all length may be changed. To illustrate, it may have a length on the order of 4 feet as, for example, may be necessary for coating the interior surface of a long tube or vessel of relatively small cross-section, as indicated in broken lines in Figure 1 at 15; for shorter or longer interior reaches of surfaces to be coated, an intermediate portion of the tubular barrel structure 13 is readily replaceable by a shorter or longer portion, as will be later described. The inner or casing end of the structure 13 can serve as a convenient hand-grip, as by the left hand of the operator, and with his right hand grasping the handle 12, the operator can effect steady manual guiding control of the changing relationship of the nozzle end of the apparatus with respect to the part being coated.

At the front end (the left hand end in Figures 1 and 5) of the casing 11 there is provided or formed integrally with a wall of the casing an air and gas receiver-distributor 16 which is interiorly divided, as indicated by the broken line 17 in Figure 3, into an air chamber 18 and a gas-mixing chamber 19, the former being supplied with air under pressure through a hose line 20 and mixing chamber being supplied with acetylene and oxygen, each under suitable pressure, through the respective hoses 21 and 22. Associated with the hose lines 20, 21 and 22 are suitable adjustable pressure regulating valves (not shown) and pressure gauges (not shown). The hose lines are connected by suitable couplings provided in the bottom walls of the receiver 16, that the hose lines are in depending relation from the apparatus and thus interfere least with the manipulation thereof; built into the bottom wall of the receiver 16 is a suitable manually controlled valve mechanism, of the cock-valve type, indicated as 23, so that the operator, as by suitable lever mechanism 24, can control the supply of acetylene and oxygen to the mixing chamber 19 and the supply of air to the air chamber 18. Insofar as details of these structural elements are concerned, they may be of any suitable known types of construction or arrangement such as for example those heretofore used or known in oxyacetylene manually operated devices.

As in such known constructions, the front wall 16 of receiver-distributor 16 is provided with an externally threaded male coupling part 25 (Figure 5) that projects forwardly (to the left in Figure 5); it may be accepting, for a central coaxial round passage 30, large enough to freely receive therethrough the oxide rods above mentioned, and excepting for a suitable number of gas passages 31 which lead to the mixing chamber 19. The central rod passage 36 extends through the receiver distributor 16, in tube 32 having at its rear end 33, the tube 32 extending through a bore 34 that is drilled through a solid part of the receiver-distributor 16. The tube mouth 33 is chamfered to allow of easy entrance of a rod without sticking.

The bore 34 is aligned with a suitably formed round channel 36 (Figure 5) that opens at the rear wall of casing 11 so that a rod can be inserted from the outside of the casing 11; if desired the open end of round chan-
nel 36 can receive an adapter or tube 37 provided with a coaxial round channel 38 diametred to suit the diameter of rods to be used in the apparatus and thus axially align the adapter rod passage 38 with the rod passage 30 that extends through the receiver-distributor 16 and through the coupling member 28. The adapter 37 has an external head to limit its entry into the channel 36 and to provide, as by suitable chamfering, an external mouth end for channel 38 so that the operator can with facility insert one rod after another as the oxide rods are used up.

Adherent the tube mouth 33 (Figure 5) we provide two coaxing feed drums or wheels 40 and 41, one above the other and having their adjacent portions projecting, through suitable cutouts in the metal of casing 11, into the large channel 36; these feed drums 40, 41 have relatively narrow peripheral cylindrical faces which are rubber-tired as at 42 and 43 for cushion-like driving engagement with the refractory rod that is entered therebetween. At their sides more remote from the observer viewing Figure 5, the feed drums 40, 41 are provided with meshing gears 44 and 45 respectively so that one drum is driven from the other and the two are driven in opposite directions, as indicated by the arrows, to feed the rod theretowards forwardly, that is, to the left in Figure 5.

Drum and gear 40, 44 are secured to a shaft 46 which has bearings (not shown) in the casing structure 11; shaft 46 is driven through reduction gearing and in a preferred manner later described.

Feed drum 41 and gear 45 are secured to a shaft 47 that is provided with bearings, as in known constructions, provided in a movable part 48 of the casing structure 11; casing part 48 is moveable in directions to shift the upper feed drum 41 toward or away from the lower feed drum 40 and for such purpose it may be pivoted on a stud shaft 50 which is suitably carried by the casing structure 11 and for adjustable setting the upper feed drum 41 there may be provided a thumb screw 51 which passes through the top wall of casing part 48 and is threaded, as shown, into a threaded hole of the casing structure 11.

Concentric with the threaded coupling part 28 is another threaded male coupling part 54 (Figure 5); it surrounds the base portion of coupling part 28 and has one or more passages 54a that lead into air chamber 18 of the part 16. Onto the large coupling part 54 is threaded a short tapered sleeve 55 which terminates in an internally threaded coupling part 56 and accordingly coupling part 56, coupling part 28 and the rod passage or channel 30 are coaxial and in coaction with coupling part 28 and coupling part 56, sealed mechanical connections may be made with other parts later described for extending to the remotely located nozzle structure NS (see Figure 1) a tube passage for containing a succession of oxide rods, tube passages for oxyacetylene mixture from mixing chamber 19 (Figure 5) and air under pressure from the air chamber 18, all within the tube-like barrel structure 13 of Figure 1. To reach from the casing passage 36 and feed drums 40—41 (Figure 5) in the casing 11 to the nozzle structure NS (Figure 1), a plurality of refractory or oxide rods, arranged in end-to-end succession, are necessary and to better illustrate this practical condition we have shown, in Figure 2, an illustrative succession of such rods, Figure 2 being purposely aligned with the apparatus of Figure 1 to show, on the same scale (though the thickness of the rods is somewhat exaggerated), an illustrative inter-relationship of several oxide rods. Thus, there is an endmost rod R1 which is relatively short, illustrating a rod of which the nozzle structure NS has already fused and deposited a substantial portion, then several full-length rods R2, R3, R4, of which rod R3, which projects from the rear wall of the casing 11 (Figure 1), is in between the rubber-tired feed wheels 40—41 as is shown in Figure 5, rod R2 being therefore the "pusher" rod of the entire succession of rods while the foremost rod R1, also shown in Figure 5, is advanced through the intermediate rods R2, R3 into the nozzle structure NS. To better understand these and other coating features, it will be helpful to describe first the nozzle structure NS.

Accordingly, turning now to Figure 5, the nozzle structure NS for coating with such a succession of rods comprises several coating components which, for flexibility of rearrangement as earlier above mentioned, are preferably detachably inter-related coaxially, and which preferably are closely compacted radially. These components comprise, in the order from right to left in Figure 5 which is the order in which they are encountered by the foremost rod of a succession, a rod gripper and load-applying device generally indicated by the reference character 60, a gas nozzle 61 which provides jet passages for combustible gas mixture, and an air nozzle 62 which acts with the gas nozzle 61 to form certain coating air-emission channels.

The gas nozzle 61 is externally frusto-conical and has a coaxial round passage 63 for the rod; it has jet-like passages 64, illustratively three in number and spaced 120° apart, that extend from its large end face through its smaller end face and it is externally of the latter face where combustion of the oxyacetylene takes place as it emerges from these jet passages 64, the latter being distributed about the rod passage 63 and the rod end projecting therefrom. The rod gripper device 60 comprises a cylindrically shaped block 62 that has a coaxial rod passage 66 therethrough and a left-hand end face abutting against the larger end face of gas nozzle 61, this left-hand end face being provided with a coaxial ring-shaped recess 67 into which the gas jet passages 64 open for supply of gas mixture, the latter regardless of relative rotational positions of the nozzle block 61 and rod gripper 60; the ring-shaped recess 67 is connected to the right-hand end face by a suitable number of passages 68, illustratively three in number and spaced 120° apart (see Figure 6). Passages 68 thus form supply channels for flow of gas mixture to nozzle 61 and they are preferably uniformly distributed in the block 65 for better abstraction of heat from the block 65 of the gripper device 60 and thus to aid in protecting the gripper device against detrimental heating derived from the gas combustion nozzle 61.

The left end portion of the gripper device block 65 (see also Figure 7) is externally threaded as at 70 for receiving thereon the internally threaded part of a coupling flange 71 which is slipped on to the frusto-conical nozzle 61 to take against an end peripheral flange 72 of the latter, whereby to tightly and coaxially secure the gripper device 60 and gas nozzle 61 altogether in the abutting end-face relationship above described. Thereby also the two round rod passages 66 and 63 become aligned.

At about its midsection as viewed in Figure 5, the metal block 65 of gripper device 60 is provided with an arrangement for gripping or holding a rod, with appropriate force, against axial movement of the rod, thus also "loading" the rod in the sense of requiring more power to move the rod axially. Preferably this arrangement comprises a suitable number of spring-pressed rod-encaging elements which are preferably appropriately distributed about the rod in order to substantially center the rod relative to the rod passage 66. For round rods, as in the portrayed illustration, we employ three such elements equiangularly spaced about the axis of rod passage 66.

As above noted, the refractory oxide rods are hard; they can also have, because of the nature of many of these oxides such as alumina, particularly crystalline alumina, abrasive characteristics. Desirably therefore we employ gripper elements that are hard, such as hardened steel, and preferably also arrange them so they can partake of rotational movement in response to axial movement of the rod. Conveniently they can be in the form
of hardened steel balls 74 (see Figures 6 and 5), arranged to be spring-pressed radially inwardly of rod channel 66, being spaced about the axis of the latter at 120° intervals where the oxide rods are round in cross-section or, for example, hexagonal.

Preferred and illustrative mounting and assembly of the balls 74 comprises the provision, for each, of a round cross-sectional radially extending recess 75 (Figure 6) which can be formed, as by drilling or milling toward the axis of the metal block 65 (see also Figure 7) and holding the tool material sufficiently of complete entry into the rod channel 66 so as to form a ring-shaped ledge 76 surrounding a hole 77 that is of lesser diameter than the drill and somewhat smaller in diameter than the diameter of the balls 74 as is better indicated in Figure 6. The ball 74 can therefore project materially into the rod channel 66 by a distance approximating the ball radius.

Slidably received in each recess 75 and bearing against ball 74 therein is a short plunger 78 (see Figure 8) which, at its outer end, has a diametrically extending slot 80 of a width slightly greater than the width of a peripherally extending groove 81 (Figures 7 and 6) turned or otherwise formed in the cylindrical block body 65 of the gripping device 66; this peripheral groove 81 intercepts the radial recesses 75 along their diameters and, with the diametric slots 80 of the plungers 78 aligned with groove 81, a split spring ring 82 (Figure 6) is sprung into the desired slot 80 and the aligned slots 80, thus not only holding the balls and plungers assembled but alsoyieldingly pressing them radially inward and, in the absence of a rod in the rod channel 66, normally seating the balls 74 against their respective ring-shaped ledges 76. The balls 74 thus form, in effect, a variable bore in the rod passage 66, the throat becoming narrower in the position of the balls just described. In Figure 6 the balls 74 are shown in an intermediate radial position, pressing radially inward upon the rod 12 which, illustratively, is of a diameter of 3/8 of an inch, the split spring ring 82 being shown in a correspondingly intermediate stressed condition. The peripheral groove 81 and the open ends of the radial recesses 75 are closed off by a metal band 84 which is precisely fitted in position and against a shoulder on the body 65 formed by an integral flange 85 which is internally threaded (Figure 5) to form a female coupling part for purposes later described.

The air nozzle 62 (Figure 5) has a main discharge passage 87 generally circular in transverse cross-section and coaxially aligned with the gas nozzle 61, substantially as shown in Figure 5, having an internal flange 88 and a frusto-conical surface 89 which is spaced from and is coaxial with the frusto-conical portion of the gas nozzle 61 to form air passage 90 therebetween. The air nozzle 62, at its right-hand end, is externally threaded to form a male coupling part 91 and to it is connected one end of a tube 93 that extends about and over the rod gripping device 60, forming therebetween an annular air passage 94 so that, when air is admitted thereto from the air chamber 18 to supply air to the nozzle air passage 90, the substantially external and generally cylindrical areas of the gripper device 66 are swept by the air moving in the annular channel 94, thus keeping the gripper device and its parts from becoming overheated even though the gripper device is in heat-conductive relation to the gas nozzle 61.

The nozzle structure NS is connected to the receiver-distributor 16 at the front of the casing structure 11 by coaxially inter-related parts of such length as to position the receiving structure NS at the desired distance from the casing 11 according to the reach needed to effect oxide coating at remote or otherwise inaccessible regions as is diagrammatically illustrated in Figure 1 with respect to the hollow device 15 to be interior coated. One of these coaxial parts 95 is in the form of an external tube 96, shown in full in the small-scale view of Figure 1 and shown broken away in the large-scale sectional view of Figure 5, and in the latter view is also shown the internal coaxial member 97 which has an external cylindrical surface of lesser diameter than that of the tube 96 so as to form between the two an annular passage 98 or channel of substantial capacity and serving for the transmission of air under pressure.

In assembly, of the two coaxial parts 96 and 97, it is internal part 97 that is first put into position, so it will be described first. As above noted it is round in cross-section; along its axis it is provided with a round bore that forms a rod channel 100 which forms an extension of rod channel 30 in the coupling part 25 and which, at its left-hand end, is to be aligned with the rod channel 66 in the gripper device 60. Spaced radially from rod channel 100 and extending lengthwise throughout member 97 is a suitable number of gas passages 101, illustratively three in number and equidistantly and equiangularly spaced about the axis of member 97.

At the right end of member 97, these gas passages open into a ring-shaped recess 102 formed in the plane end face of member 97 and adapted to overlie the gas passages 31 through the coupling part 25; the right end of member 97 is flanged at 103 by which, through the flanged internally threaded coupling ring 104, the right end of member 97 is tightly secured against the companion end face of coupling part 25 and in coaxial relation so that rod channels 30 and 100 are neatly aligned. Thereby also gas mixture from mixing chamber 19 can flow through the gas passages 31 to the ring-shaped recess 102 from which it is distributed to the gas passages 101.

At the left end face of internal member 97, which has a length commensurate with the length of the external tube member 96, the gas passages 101 terminate in a ring-shaped recess 105 adapted to overlie the gas passages 68 which terminate in the right end face of rod gripper 60, these companion end faces being brought into tight relation by the threaded interconnection of female coupling flange 85 of the rod gripper 60 with the externally threaded coupling flange 109 provided at the left end of member 97. Thereby also the rod channels 100 and 66 are neatly aligned coaxially. And with gas nozzle 61 in threaded connection with the left end of rod gripper 60, as above described, the several sections or component lengths of round rod channels form a dependable straight line that become coaxial aligned and their straight-line continuity throughout the entire length of the apparatus, that is, from the entry channel 33 in the back wall of casing 11 to the exit end of rod channel 65 in the gas nozzle 61, becomes completed for the reception of the above-described succession of rods such as rods R2, R3 and R4 of Figure 2. At the same time the gas passages in the several axially aligned component parts become inter-connected and their continuity is completed for the flow of gas from the mixing chamber 19 to the discharge jet passages 64 of the gas nozzle 61.

Air nozzle 62 has detachably threaded to it, as above described, the short tube member 95 which is to extend over the rod gripper 60 and provide the annular air-cooling passage 94, and they may now, for completing the assembly, be treated as a sub-unit which as such is connected to the left end of the long outer tube 96; for this purpose tube 95 is internally threaded as at 106 to receive the externally and threaded coupling end 107 of the long intermediate tube 96; the right-hand end of long tube 96 is externally threaded as at 108 and is connected with the internally threaded part 56 of the coupling sleeve 55. This last threaded connection, which is preferably locked by a lock nut 110, locates the long tube member 96 coaxially with the internal part 97, and thus the long annular gas passage 98 is formed therebetween and air nozzle 62 becomes coaxially positioned relative to the gas nozzle 61 and the respective frusto-conical surfaces of the latter two parts are fixed in coaxial and radially spaced relation to form the air passage 99 therebetween. Accordingly air flow may take place from the air chamber 18, through the passages 56.
and into the coupling sleeve 55, and thence along the angular passages 98 and 94 to the nozzle passage 90.

To initially load the apparatus with a succession of oxide rods, the operator releases the movable casing part 43 (Figure 5) to move the upper feed drum 41 away from the lower feed drum; the operator then, without obstruction from the feed drums, inserts one oxide rod after another, through the mouthed entry opening in adapter 37 at the rear of the casing 11, each successively inserted rod pushing those ahead of it toward the left in Figures 1 and 5 to fill up the long centrally located rod passage or channel. In so doing, he is not bothered by losing inserted rods out of the distant nozzle end of the apparatus, for closely adjacent to the gas nozzle 61 is the rubber gripper device 60 with the balls 74 projecting into or constricting the continuous rod passage and they block the inserted rods from sliding or falling out. In this operation, the last-inserted rod, such as rod R4 of Figures 1 and 2, can project rearwardly from the apparatus so long as a forward portion of it is in position to be acted upon by the feed drums 40, 41.

The operator may, by pushing the last-inserted rod, advance the entire succession of rods so that the end of the foremost one passes through the yieldingly expansible throat formed by the balls 74 in order to bring its end to the end of rod channel 63 in the gas nozzle 61 or he may leave a short distance unoppressing movement to the rod-driving action of the feed drums 40. In either case he restores the movable feed drum 41, suitably setting the thumb screw 51 so that the rubber-cushioned drums 46, 41 press against the rod therewithin, from opposite sides thereof, and, because of the yieldability of the rubber, the two feed drums not only avoid detrimental straining the refractory rod but also obtain substantial areas of contact with the hard surface of the rod in order, upon rotation of the drums, to apply to the rod a steady and substantially non-slipping driving force. In either case, even though the spring pressure applied to the balls 74 is relatively substantial, a 3/8" end, because of the curvedness presented to it by the balls, in effect wedges or cams them radially apart to enlarge the throat and to bring them, as the rod progresses, into engagement with its outside cylindrical surface, as in Figure 6, the balls making contact in virtually points of tangency and thereafter acting to virtually center the rod in the rod passage 63 of the gas nozzle 61.

Upon drive of the feed drums 40, 41 at suitable surface speed, the pusher rod R4 (Figures 1 and 2) is fed to the left end and the entire succession of rods R3, R2, R1, R0 advances, the last end of the foremost oxide rod R2 being progressed into the region of high-temperature combustion of the oxygen-cyclohexene mixture emitted from the jets of the gas nozzle 61 and coating therewithin is air emitted from the coaxially arranged air nozzle passage 90, achieving high-temperature fusion of oxide particles which are released, as fused particles or agglomerates of fused particles, for substantial high-velocity projection thereof on the metal or other surface to be coated, in the manner of the process earlier described. Illustratively, 3/16" alumina rods may be fed at the rate of 1.18 inches per minute with the oxygen supply at 15 to 20 pounds, the acetylene at 15 to 20 pounds, and the air at 60 pounds per square inch. Illustratively, for 3/16" zirconia rods the feeding rate may be about 1.5 inches per minute, the oxygen can be at 15 to 20 pounds, the acetylene at 15 to 20 pounds, and the air at 40 pounds per square inch. In the structure depicted in Figure 5, the picking-off of molten oxide particles during the fusion rod end may be said to be effected primarily by the emitted air blast, and such action may be enhanced by the action of a deflector 114 (Figure 5) in the form of a small plate attached, as by screws 115, across the upper half of the front end of air nozzle 62, the plate 114, overhanging a cutout 116 in the vertical face of which terminate several air passages 117, illustratively one on each side of the central vertical plane of the structure, and leading, as shown, to the air passage 90, so that air emitted from passages 117 is deflected in generally downward and transverse directions, by deflector plate 114, to coast with the larger volume of moving air and gases of combustion, thus conjointly operating upon the fusing end of the oxide rod. In a generic sense however the pick-off of molten oxide particle or molten agglomerates thereof, and the projection thereof onto the surface to be coated, is effected by movement of a gas or gaseous medium. This is so where the medium is air. Also, in some cases combustible gas, such as the acetylene, and the combustion-supporting gas, such as the oxygen, can have enough pressure to serve as such a medium; in a sense this applies to the illustrative example given above because the air blast assists in supporting combustion for it provides oxygen additional to that supplied through the hose 22.

As above noted, sinter-bonded alumina and zirconia rods are given as examples; other oxides, preferably suitable refractory metal oxides, are usable in making up the rods and for effecting coatings as above described. By way of illustration of other materials of which to make the rods, but not by way of limitation thereof, we may mention such as barium oxide, beryllium oxide, calcium oxide, iron oxide, manganese oxide, nickel oxide, strontium oxide, thoria oxide, titanium oxide, and uranium oxide; also spinels of which a well-known type is magnesium-aluminum spinel. Also mixtures of such substances may be used in making up the refractory rods for use in our apparatus. In general, for coating objects with spinel or other oxides, the air and acetylene pressures can be the same though, for a given cross-section of refractory rod, rate of feed has to be appropriately suited, and for materials fusing below 2000° C. an air pressure of about 60 pounds is preferred whereas for materials fusing above 2000° C. the air pressure should be a little lower. These factors are easily ascertainable in various ways, usually by trial tests and making appropriate adjustments by the balls. Moreover they are self-accommodating to possible irregularities or variations in rod contour and in that respect they might cause some variations in the load that they impose upon the feed-drive mechanism; also such an effect might be caused when the more or less butt-ended junction between two successive rods reaches and enters the throat formed by the balls. Preferably we employ an electric motor of adjustable constant speed for driving the feed drums 40, 41, through suitable reduction gearing, and preferably adapted, for any selected speed, to be inconsequentially affected as to speed by such variations in load as just mentioned. The electric motor is preferably a D. C. shunt motor; it is diagrammatically shown at M in Figure 4 and may take any suitable compact form, as shown in Figure 3, for ease of attachment to, and at a side of, the casing structure 11, as by providing it with an attaching flange 121 (Figure 3) to rest against a suitable external face plate 122 of the casing 11, to which it is attached as by screws 123 (Figures 3 and 5). With such mounting, the motor shaft, or a suitable extension thereof, shown at 125 in Figure 5, extends into...
the casing structure 11 where it carries a worm 126 that meshes with a wormwheel 127 on a shaft 128 carried in spaced bearings 130 and 131 between which the shaft carries a worm 132 that meshes with a wormwheel 133 on the shaft of the lower feed drum 40. A flexible cable 135 extends from the underside of the motor M, cable 135 having therein suitable conductors leading to the motor armature and to its shunt field, shown respectively at A and F in Figure 4, and, if desired, also control circuit conductors where it is desired to control, as from suitable manually operated devices or the like (not shown) mounted on the motor casing or on the casing structure 11, remotely located motor-speed setting devices.

Unidirectional current for energizing motor M is preferably derived from any usual alternating current power supply line, such as a 110-volt 60-cycle circuit diagrammatically indicated in Figure 4 at 137-130. Any suitable means of which various types are known, may be employed to supply the shunt field F with direct current and to supply the armature A also with direct current but of selectible voltage, throughout a suitable voltage range, in order to set the motor speed at the desired value. The selectible voltage means is diagrammatically indicated by the broken line rectangle PS in Figure 4. For example, it may comprise a rectifier 140 which, through conductors 141 and 142, energizes the shunt field F at preferably a fixed voltage, and it may include an auto-transformer 143 provided with a variable control tap 145, which may be remotely controlled, in order, through a suitable rectifier 146, to energize, via conductors 147 and 148, the armature A at any selected voltage corresponding to the motor speed desired. With such an arrangement, motor speed is substantially constant for any selected applied armature voltage. In this manner, a suitable surface speed for the feed drums 40-41 and feed speed for the succession of rods R1, R2, etc. may be selected according to the refractory employed in the rods as well as according to the cross-section of the rods, for, as the cross-section is increased, the feed rate should be diminished, other factors, including conditions of combustion, being equal. As lower feed speeds are used, the armature current in motor M increases and the armature speed becomes more sensitive to and more responsive, at any intended speed, to changes in load. Because corresponding armature current changes introduce detrimental voltage drops, as for example in the rectifier and in the transformer 144; accordingly the rectifier 146 may include any suitable means, of which various types are known, such as electronic tube circuits or arrangements of saturable inductance, for compensation for such voltage drops and in that way maintain applied armature voltage constant as well as the rate of feed of the succession of rods, particularly where the rods might impose, as by the rod gripper device 60, variations in load. Several illustrations of possible load variation we have given above; also, it will be noted, that rate of feed of rods, that is, in terms of rate of lineal movement, may be relatively low, being on the order of 1.5" per minute for a 1/4" zirconia rod. Where there is uniformity of relative traverse between the surface being coated and the nozzle NS, these features contribute toward uniformity of coating deposition, and where the operator manually guides and traverses the apparatus as earlier described, dependable constancy of rate of rod feed contributes toward avoiding bothersome interference with the operator's utilization of the apparatus.

The rod gripper device 60, positioned as close as possible to the exit end of the rod passage 63 of the gas nozzle 61, holds the endmost rod R1, whatever its length as its forward end is being used up in coating deposition, against being driven out of the rod passage by the action of the discharging gas mixture, air blast, and gases of combustion, for the latter surround the protruding end of the rod and move in a general axial direction and thus impose an ejecting force or pull on the rod. The rod gripper device exerts gripping force on the endmost rod not only sufficient for the just stated purpose but also to resist the additional force, in ejection direction, which the weight of the rods behind the rod R1 impose upon the latter when the apparatus is tilted with its nozzle end downward as is oftentimes necessary in coating operations as in reaching the inside bottom surface of a deep vessel or container. The gripper device accordingly imposes, upon the motor driving the feed drums 40, 41, a more or less fixed magnitude of load over and above that which would otherwise be needed to feed a succession of rods, and this has the advantage of achieving better inherent speed regulation of the shunt driving motor M for armature-current changes due to operational variations in load are in effect measurable against the armature current corresponding to this more or less fixed load and are therefore proportionately of lesser detrimental IR drop effect.

Though in heat-conductive relation to the gas nozzle 61 or in other respects subject to heating because so closely positioned where the high-temperature combustion takes place, the gripper device and its several coating elements are protected against detrimental heat effects by the heat-abstracting action of the gas mixture flowing through the uniformly distributed gas passages 63 (Figures 5 and 6) on its way to the nozzle passageway 64 and by the heat-abstracting action of the rapidly moving air, of substantial volume, along the annular passage 94 on its way to the air nozzle passageway 90. Thus, durability of spring action, as by the split wire spring 82, is maintainable and, where the rod-engaging elements such as the balls 74 and also their spring-pressed plungers 73 are made of hardened steel for good wear resistance, risk of drawing the temper of these parts and thus softening them can be lessened. Moreover, in the illustrative and preferred embodiment utilizing balls 74, the balls may partake of rotational shift as rod feed progresses, and wear thereof is minimized because their engagement with the feeding rod can be in effect a rolling engagement and in that way successively different points on the ball surfaces are brought into engagement with the moving rod and also with the spring-pressed plunger 73.

The compact nozzle structure NS, comprising gas nozzle 61 with its rod gripper device 60 axially complemented therewith and air nozzle 62 with its tube extension 93 which together envelope the gas nozzle and gripper device, are readily accommodated to the casing structure 11 and the motor-driven feed drums of the latter, with the nozzle structure NS positioned at any desired distance from the casing 11, according to the particular need met with in practice, parts 97 and 96 (Figure 5) of the desired length are selected and for that purpose sets of parts 97 and 96 of different lengths may be made up for selective substitution in the apparatus. Coaxial parts 97 and 96 together constitute the readily replaceable intermediate portion of the tubular barrel structure 13 (Figure 1) earlier mentioned above; as there stated by way of illustration, their length may be about 4 feet where a long reach of that order of magnitude, for coating application, has to be effected as is diagrammatically shown with the nozzle structure NS positioned to the member 12. These parts 97-96 are readily detachable by way of the various threaded coupling elements at their respective ends; accordingly, where a longer or a shorter reach has to be made, parts 97-96 are easily disassembled and replaced by a pair of internal and external coupling elements of the desired greater or shorter length. The number of refractory rods R1, R2, etc., that constitute a succession of rods accommodated in the resultant continuous rod channel may therefore vary, yet dependable realization of coatings and advantages such as those above described is assured. In the event such a double structure NS may be brought closely adjacent to casing structure 11 and receiver-distributor part 16 by mating or selecting intermediate members 97-96 of such short length that they are almost like short coupling elements,
resulting in an assemblage that would look like Figure 5 if the break at the center of the parts 97 and 96, in that figure, were disregarded. For many uses, apparatus of such short over-all length is desirable. The described mechanism always insures efficient utilization of oxide rods and of broken-off lengths of rods for the initially accommodated rod length, as it shortens from fusion at the nozzle end, is pushed on into the high-temperature flame by the succeeding rod. It will thus be seen that the construction we have provided is of wide adaptability to achieve many advantages under varying conditions of practical use.

The ready detachability or disassembly of the parts of the nozzle structure NS is also of advantage; for example, gas nozzles, like gas nozzle 61 of Figure 5, of different characteristics such as different sizes or angularities of gas jet passages may be substituted, being easily attachable, by coupling ring 71, to the left end of the rod gripper device 60. To effect such replacement, all that has to be done is to unscrew the air nozzle-tube unit 62—93 at the threaded coupling 106—107 to gain access to the coupling ring 71. Also where desired, air nozzles of different configuration or character may be substituted for the illustrative air nozzle 62, at the threaded coupling 106—107. Thus, gas nozzle or air nozzle may be readily changed or replaced, while always retaining the rod gripper device 60 in contacting relation both as to its functioning as above described and as to cooling action thereon by air in the surrounding air passage 94 and by gas mixture flowing in the gas ports or passages 68 through the main body of the gripper device itself.

It will thus be seen that there has been provided in this invention an apparatus in which the various objects hereinbefore set forth together with many thoroughly practical advantages are successfully achieved. It will be seen that the apparatus is of dependable construction and of reliable and efficient action for the conversion of high melting point rod-like forms of refractory oxide and the like into dependable coatings of metal parts, graphite parts, and parts made of any other materials compatible with the reception thereon of such coatings. Moreover, the apparatus is of wide flexibility of assemblage and rearrangement of certain of its parts to the end that, without impairment of the coating of its parts or of its many advantages, the apparatus be utilized by adhering to such requirements of the parts to be coated as size or configuration or relative location or accessibility of the surface area or areas thereof to be coated.

As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

We claim:

1. An apparatus for coating parts with refractory metal oxides and the like comprising a casing having therein a straight-line channel for entry therein endwise of relatively inflexible frangible oxide rods, said channel having coating therewith opposed feed drums having operative faces of yielding material for receiving therebetween and feeding endwise an oxide rod in the channel, said apparatus having a nozzle structure positioned internally of the casing and spaced therefrom in line with said channel, said nozzle structure comprising a gas nozzle having a central rod passage at the entry end of which is a rod gripper device having a central rod passage with spring-pressed rod-engaging means projecting into the latter and forming a yieldable thrust for yieldingly holding a rod therein against feeding movement, said gas nozzle having gas passages therethrough and said gripper device having gas passages therethrough and distributed in spaced relation about its rod passage, with air nozzle means about said gas nozzle for discharge of air adjacent the exit end of the rod passage and gas passages in the gas nozzle, said air nozzle means having a air-supply part that extends in spaced relation about said rod gripper device for the flow of air in heat-abstractive relation to the latter, coaxial means connecting said nozzle structure to said casing and comprising an external tube member having an internal part forming an air passage therebetweentherein, said internal part having a straight-line rod passage at its axis for receiving successively oxide rods fed thereto in end-to-end relation by said feed drums and having gas passage means extending lengthwise thereof to the gas passages in said rod gripper device, said tube member being connected to said tube-like part of said air nozzle means, a shunt motor for driving said feed drums at a selectable rod-feed rate, said shunt motor being provided with means for selectively setting the voltage applied to its armature, said rod gripping device imposing a substantially fixed load on the motor whereby the inherent speed regulation of the motor during feed of oxide rods is improved.

2. An apparatus for coating parts with refractory metal oxides and the like comprising a casing having therein a straight-line channel for entry therein endwise of relatively inflexible frangible oxide rods, said channel having coating therewith opposed feed drums having operative faces of yielding material for receiving therebetween and feeding endwise an oxide rod in the channel, said apparatus having a nozzle structure positioned externally of the casing and spaced therefrom in line with said channel, said nozzle structure comprising a gas nozzle having a central rod passage at its axis for receiving successively oxide rods fed thereto in end-to-end relation by said feed drums and having gas passage means extending lengthwise thereof to the gas passages in said gas nozzle means, said tube member being connected to said tube-like part of said air nozzle means, a shunt motor for driving said feed drums at a selectable rod-feed rate, said shunt motor being provided with means for selectively setting the voltage applied to its armature, said rod holding means imposing a substantially fixed load on the motor armature whereby the inherent speed regulation of the motor for substantially constant rate of selected feed of oxide rods is improved.

3. An apparatus for coating parts with refractory metal oxides and the like comprising a casing having therein a straight-line channel for entry therein endwise of relatively inflexible frangible oxide rods, said channel having coating therewith opposed feed drums having operative faces of yielding material for receiving therebetween and feeding endwise an oxide rod in the channel whereby as the trailing end of a rod emerges from in between the feed drums it is then pushed by a broken rod engaged by the drums, an air discharge and gaseous combustion nozzle structure positioned externally of said casing and held in spaced relation therefrom by air-and-gas supply means having extending therethrough and in line with said channel a rod passage for passage endwise to the action of said nozzle structure as the rod is fed directly by said feed drums or indirectly fed there by through at least one succeeding rod engaging it at its trailing end face according as the trailing end thereof is approaching or has passed beyond said feed drums, and means connecting with said nozzle structure and operating
in proximity to the leading end portion of the rod for yieldingly holding it against feeding movement and thereby maintain its trailing end in engagement with a preceding rod pushing it, whereby also said yielding rod-holding means imposes per se a substantially fixed load upon said feed drums, and a shunt motor for driving said feed drums at a selectable rod-feed rate, said shunt motor being provided with means for correspondingly setting the voltage applied to its armature and thereby select the rate of drive of said feed drums whereby said substantially fixed load improves the inherent speed regulation of the motor for the selected speed of its armature.

4. An apparatus for coating parts with refractory metal oxides and the like comprising a casing having therein a straight-line channel for entry therein endwise of relatively inflexible frangible oxide rods, said casing having coating therewith opposed feed drums having operative faces of yielding material for receiving therebetween and feeding endwise an oxide rod in the channel, said apparatus having a nozzle structure positioned externally of the casing and spaced therefrom in line with said channel by air-end gas supply means having extending therethrough a rod passage aligned with said channel for passing a rod endwise to the action of said nozzle structure as the rod is fed directly by said feed drums or indirectly fed thereby through at least one succeeding rod engaging it at its trailing end face according as the trailing end thereof is approaching or has passed beyond said feed drums, there being interposed at the exit end of said rod passage a rod gripping device having a central rod passage into which open a plurality of radial recesses with spring-pressed wear-resistant members projecting therefrom and into the rod passage of the device for substantially centering a rod therein endwise for yieldingly holding it against feeding movement and thereby maintain its trailing end in engagement with a preceding rod pushing it, and means for driving said feed drums at a substantially constant surface speed.

5. In an apparatus for coating parts with refractory metal oxides and the like, in combination, a casing having at one end concentrically arranged inner gas-supply and outer air-supplied threaded coupling elements of which the inner has a central opening forming the terminus of a straight-line channel in the casing for successive entry therein of relatively inflexible frangible oxide rods, with driven rod-feed means engaged with a rod in said channel to feed it endwise or to push a rod ahead of it in direction toward said coupling element central opening, a nozzle structure positioned externally of said casing and spaced therefrom in line with said channel, said nozzle structure having gas-nozzle and rod-holding means comprising a rod passage through the terminus of which is provided a rod end to flame produced at the nozzle means and coating yielding means closely adjacent said rod passage terminus for yieldingly engaging with a rod in said rod passage but with force insufficient to prevent feeding movement thereof and for yieldingly holding it against lengthwise shift after it has passed out of engagement with said feed means except as it is pushed at its trailing end by the action of said feed means upon a succeeding rod that is in engagement with said feed means, said nozzle structure having air-nozzle means for discharge of air adjacent the exit end of said rod passage, said feed and rod-holding means and said air nozzle means having means respectively connecting them to said inner and outer coupling elements for gas supply to the gas nozzle and air supply to the air nozzle and to align said rod passage and rod-holding means with said central opening and with said channel for the successive entry, feed and rod of rods thereof endwise.

6. An apparatus as claimed in claim 5 in which said gas-nozzle and rod-holding means comprise two axially aligned coupled-together parts through which said rod passage extends and of which one part forms the gas nozzle and the other part carries said yielding rod-holding means.

7. An apparatus as claimed in claim 6 in which the meansyieldingly bearing against the rod in the rod passage comprises a plurality of members projecting radially into said rod passage with spring means acting to yieldingly restrict radially the throat which they form.

8. An apparatus as claimed in claim 5 in which the means for yieldingly holding the rod against lengthwise shift along the rod passage comprises at least one rotatable element whereby it may partake of wear-reducing substantially rolling contact with the surface of the moving rod.

9. An apparatus as claimed in claim 5 in which said last-mentioned respective connecting means are relatively long for achieving a length reach for oxide coating application to a part remote from the casing and having a correspondingly long rod passage intermediate of said first mentioned rod passage and said central opening for accommodating therein a succession of oxide rods in end-to-end relation, said yielding rod-holding means holding the most remote rod against being moved by the remaining rods except as the driven feed means pushes the entire succession of rods, and said connecting means for the air-nozzle means of a rod passing air to the latter comprises a tube-like outer element about said gas nozzle and rod-holding means and providing passage means for heat-absorbing air flow relative to the latter.

10. An apparatus as claimed in claim 5 in which said last-mentioned respective connecting means are relatively short for application to a rod passing forward, in which case, said rod passage means is a rod-conducting channel, said feed means and rod-holding means being so arranged as to pass a rod through with said casing means for a rod passage channel to which it is conveyed by a rod passing forward.

11. An apparatus for coating parts with refractory metal oxides and the like comprising means forming a straight-line guideway having an entry end and an exit end for the successive entry therein of relatively inflexible frangible oxide rods, said guideway means having external thereof and adjacent its exit end nozzle means for receiving gaseous medium to produce heat by combustion for fusing the material of a rod passing therethrough to by way of said exit end and to produce a blast to project fused particles from the rod end, said nozzle having a deflector to deflect said blast, said exit end of said guideway means having associated therewith yielding means for yieldingly engaging with the rod that is at the exit end of said guideway means and for holding it against lengthwise shift along said guideway means, the latter having associated with it adjacent its entry end driven feed means engageable with a rod thereat for transmitting endwise movement thereto to move it toward said exit end of the guideway means, said yieldindrod-engaging means adjacent said exit end exerting a holding force on the rod that is insufficient to prevent feeding movement thereof directly by said feed means or indirectly by the latter through at least one succeeding rod in said guideway means, but sufficient to restrain rod ejecting thrust on the rod end of said rod passage.

12. An apparatus as claimed in claim 11 in which said guideway means consists of a length relative to the length of the rods to accommodate therein a succession of the latter in end-to-end relation, said yielding rod-holding means holding the rod at the exit end against being moved by the remaining rods except as the driven feed means pushes the entire succession of rods and thereby maintain continuity of end-to-end relation of rods in said guideway for feeding movement of the leading rod of the succession of rods.

13. In an apparatus for coating parts with refractory metal oxide and the like, in combination, a casing having therein a straight-line channel for entry therein endwise
of relatively inflexible oxide rods and having driving means for engaging and feeding endwise an oxide rod in the channel whereby as the trailing end of a rod disengages said feeding means it is then pushed by a succeeding rod engaged by said feeding means, a nozzle structure for receiving a gaseous medium to produce a flame for fusing the rod material and having a channel to convey air under pressure to produce a blast for projecting particles fused by the flame, an air deflector plate to deflect the blast away from the axis of the channel, said nozzle structure being positioned externally of said casing and held in spaced relation therefrom by means for conducting gaseous medium to the nozzle structure, said last-mentioned means having extending there-through and in line with said casing channel a rod passage for passing a succession of rods endwise to the fusing and blast action of said nozzle structure as the rod is fed directly by said feed means or indirectly fed thereby through at least one succeeding rod engaging it at its trailing end face accordingly as the rod whose leading end is in the region of the flame produced at the nozzle structure is in, or has passed out of, feeding engagement by said feed means, said nozzle structure and air channels and said deflector plate in producing said flame and directing said blast exerting a forward feeding force on the rods tending to eject them from the nozzle, and gripper means adjacent said nozzle structure and operating in proximity to the leading end portion of the rod for yieldingly holding it against ejecting movement and thereby maintaining its trailing end in engagement with a succeeding rod pushing it.

14. Apparatus for fusing and atomizing relatively inflexible oxide rods comprising a casing, rod feeding means in the casing, a nozzle, a tube like barrel to conduct air under pressure to the nozzle to produce a blast, a deflector in the nozzle to deflect the air, said barrel having channels to conduct gases of combustion to said nozzle, said barrel having a channel for the rods, and a rod gripper to restrain the rods which have been advanced out of contact with the feeding means from ejection by the blast, the barrel connecting the casing and the rod gripper which is adjacent the nozzle.

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