This invention relates to apparatus for applying metallic coatings to extended flexible metal articles by dipping such articles in a bath of molten coating metal, and particularly to apparatus for coating aluminum on extended flexible articles of ferrous metal in this manner. More specifically, the invention is directed to the provision in such apparatus of a new sinker roll assembly adapted to guide a moving length of the ferrous article beneath the surface of the molten aluminum bath, the new assembly being characterized in that at least the greater part of its submerged elements are formed from bonded silicon-carbide.

In hot-dip coating apparatus of the type described, means must be provided in the crucible containing the molten coating metal for drawing the moving length of the extended flexible article beneath the surface of the bath so that it is thoroughly immersed in the coating metal. This is usually accomplished in low-temperature coating operations by a device known as a sinker roll, which is simply a pulley submerged in the coating liquid for carrying the extended article around the lowest point in its path of travel. In hot-dip coating, however, great difficulty is encountered in providing a sinker roll assembly which can operate while submerged in molten metal, and particularly in molten aluminum. Primarily, the problem is one of material since the assembly must be mechanically strong and yet possess exceptional resistance to corrosion and chemical attack by molten metals. Steel, for example, cannot be used in the submerged parts of a hot-dip sinker roll because it is severely attacked and corroded by molten aluminum within minutes. Similarly, even the most heat-resistant cast iron cannot withstand attack for too long if used in the smaller parts of such a sinker roll. On the other hand, porcelain and most inert refractory ceramics are capable of resisting corrosion and chemical attack by molten aluminum but they lack mechanical strength to such a degree that they invariably fracture or break under operating conditions, especially when used to form the moving parts of the sinker roll.

It is the primary purpose of the present invention, therefore, to provide a sinker roll assembly for hot-dip coating apparatus which possesses the corrosion resistance to molten metal of ceramic materials, and yet has sufficient mechanical strength to withstand the normal stresses which occur during operation.

The sinker roll assembly of the invention is to be used in apparatus for hot-dip coating extended flexible metal articles with a coating metal. Such apparatus includes a refractory crucible for containing a bath of molten coating metal and exterior guiding means for directing a moving length of the metal article into and out of the bath. Broadly stated, the new sinker roll assembly comprises a frame positioned below the normal surface level of coating metal in the crucible. Journal bearings are mounted in the frame and a pulley member is rotatably mounted in the journal bearings for carrying the moving length of the article beneath the surface of the coating metal bath. The journal bearings and the pulley member are formed from bonded silicon carbide and in normal operation are submerged in the bath of molten coating metal.

Bonded silicon carbides possess excellent resistance to corrosion and chemical attack by molten aluminum. Moreover, as a result of the compacting, pressing and casting techniques presently in use, bonded silicon carbide can now be formed into many shapes which, after firing, have a relatively high degree of mechanical strength. Accordingly, the invention contemplates the use of this refractory material in a sinker roll assembly which is especially designed to take advantage of the material's exceptional resistance to corrosion and chemical attack and, at the same time, to compensate for its strength limitations.

Hence, when constructed in the manner described above, a mechanically dependable sinker roll assembly results which is capable of functioning indefinitely in a bath of molten aluminum. Moreover, since the bonded silicon carbide parts of the new assembly are inert to attack by the molten metal, they do not constitute a source of contamination to the bath.

Of the various bonded silicon carbide materials commercially available, it has been found that particularly good results are achieved with a silicon carbide bonded with silicon nitride. This material is preferable because of its markedly superior mechanical strength. However, other types of bonded silicon carbide materials may also prove to be quite suitable, such as silicon carbides bonded with clay, glass, porcelain or carbon.

In a preferred form, the sinker roll assembly of the invention is adapted to be lubricated by the molten metal in which it is immersed. Thus, clearances are provided between the moving parts of the assembly so that the molten metal can circulate freely therethrough. Not only does this reduce friction, but it also minimizes the impact stresses and the like to which such parts are subjected during operation thereby lessening the risk of mechanical failure.

These and other advantages of the new sinker roll assembly are made apparent in the following description of a preferred embodiment of the invention, wherein

FIG. 1 is an elevation of hot-dip coating apparatus of the type described adapted to coat a plurality of ferrous metal wires with aluminum at one time;

FIG. 2 is a fragmentary enlarged section taken along the line 2—2 of FIG. 1 showing the new sinker roll assembly in operative position in the apparatus;

FIG. 3 is a fragmentary plan view of the sinker roll assembly of FIG. 2;

FIG. 4 is a section taken along the line 4—4 of FIG. 2; and

FIG. 5 is a fragmentary side elevation of the mounting means for the sinker roll assembly of FIG. 2.

Referring first to FIGS. 1 and 2, the hot-dip coating apparatus includes a pot-type furnace which forms a crucible 10 for containing molten aluminum. The crucible 10 is encased in a plurality of steel shell sections 11 and is peripherally covered by an annular covering plate 12 extending around its rim. As seen most clearly in FIG. 2, a refractory lining 14 is disposed about the inside surface of the crucible 10 to define a cavity adapted to contain a bath 15 of molten aluminum. The covering plate 12 substantially overlies the upper periphery of the refractory lining 14 and forms the rim of the crucible 10. Mounted above the crucible 10 and extending downwardly into the bath 15 is a gas burner assembly 17 of any suitable type for maintaining the bath 15 in molten condition. Also mounted over the crucible 10 is a frame 18 supporting an inlet pulley 19 and a cooling tower 20 having an outlet pulley 21 mounted on its upper end.

In the operation of this typical hot-dip coating apparatus, a plurality of moving lengths of ferrous metal wire 22 are passed over a corresponding plurality of grooves in the inlet pulley 19 and are directed downwardly into the bath 15. After the wires 22 are thoroughly immersed
in the molten aluminum of the bath 15, they are drawn upwardly adjacent the tower 20 to permit the aluminum coatings to solidify. The coated wires 22 are then passed over corresponding grooves in the outlet pulley 21.

To insure that the wires 22 are guided beneath the surface of the bath 15, a singer roll assembly 24 is provided by the invention. As is shown in FIGS. 2 through 5, this singer roll assembly includes an extended melting plate 25 spanning the rim of the open crucible 10. The opposite ends of the mounting plate 25 are releasably secured by a pair of clamping means each of which includes a lower block 26 underlying the plate 25 and an upper gripping arm 27 clamping down on the plate 25. The upper gripping arm 27 is supported on a spacer 29 and is forced downwardly against the corresponding end of the mounting plate 25 by means of a pair of bolts 30 threaded with nuts 31 and extending through the block 26 on each side of the spacer 29. The bolts 30 are secured at their lower ends to the cover plate 12 forming the rim of the crucible 10 in the central portion of the mounting plate 25 directly over the bath 15 of molten aluminum, an arrangement of oblong holes 33 extending through the plate 25. A lug 34 is attached to the plate 25 in the center of this arrangement of holes 33 to provide means for lifting the assembly.

From the underside of the mounting plate 25, a pair of opposed brackets 36 and 37 extend downwardly into the bath 15. The brackets 36 and 37 are attached to the plate 25 by means of a plurality of bolts 38 which extend through the holes 33. Because of the oblong shape of the holes 33, the brackets 36 and 37 can be moved apart to various fixed distances relative to one another. In the lower end portions of the brackets 36 and 37, there is a pair of coaxial octagonal apertures 40 and 41 respectively (see FIG. 4) which are located considerably beneath the surface of the bath 15 of molten aluminum. Even though these lower end portions of the brackets 36 and 37 are submerged in the molten aluminum, a heat-resistant cast iron, such as Meehanite for example, can be used to form them because they are heavy parts of thick cross section. Because of their great size, whatever corrosion by the molten aluminum does occur will not critically affect their operating life.

A pair of journal bearings 43 and 44 of octagonal exterior cross section are seated closely and non-rotatably within the apertures 40 and 41 respectively. In order to reduce stresses on the bearings, they are advantageously constrained by four segmental or trapezoidal quadrant elements as shown in FIG. 4. The four elements are contained within the respective apertures 40 and 41 so that they remain in position during operation. Each of the journal bearings 43 and 44 has an integral flange portion 45 and 46 respectively extending outwardly at one end thereof. When the journal bearings 43 and 44 are operatively positioned in the apertures 40 and 41, these flanges 45 and 46 are positioned against the inwardly facing sides 47 and 48 respectively of the brackets 36 and 37 so that the journal bearings cannot pass through the apertures. The inner bearing surfaces of the journal bearings 43 and 44 are of smooth, uniformly circular cross section.

In the assembled device, the opposite ends of a hollow cylindrical spindle 50 extend through the respective journal bearings 43 and 44 in loose rotatable engagement with the inner bearing surfaces thereof. The outside diameter of the spindle 50 is such that it is barely capable of being rotated in each of the journal bearings. In this manner, the molten aluminum of the bath 15 is permitted to circulate around the ends of the spindle and lubricate it as it rotates in the journal bearings during operation.

Secured coaxially about the spindle 50 are a pair of annular supporting discs 52, only one of which is shown in FIG. 7. Each of the supporting discs 52 is located closely adjacent the flanged end of the adjacent journal bearing so that longitudinal movement of the spindle 50 between the inwardly facing sides 47 and 48 of the brackets 36 and 37 is limited during operation of the device. A substantially cylindrical pulley drum member 54 is affixed about and extends between the peripheries of the discs 52 between the brackets 36 and 37. Formed about the circumference of the pulley drum member 54 is a plurality of circular grooves 55 each of which is adapted to carry one of the wires 22 being coated. According to the invention, the journal bearings 43 and 44, spindle 50, supporting discs 52, and pulley member 54 are each formed from bonded silicon carbide and are joined by a suitable refractory cement 58. As described previously, bonded silicon carbide can be easily formed into the respective shapes shown by many compacting, pressing or casting processes. These shapes have been designed to provide uniform cross sections and a minimum of projections, thereby compensating for the relatively low tensile and bending strength of the material. Various types of bonded silicon carbides are in the efficiently and, of course, corrosion resistant to be suitable in forming these parts, such as silicon carbide bonded with clay, glass, porcelain or carbon.

It has been found, however, that the recently developed nitride bonded silicon carbides are preferable since they possess considerably superior mechanical properties retaining the excellent refractory characteristics of the other bonded silicon carbides. Especially satisfactory is silicon carbide bonded with silicon nitride, which is formed by mixing silicon metal in the silicon carbide prior to kiln-firing. During firing, the silicon metal is nitrided to form a bonding material which considerably increases the strength of the silicon carbide. Not only has this ceramic material shown excellent resistance to corrosion and chemical attack by molten aluminum, but it also possesses a degree of mechanical strength which approaches that of cast metal.

In assembling the new singer roll, either one of the brackets 36 or 37, for example the bracket 37, is detached from the mounting plate 25 when the assembly is out of the crucible 10. The journal bearings 43 and 44 are then seated in the respective octagonal apertures 40 and 41. One end of the spindle 50 is inserted in the bearing surface of the journal bearing 43, and the journal bearing 44 and bracket 37 are brought up around the other end of the spindle 50. The bracket 37 is then attached loosely to the mounting plate 25 by the bolts 38. Next, the brackets are brought together by adjusting the position of the bolts 38 in the oblong holes 33 until the pair of supporting discs 52 on the spindle 50 are closely adjacent the flanges 45 and 46 on the journal bearings 43 and 44, and the bolts 38 are tightened. The assembly is then lifted by means of the lug 34 and lowered in place on the crucible 10 substantially centrally over the bath 15. Finally, the clamping arms 37 are tightened against the opposite ends of the mounting plate 25 to hold the assembly in place on the rim of the crucible.

During operation, the plurality of wires 22 being coated are directed downwardly over the inlet guiding pulley 19 into the bath 15 and around the submerged pulley drum member 54. Each of the wires 22 is carried in a separate groove 56 formed in the circumference of the pulley member 54. After being carried beneath the surface of the bath 15 by the singer roll assembly, the coated wires are directed upwardly through the cooling tower 20 and over the outlet pulley 21. At the new bonded silicon carbide in which the journal bearings are situated, the bearing surfaces of the same material, the molten aluminum circulates within the journal bearings and lubricates the device. It has been found that these parts can operate almost indefinitely without failing mechanically or undergoing any substantial corrosion by the molten aluminum.

Normally which is 36 and 37, forming the journal bearings 43 and 44 are sufficiently thick and heavy to permit them to be formed from heat-resistant cast iron, as noted previously. Under certain circumstances, however, it might be advantageous to form the brackets 36
and 37 of a ceramic material, such as the bonded silicon carbide used in the other submerged parts of the apparatus. While the new sinker roll assembly is described here in apparatus for hot-dip coating a plurality of wires, it may be used in apparatus for coating many other types of extended flexible articles. For example, it can be modified readily for the coating of strips and even sheets of the base metal. The multi-grooved pulley mean member 54 would then be replaced by a drum member having only one or two wider grooves to carry the wider articles. If the width of the article is particularly great, only one groove would be incorporated and, if necessary, additional supporting discs 52 might be added between those shown to support the drum member internally intermediate its ends.

I claim:

1. In apparatus for hot-dip coating extended flexible articles of ferrous metal with aluminum, said apparatus including a refractory crucible for containing a bath of molten aluminum and exterior guiding means for directing a moving length of said metal article downwardly into and upwardly out of said bath, a sinker roll assembly for guiding the article beneath the surface of said bath comprising a mounting plate spanning the rim of said open crucible, clamping means on said crucible for releaseably securing said mounting plate to the rim of said crucible, a pair of brackets attached to and extending downwardly from said mounting plate and adjustable secured thereto to permit varying the spacing between said brackets, a pair of opposed journal bearings having an outer surface of polygonal cross section flanged at one end and an inner bearing being nonrotatably mounted in opposed apertures of corresponding polygonal shape in the lower end portions of the respective brackets with their flanges against the inwardly facing sides of the opposed brackets, each of said journal bearings being made up of four contained segmental elements which together form a substantially cylindrical bearing, a substantially cylindrical spindle loosely fitted at its opposite ends in the bearing surfaces of the respective opposed journal bearings for rotation therein, at least two supporting discs cemented coaxially to said spindle with the outermost discs positioned closest adjacent the respective journal bearings, and a substantially cylindrical pulley drum member cemented about the peripheries of said discs between said brackets, said journal bearings, spindle, discs and pulley drum member being formed from bonded silicon carbide and being in normal operation at least partly submerged in said bath of molten aluminum.

2. In apparatus for hot-dip coating extended flexible metal articles with a coating metal which includes a refractory crucible for containing a bath of molten coating metal and exterior guiding means for directing a moving length of said metal article into and out of said bath, a sinker roll assembly for guiding the article beneath the surface of said bath comprising a bracket means extending below the normal surface level of coating metal in said crucible, crucible bearings mounted in said bracket means, a substantially cylindrical spindle loosely fitted at its opposite ends in the bearing surfaces of the respective opposed crucible bearings for rotation therein, at least two supporting discs cemented coaxially to said spindle with the outermost discs positioned closest adjacent the respective crucible bearings, and a substantially cylindrical pulley drum member cemented about the peripheries of said discs, said journal bearings, spindle, discs and pulley drum member being formed from bonded silicon carbide and being in normal operation at least partly submerged in said bath of molten aluminum.

3. In apparatus for hot-dip coating extended flexible articles of ferrous metal with aluminum, said apparatus including a refractory crucible for containing a bath of molten aluminum and exterior guiding means for directing a moving length of said ferrous article downwardly into and upwardly out of said bath, a sinker roll assembly for guiding the article beneath the surface of said bath comprising a mounting plate secured to and spanning the crucible above the surface of the bath of molten aluminum, a pair of brackets attached to and extending downwardly from said mounting plate into said crucible, a pair of opposed journal bearings mounted on the lower end portions of the respective brackets, a substantially cylindrical spindle loosely fitted at its opposite ends in the bearing surfaces of the respective opposed journal bearings for rotation therein, at least two supporting discs cemented coaxially to said spindle with the outermost discs positioned closest adjacent the respective journal bearings, and a substantially cylindrical pulley drum member cemented about the peripheries of said discs between said brackets, said journal bearings, spindle, discs and pulley drum member being formed from bonded silicon carbide and being in normal operation at least partly submerged in said bath of molten aluminum.

4. A sinker roll assembly according to claim 3 where in said silicon carbide is bonded with silicon nitride, and each of said journal bearings is made up of a plurality of contained segmental elements which together form a substantially cylindrical bearing.

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