Jan. 29, 1935. J. H. L. DE BATS 1,989,186

METHOD OF FORMING ROLLS

Filed Oct. 5, 1932

Fig. 1.

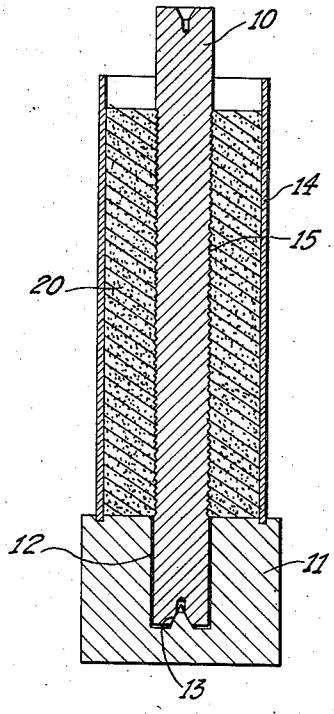



Fig. 2.

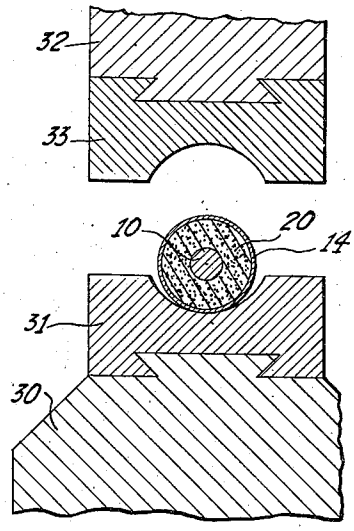



Fig. 3.

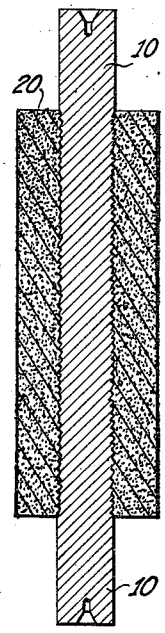



Fig. 4.

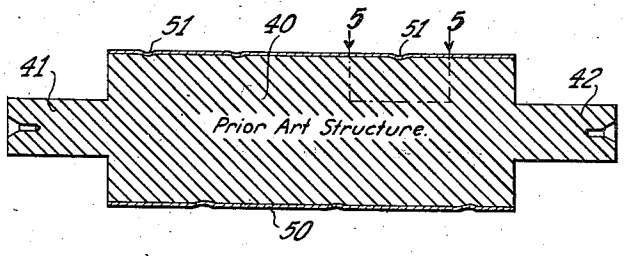
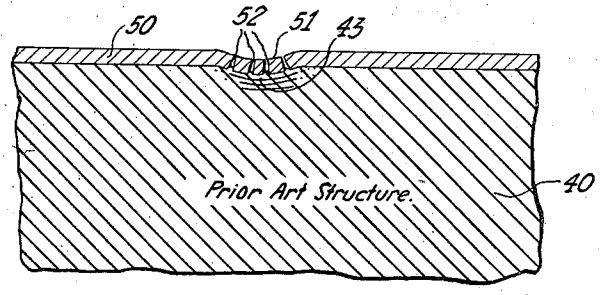



Fig. 5.




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## METHOD OF FORMING ROLLS

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Application October 5, 1932, Serial No. 636,283

4 Claims. (Cl. 29—148.4)

This invention relates to improvements in methods of forming rolls from nitrided steels and other alloys and the improved compositions and articles prepared therefrom.

Hitherto, it has been proposed to nitride aluminum bearing steels and other alloy materials by exposing articles prepared therefrom to atmospheres of nitrogeneous compounds such as ammonia. Such processes are inherently costly and lacking in efficiency, due to the fact that penetration of the surface of the metal article by the nitrogen is extremely slow, as much as ninety hours being required for the formation of a "case" or "skin" of substantially 1/64" in depth of a nitrogen alloy, the so called "nitride".

While the nitrides thus formed apparently exhibit an inhibiting effect on the nitrogen gas liberated in situ and prevent its further reaction with the metal, due to the fact that the case, skin or sheathing of nitride formed is substantially saturated with respect to nitrogen, the fact remains that the iron nitride or other nitrides formed are very resistant to decomposition, even under relatively high heats. Thus, it will be seen that, upon the formation of a stable surface layer of nitride, the underlying unreacted metal is protected from the nitrogeniferous composition used, and the surface or skin itself, immediately after its formation, becomes a barrier or bar to the smooth continuance of the nitriding reaction. As pointed out above, the attainment of a nitrided case of substantially 1/64" in depth, requires about ninety hours heat treatment in a stream of ammonia.

Metallic articles having a nitrided case, are characterized by great surface hardness, the hardness of iron nitride approximating that of the heavy metal carbides, such as tungsten carbide. Such hard surfaces are particularly desirable for use in rolls for rolling mills and for wearing parts generally, which are subjected to abrasive wear. However, owing to the thinness of the skin of nitride, as compared to the bulk of the body of the roll, the skin does not have a backing or support of sufficient strength to permit the article to be used to a great extent, commensurate with the capabilities of the nitride alone.

It has been found that surface nitrided rolls break down, under use, due to the fact that the supporting metal of the roll is softer and is displaced readily when the surface of the article is subjected to uneven pressures, with the result that the skin of nitride at such points is ruptured or becomes depressed. This is due, in part, at least, to the fact that the nitriding reaction results often-times in an uneven, pitted surface, occurring when carbide particles are present, and also due to the fact of unevenness in surface reaction, caused by oily finger marks formed or imprinted on the surface in the preliminary handling of the roll or other article to be treated. Extreme care is therefore necessary to avoid any or all of these defects, although certain of them may be inherent and not readily detectable save at great cost.

It has now been found that the desirable characteristics of nitrided alloys may be made use of and rendered available in a wide variety of articles and in most any thickness whatsoever. This improvement is accomplished by first preparing the alloys to be nitrided, as such, according to the general principles laid down in my application for improvements in Metallic nitrides and methods and apparatus for preparing same, filed October 1, 1932, Serial Number 635,818 and to then further process them with particular modifications, as will be hereinafter described with greater particularity to obtain nitrided material.

The so prepared nitride alloys are formed or tamped in place in a suitable mold, and thereafter heated, preferably not above 875° F. or 900° F., to a desired forging or working temperature. The rough formed and heated articles are then forged, either in a press or by swaging, or by any other well known manner, to the desired dimensions, and cooled. The resulting articles may be finish ground or machined to the desired final dimensions, and the finished product will be substantially shock proof and wear resistant, due to the fact that the actual wearing surface or surfaces are formed or supported on materials of like physical characteristics. This uniformity of composition, and of physical characteristics, assures evenness of wear and uniform results in operation. In addition, due to the speed with which the nitride alloys can be made and formed, according to the practices of the present invention and those of my invention above referred to, the cost of preparing a roll of a nitride alloy is appreciably less than that of forming a skin of nitride on a roll. In addition, the time involved becomes a matter of a few hours at the most, as compared with the ninety hours or more required to form the relatively thin, inefficient, nitride skin according to prior methods.

Forming rolls, dies, and other machine parts, which are subjected to heavy wear, may thus be made rapidly, economically and in a superior and absolutely uniform manner, so as to assure a

superior and entirely uniform product or products which can be duplicated at will, and which will permit of desirable economies in all types of machine parts.

The novel features and advantages of the present invention, as intimated hereinabove, will be described more in detail with particular reference to the drawing, although it will be understood that it is not intended to be limited to the matter herein disclosed, except as such limitations are imposed by the appended claims.

In the drawing, like numerals refer to similar parts throughout the several views, of which

Fig. 1 is a vertical section of a mold for forming a roll with the several parts in place;

Fig. 2 is a transverse vertical section of a roll in a forging press;

Fig. 3 is a vertical elevation, partly in section of a finished roll;

Fig. 4 is a longitudinal section through a roll, as made according to prior processes;

Fig. 5 is an enlarged vertical section of a portion of the surface of the prior art roll, taken on lines 5—5 of Fig. 4.

Referring now more particularly to the drawing, a shaft or core 10 is mounted on a base or support 11, which is provided with a central depression or well 12, and, if desired, with a centering pin 13. A casing or sheathing 14 of seamless tubing, of iron, steel, or any other desired material, is mounted on the support 11 and uniformly spaced from the shaft or core 10.

The shaft 10 may be provided with serrations 15, or a coating of any suitable metal, such as copper, brass, or the like. The member 14 constitutes a mold or form in which a nitride composition 20 is rammed up into intimate contact with the shaft or core 10.

This nitride composition may comprise a steel or iron base material, which may have been subjected, while in particle form, to an atmosphere of a nitrifying agent, such as ammonia, in an apparatus and according to the method set forth and claimed in my application for Improved method and apparatus for making powdered metals, Serial Number 627,548, filed August 5, 1932. The nitride alloy so formed may be ball milled to a suitable fineness to insure uniformity of composition and density, as well as to promote packing of the same when rammed or pressed up in suitable molds.

While the nitride alloys are preferably prepared in powdered form by the method recited above, the novel concepts of the present invention also comprehend the preparation of the same by reacting metal chips, grindings and finely divided portions in an atmosphere of ammonia, and while heated to a desired temperature of the order of 875° F., or above, while subjecting the materials to attrition. This may be accomplished by placing the materials in a tumble mill, provided with rods, balls or other devices, which mill may be disposed in an induction furnace or heated in any desired manner, and which is also provided with a current of ammonia gas or other nitrogeneous material adapted to react with the metal contained therein, to nitrify the same, all as set forth in my application, Serial Number 635,818, filed October 1, 1932.

It will be seen that, due to the nitrifying of substantially infinitely small particles of metal, the nitride alloy will be uniform in composition and not restricted to a surface casing, skin or coating. By suitable reduction of the particles to a desired fineness, complete homogeneity of the alloy is assured. When a desired amount of this material is rammed up in a mold, it will be obvious that the article formed therefrom will be uniform in its physical characteristics, as well as being uniform in chemical composition. In addition, the material so formed will partake of the nature of true iron and steel alloys in that they remain forgeable and may be readily hot worked according to well known methods, and may be cold worked, although, of course, to a considerably less degree than hot worked.

The composite article is heated to a forging temperature of about 875° F., in the presence of a reducing gas, and is forged or swaged to a desired shape, as indicated in Fig. 2. Any well known type of forging or swaging apparatus may be used such as one shown in Fig. 2, wherein the anvil 30 is provided with a removable swaging block 31, with which cooperates a hammer 32, provided with a removable face or head 33, configured to the anvil face 31. After the member 20 has been reduced to the desired dimensions, the sheath 14 is removed in any well known manner, as by grinding or machining, and the surface is finish ground to give a finished roll, as shown in Fig. 3. Where the nitride composition 20 is applied to the core without using a sheathing, the swaging or forging may desirably take place in a reducing atmosphere to prevent oxidation of the surface. However, if the surface is oxidized, the coating may be removed by a finish grinding or machining.

The uniformity of performance of the surfaces of the members 20, as formed by the methods of the present invention, and the desirable results obtained, are strikingly illustrated by comparison with the structures shown in Figs. 4 and 5. In Fig. 4, there is disclosed a longitudinal section of a roll 40, having shaft portions 41, 42 formed integral therewith, although, of course, the shaft may be a continuous member with a body or roll portion shrunk thereon. The roll may be provided with a nitrided surface 50, which, as indicated hereinabove, may attain a depth of about 1/64" after ninety hours heating in an atmosphere of ammonia and at a temperature of about 875° F. The skin or surface 50 is possessed of a markedly different chemical composition from that of the underlying material of the body 40. This difference in composition is accompanied by differences in physical characteristics, among which, for the purposes of the discussion, that of hardness is most pronounced. The iron nitride of the skin 50 has a hardness, approximately 110 Scleroscope (Shore), of the order of that of tungsten carbide, vanadium carbide, tantalum carbide and other like compounds of the heavy metals. The body portion 40, however, is relatively soft, even if made of so called high speed steel, which may attain a maximum hardness, in some grades, of about 100 Scleroscope (Shore).

When the roll or other article is subjected, during use, to uneven pressures, pittings or depressions 51 may be formed therein due to the compression of the underlying portions 43 of the metal body. The skin is fractured or ruptured, as indicated at 52, and the surface of the roll is damaged, requiring refinishing. This refinishing is a costly procedure, as the skin can not be built up, but must be ground or machined off and the roll again subjected to a nitriding operation. If the roll is required to have certain standard dimensions, a surface of the body material will have to be built up thereon, as by welding or

casting, or sweating a tube or sheath of the same material in place, after which the nitriding operation is carried out, as the "case" formed is the result of a reaction with the surface material and not a superposition of added material.

While a body 20 of a pure nitride alloy has been disclosed as the preferred embodiment of the present invention, it will, of course, be appreciated that any thickness of surface of this material may be used and a layer or sheath of any desired depth may be superposed on a previously formed roll, without departing from the spirit and scope of the present invention.

The novel material and method of the present invention may be applied to the surfacing and/or formation of wear resisting articles generally, including slide faces, guides, wrist guides, wearing surfaces or bearings for locomotives and other heavy machinery, roller bearings, forming members and facings for the same for use in metal bending either in sheet metal work or boiler plate work. In fact, the applications of the principles and products of the present invention are limited to no small degree by the machines now in use in industry.

It will now be appreciated that there has been provided an improved method of forming rolls of nitrided alloy products, which products and articles are characterized by high wear resistance, coupled with ease of formation and application, and which are characterized further by low cost in manufacture, coupled with economy of time and labor, and in which the thickness of the nitriding portion may be readily designed and governed.

While certain novel features of the invention have been disclosed and are pointed out in the annexed claims, it will be understood that various omissions, substitutions and changes may be made by those skilled in the art without departing from the spirit of the invention.

What is claimed is:

1. The method of forming rolls for metal rolling machines and the like, and having working surfaces of a tough, hard alloy of iron nitride in solid solution in iron, comprising forming a conformed mold chamber, inserting a nitrided alloy composition, in discrete form, in the so formed mold, ramming up the nitride composition to a desired degree, heating the mold and contained nitride to a swaging heat, hammer working the heated composite to desired dimensions, and thereafter cooling the roll and removing the sheath.

2. In the formation of rolls, wearing parts and the like for heavy machinery, the improvements comprising forming a tubular, metallic mold member of the general shape of the article to be formed, filling the mold with a discrete iron nitride composition, compressing the same in the mold, thereafter heating the mold and contained nitride to a hot working temperature of the order of 875° F., but below the temperature of decomposition of the nitride, hot working the so heated composite to secure a desired final shape, and thereafter removing the sheath or mold member.

3. The method of forming rolls for metal working machines and the like and having working surfaces of a tough, hard alloy of iron nitride in solid solution in iron, comprising inserting a shaft member in a conformed tubular sheath and centrally thereof, inserting an alloy comprising iron nitride in solid solution in iron and in discrete form in place between said sheath and said core, compressing the said alloy to a desired density, heating the composite sheathed alloy roll in a suitable furnace and to a temperature not exceeding the decomposition temperature of the alloy material, thereafter pressure working the said sheathed article to a desired finished shape, and removing the sheath from the formed alloy article.

4. The method of forming rolls for metal rolling machines and the like, and having working surfaces of a tough, hard alloy of iron nitride in solid solution in iron, comprising forming a conformed mold chamber, inserting a nitrided iron-base alloy composition in finely divided form in the said mold, ramming up the nitride composition to a desired degree, heating the mold and contained nitride to a forging temperature of the order of about 875° F., hammer-working the so-heated composite to desired dimensions and thereafter cooling the roll and removing the sheath.

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