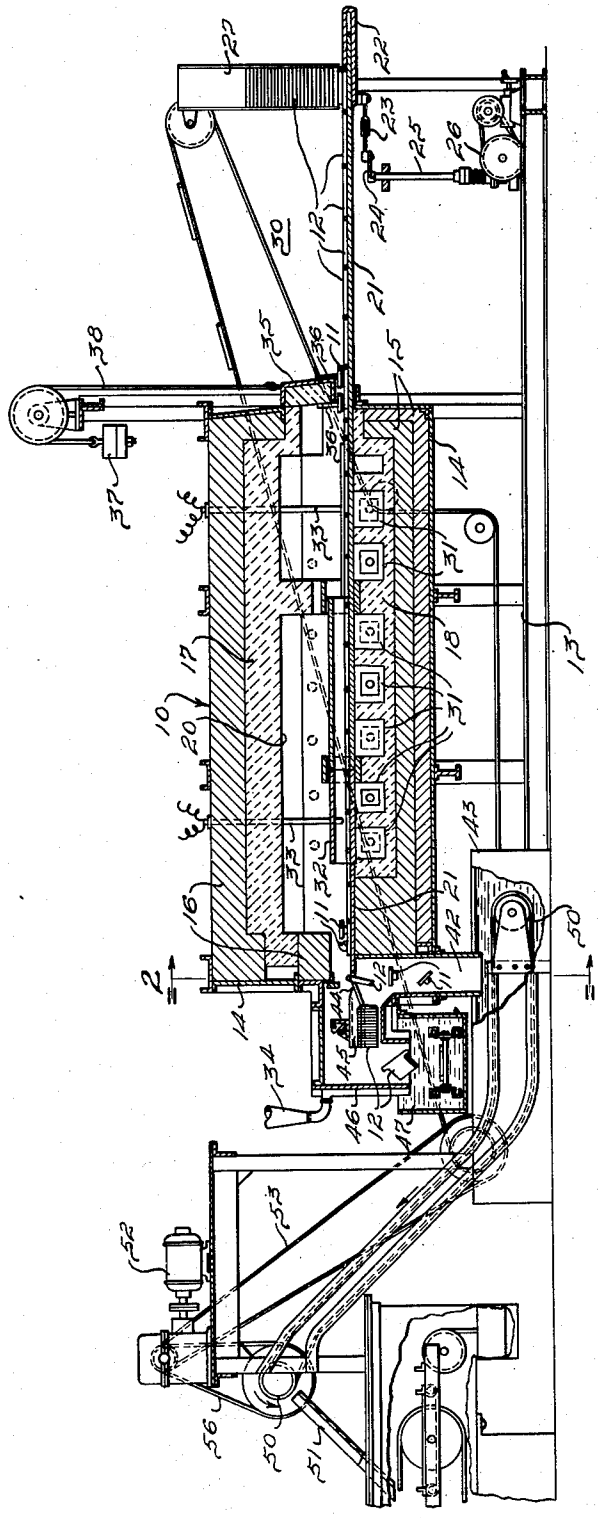
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METHOD FOR HEAT TREATING POROUS METAL STRUCTURES

Filed May 19, 1934 2 Sheets-Sheet 1



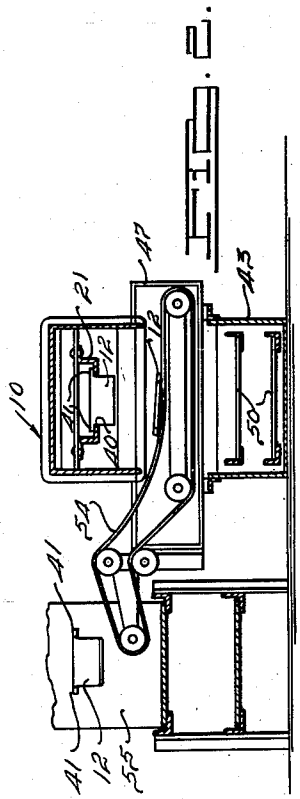


FIG. 2.

FIG. 1.

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METHOD FOR HEAT TREATING POROUS METAL STRUCTURES

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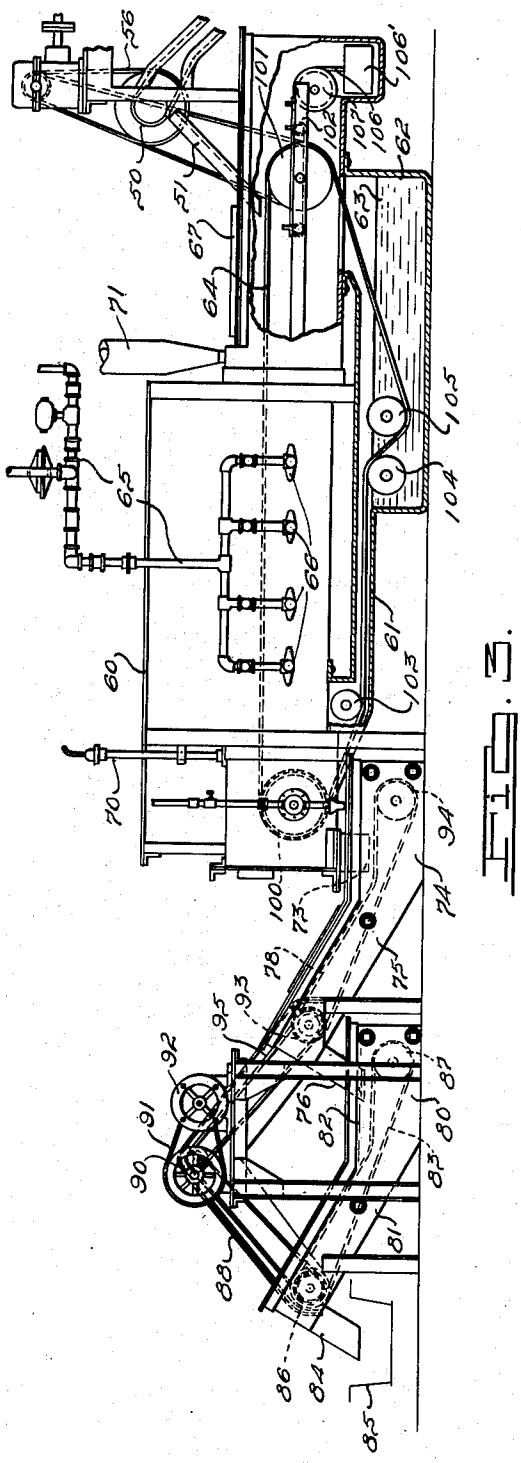


Fig. 3.

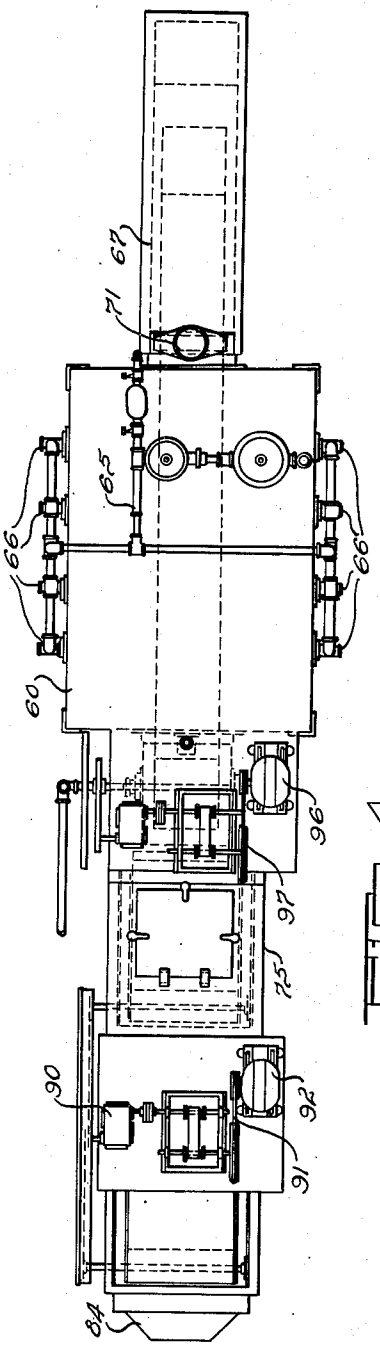


Fig. 4.

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# UNITED STATES PATENT OFFICE

2,074,185

## METHOD FOR HEAT TREATING POROUS METAL STRUCTURES

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4 Claims. (Cl. 148—1)

This invention relates to improved methods and apparatus for heat treating porous metal structures and for filling the voids of interstices of such structures with lubricant or other desired impregnating material.

Porous metal structures of the character to which this invention relates generally include a mixture of powdered metals having different melting points and with the metal or metals constituting the major portion of the structure preferably in the amorphous state in which the particles of the metal are highly porous or spongelike. Such mixtures of powdered metals are compressed to form structures of the desired shape and these are heated at temperatures above the melting point of one of the metals and below the melting point of another metal to sinter the composition. The metal composition is sintered in a non-oxidizing or reducing atmosphere, and when the structures are to be used for bearing purposes, their pores, voids or interstices are filled with a lubricating material by immersing the structures while hot in a bath comprising an impregnating material such as oil or other suitable lubricant.

The principal object of this invention is to improve the art of fabricating filled porous metal structures.

Another object is to provide an improved method for heat treating and filling porous metal structures with lubricant, by virtue of which method, exposure of the structures to atmosphere or other oxidizing agents while at elevated temperature and before impregnation thereof by a lubricant is avoided.

Another object is to provide for annealing the structures when the major portion of the metals employed is of such nature as to become tempered or embrittled during the sintering process.

Another object is to provide a method of subjecting porous metal structures to heat treatment and impregnation with a lubricant so that the treated structures are clean and bright on their surfaces and free from oxides in the interior thereof, thus affording greater strength of the structures and simplifying the detection of flaws, cracks or other defects.

Other objects and advantages will become apparent from the following description and appended claims.

For the purpose of illustrating the genus of the invention, typical concrete embodiments are shown in the accompanying drawings for carrying out the process sintering, heat treating and impregnating porous metal structures according to the principles of this invention.

In the drawings:

Fig. 1 is a side elevation, with parts broken away and in section, of a sintering furnace together with feeding, conveying and quenching apparatus employed in conjunction therewith in fabricating porous metal structures;

Fig. 2 is a section on the line 2—2 of Fig. 1;

Fig. 3 is a view similar to Fig. 1 of an annealing or sintering furnace together with conveying and quenching apparatus employed in conjunction therewith in fabricating and impregnating porous metal structures; and

Fig. 4 is a top plan of apparatus shown in Fig. 3.

Porous metal structures, to which this invention pertains, are formed by pressing different metals, each in a finely comminuted condition and preferably in the amorphous state, with or without a binder, to produce briquettes of the form of the structure desired. These briquettes are sintered by subjecting them, in a non-oxidizing or reducing atmosphere, to a temperature at least above the melting point of one of the metal constituents but below the melting point of another metal constituent. The structures while hot, and before exposure to an oxidizing atmosphere while hot, are immersed in an impregnating material to cause the voids, pores or interstices thereof to be filled with the impregnating material. In the event that the structures are employed as bearing elements, the impregnating material is preferably a lubricant such as oil, grease, or graphite. Bearing structures may be made of a mixture of approximately 85 parts copper and 15 parts tin, by weight, and sintered at a temperature of approximately 1500° F. The sintered structure may be quenched from approximately this temperature, at which temperature the various pores and interstices of the metals are expanded to their maximum degree since the mixture of metals has a melting point slightly thereabove. Upon engaging an impregnating material, as oil, for example, at such temperature, the metal cools and contracts causing a maximum of oil to be absorbed by the structure. The presence of oil in the interstices of the structure prevents oxidation of the walls of the interstices. A very small amount of occluded gas remains in the pores of the structure.

Another satisfactory composite for bearing structures is approximately 85 parts, by weight, of sponge iron and 15 parts of copper. Sponge iron is a finely comminuted amorphous iron powder having particles that are highly porous or spongelike. This composition is pressed into

briquettes in the form of the structure desired, with or without a binder as before, and sintered at a temperature of approximately 2100° F. This is below the melting point of iron. At this temperature the copper fuses and effects the sintering of the metal composition. The iron-copper structures are preferably quenched in water from approximately this temperature, since this temperature effects quite complete absorption by the solid solution of the free ferrite giving fine grain hard material. Quenching sets the elements in this relation but leaves the structure in a state of internal strain. A reheating is necessary to eliminate the latter condition. This may be effected by heating to an annealing temperature which is maintained for a sufficient time to increase the ductility of the structure, which results in greater resistance to impact stress, incident to vibration and blows to which bearings are subjected. It also tends to produce a uniform elastic limit and tensile strength throughout the entire section of the structure. The structure is quenched in impregnating material, such as oil, from this temperature to absorb the maximum quantity of impregnating material and to prevent embrittlement of the structure. The structures are not exposed to oxidizing atmospheres while at elevated temperatures so that neither surface nor internal oxidation can occur and bright, clean surfaces result, affording easy detection of flaws, cracks or other defects and avoiding internal weakening of the structure.

Referring to the drawings and more particularly to Fig. 1, the numeral 10 designates a furnace adapted to be employed in sintering porous metal compositions in which the major constituent is iron, such as the 85—15 iron-copper composition previously described. Briquettes 11 in the form of the structures ultimately desired are passed through the furnace 10 from right to left as indicated in Fig. 1 upon carrier plates 12. The furnace 10 is provided with a suitable base frame 13 and a housing 14 mounted thereon which is lined by suitable heat resistant elements 15 and 16 and these are in turn faced with refractory linings 17 and 18. The lining elements 15 and 16 and refractory linings 17 and 18 provide a heating chamber 20 extending longitudinally of the furnace. A slideway 21 extends longitudinally through the furnace and the carrier plates 12 are adapted to slide along such slideway.

The carrier plates 12 are fed through the furnace by means of a U-shaped actuator 22 extending above and below the slideway 21 and operated by a connecting rod 23 and crank arm 24 driven through shaft 25 by means of a motor 26. The carrier plates 12 are initially stacked in a holder 27, the bottom end of which is spaced from the slideway 21 so that the actuator may feed the carrier plates one at a time therefrom. The actuator 22 forces a line of abutting carrier plates along the slideway 21 from right to left of the furnace, as illustrated in Fig. 1. At a loading station indicated generally by the numeral 30, an operator places the briquettes 11 on carrier plates 12 so that the briquettes are carried by the latter through the heating chamber 20 of the furnace. Since the briquettes are to be sintered at a temperature of approximately 2100° F., electrical heating elements 31 are preferably provided for this purpose.

A hood or muffle member 32 extends over a plurality of the heating elements 31 so that a uniform heating sintering temperature may be maintained under such hood. The remaining heating elements to the right of the hood 32 effect a preliminary heating of the briquettes. Pyrometers 33 may be provided for indicating the temperature within the hood or muffle 32 and above the preliminary heating elements.

The sintering of the briquettes 11 is carried on in non-oxidizing atmosphere, and to this end an inert or reducing atmosphere is admitted through the inlet 34 and flows through the heating chamber 20 from left to right as illustrated in Fig. 1. The non-oxidizing atmosphere is used to prevent oxidation of the briquettes 11 while at elevated temperatures and to effect the sintering of the metal components of the briquettes. The general flow of the non-oxidizing atmosphere is counter to the travel of the briquettes through the furnace and at the point of admission of the briquettes to the heating chamber a slidable door 35 is provided which may be equipped with curtains or wipers 36 of asbestos or other suitable material to minimize the escape of the non-oxidizing atmosphere at this point. A counterweight 37 may be connected by a cable 38 to the door 35 to facilitate the elevational adjustment of the door 35.

Referring also to Fig. 2, the slideway 21 is provided with a cut-out portion 40 at the left hand end, as viewed in Fig. 1, and the carrier plates 12 are provided with laterally extending lugs 41 at the rear edges thereof. As the carrier plates 12 are advanced by the actuating means 22, the central portion of the carrier plates will tip downwardly relative to the laterally projecting lugs 41 and dump the briquettes 11 into a vertically extending chute 42 which conducts the briquettes to a quenching tank 43 filled with water to a lever above the bottom of the chute 42.

The slideway 21 is inclined downwardly adjacent the cut-away portion 40 as indicated at 44, and terminates in a horizontal portion 45 on which a plurality of carrier plates 12 may be stacked with the plates suspended by the lugs 41. As each carrier plate 12 dumps the load of briquettes 11 carried thereon and slides down the inclined portion 44, it knocks or pushes carrier plate 12 from the end of the horizontal portion 45. As the carrier plates 12 are discharged from the end of the horizontal portion 45 of slideway 21 they are conveyed by a vertically disposed chute 46 extending downwardly into a quenching tank 47 filled with water to a level above the bottom of the chute 46. The lower ends of the chutes 42 and 46 extend into the water contained within the quenching tanks 43 and 47 and the delivery end of the heating chamber 24 is otherwise closed to prevent the escape of the non-oxidizing atmosphere at this end of the furnace. The briquettes 11 are conveyed by a belt conveyor 50 from the quenching tank 43 to a chute 51. The conveyor 50 may be operated through a belt 56 by a motor 52 which also operates through a belt 53, a transverse belt conveyor 54 adapted to transfer the carrier plates 12 from the quenching tank 47 to a belt conveyor 55 for conveying the carrier plates 12 back to the loading station 30 at which point an operator again stacks the carrier plates 12 in the holder 27 with the lugs 41 arranged rearwardly.

Referring to Figs. 3 and 4 of the drawings, the numeral 60 designates a furnace adapted to be employed either in sintering porous metal compositions in which the major constituent is copper, such as the 85—15 copper-tin composition, previously mentioned, or for annealing the briquettes 11 of the iron-copper composition which

were sintered in the furnace 60. The furnace 60 is provided with a suitable base 61, a portion of which provides a quenching tank containing water or other cooling liquids, indicated at 63, for cooling a belt 64 adapted to carry briquettes from right to left through the furnace 60. Since this furnace is adapted both for sintering the lower melting point porous metal structures such as the copper-tin compositions or for annealing an iron-copper composition, lower temperatures may be employed. It is, therefore, preferred to employ fuel gas as the heating medium which is conducted into the furnace 60 by piping 65 supplying various gas burners 66 within the interior of the furnace to maintain a temperature in the neighborhood of 1450° F. to 1500° F. The structures to be treated are carried through the furnace from right to left as viewed in Figs. 3 and 4, and in the case of the iron-copper composition the briquettes 11 may be delivered by the chute 51 to the belt 64. In the case of copper-tin porous metal structures, these may be disposed upon the belt 64 from a loading station 67 so as to be conducted to the furnace 60 in a similar manner. Approximately the same temperatures are maintained within the furnace 60 both for annealing the iron-copper composition and for sintering the copper-tin composition. The furnace 60 thus may be employed for either purpose.

In this furnace it is also desirable to convey the structures to be treated in a direction counter to the flow of an inert gas through the heating chamber of a furnace. To this end an inert gas may be admitted to the heating chamber of furnace 60 through inlet piping 70 and exhausting through piping 71 so that the inert gas will flow from left to right through the furnace as viewed in Figs. 3 and 4 and in a direction counter to the direction of movement of the briquettes carried by the belt 64. The briquettes passed through the furnace 60 are delivered through a vertical chute 73 to a closed chamber 74 having an upwardly inclined portion 75 and a delivery chute 76. A belt 78 is provided within the chamber 74 for carrying the briquettes from this chamber upwardly through the inclined portion 75 to deliver the same to the chute 76. The inert gas admitted into the furnace 60 through the inlet piping 70 also fills the chute 73, the chamber 74 and the chute 76. The briquettes are delivered from the chute 76 into an oil tank 80 provided with an upwardly inclined portion 81 and filled with oil to a level indicated at 82 which is above the lower end of the chute 76 to prevent the escape of inert gas through the latter. The briquettes are delivered from the chamber 80 by a belt 83 which is adapted to travel very slowly so as to give the briquettes plenty of time to cool and in cooling to absorb the oil or lubricant into the pores thereof. The belt 83 delivers the briquettes to a chute 84 which in turn delivers them to a drain basket 85 or other suitable means for permitting the surface oil or lubricant to run off from the briquettes.

The belt 84 may be trained over suitable pulleys 86 and 87 which may be driven through belt means 88 and suitable reduction gearing 90 and belt means 91 from a motor 92 or other suitable source of power. The reduction gearing 90 is operated to obtain the slow drive of the belt 83. The belt 78 is trained over suitable pulleys 93 and 94 and may be driven from the same source of power 92 by means of a belt 95, but preferably is driven from a separate source of power 96 in the form of a motor or other suitable driving means. By providing a separate source of power 96 adapted to drive the belt 78 through suitable power transmission means indicated generally at 97, the cooling of the briquettes delivered from the belt 64 or furnace 60 may be minimized so that they may be delivered to the coil chamber 80 without material reduction in temperature before reaching the oil.

The belt 64 is trained over a pulley 100 at the left hand end of the furnace 60 and over a drive pulley 101 mounted in a horizontally reciprocable carriage 102 mounted in suitable guides in the frame 61 of the furnace so that the tension on the belt 64 may be adjusted as desired. The belt 64 is also trained around suitable guide pulleys 103, 104 and 105, the latter two guide pulleys being disposed within the quenching tank 62. A cable or belt section 106 is trained over a pulley 107 and fixed at one end to the slidable carriage 102 and at the other end to a weight 106' to automatically tension the belt 64. The belt 64 is preferably driven by the pulley 101 through a belt means 57 by the motor 52 of the furnace 10. By making the pulley 101 the drive means for the belt 64, tension is placed upon the cooled strand of the belt after such cooled strand has passed through the water 63 or other suitable cooling liquid within the cooling tank 62. Thus the upper or heated strand of the belt 64 which carries the briquettes through the furnace is submitted to a much less tension than would be the case if the drive for such belt were effected through the pulley 100.

The furnace 60 may be employed for sintering briquettes of the copper-tin composition by passing the briquettes through the heating chamber of the furnace and delivering them at a suitable rate of speed through the chamber 74 so that they may be delivered through the oil chamber 80 at a suitable temperature for absorbing oil or lubricant into the pores thereof. The briquettes travel slowly through the oil chamber 80 and are delivered to draining means 85. The furnace 60 is also adapted to be employed for annealing briquettes of the iron-copper composition in much the same manner. As previously pointed out, the rapid cooling of the briquettes by quenching the same in water causes a dispersion of the ferrite and leaves the structures in a state of internal strain so that a reheating or drawing of temper is necessary to eliminate such strain. The annealing treatment produces an increase in the ductility of the structure which results in greater resistance to impact stresses and also tends to produce a uniform elastic limit and tensile strength throughout the entire section of such structure. The iron-copper structures are passed through the furnace 60 in much the same manner as are the copper-tin structures so as to anneal the same and impregnate the pores thereof while hot with oil or other suitable lubricant. The speed of travel of the iron-copper structures through the chamber 74 may be varied so as to allow these to cool to a proper temperature before delivery to the oil bath 80.

In the above processes the quenching of the briquettes in oil before exposure to atmosphere or other oxidizing agent causes little or no oxidization or discoloration of the products. The surfaces of the briquettes are clean and shiny so that detection of flaws, cracks or other defects is made easy. The absence of metal oxides in the interior of the briquettes adds to the strength of the latter.

As many changes could be made in the above constructions and many apparently widely different embodiments of this invention could be ef-

fected without departing from the spirit thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A process for heat treating and impregnating composite porous metal structures, which process comprises, subjecting, in a non-oxidizing atmosphere, an adherent mass of finely comminuted iron and a more fusible metal in the form of the structure desired, to a temperature below the melting point of iron but above the melting point of the more fusible metal constituent to sinter the mass, then quenching said structure while hot and before exposure to an oxidizing atmosphere, then heating the structure to an annealing temperature for iron in a non-oxidizing atmosphere, and then quenching the structure while hot and before exposure to an oxidizing atmosphere in an impregnating material.

2. A process for heat treating and impregnating composite porous metal structure, which process comprises, subjecting, in a non-oxidizing atmosphere, an adherent mass of finely comminuted iron and a more fusible metal in the form of the structure desired, to a temperature below the melting point of iron but above the melting point of the more fusible metal constituent to sinter the mass, then quenching said structure while hot and before exposure to an oxidizing atmosphere, then heating the structure to an annealing temperature for iron in a non-oxidizing atmosphere, and then quenching the structure from substantially said annealing temperature and before exposure to an oxidizing atmosphere in an impregnating material.

3. A process for fabricating bearing structures which comprises, subjecting comminuted sponge iron and comminuted particles of more fusible metal to pressure to form a briquette of the shape of the structure desired, then subjecting the briquette to a temperature below the melting point of iron but above the melting point of a more fusible metal constituent in a non-oxidizing atmosphere to sinter the metals, then quenching said structure while hot and before exposure while hot to an oxidizing atmosphere, then heating the structure to an annealing temperature for iron in a non-oxidizing atmosphere, and then quenching the structure while hot and before exposing to an oxidizing atmosphere while hot in a lubricant to impregnate the interstices of the structure with lubricant.

4. A process for fabricating bearing structures which comprises, subjecting comminuted sponge iron and comminuted particles of a more fusible metal to pressure to form a briquette of the shape of the structure desired, then subjecting the briquette to a temperature below the melting point of iron but above the melting point of a more fusible metal constituent in a non-oxidizing atmosphere to sinter the metal, then quenching said structure while hot and before exposure while hot to an oxidizing atmosphere, then heating the structure to an annealing temperature for iron in a non-oxidizing atmosphere, and then quenching said structure from substantially said annealing temperature in a lubricant to impregnate the interstices of the structure with lubricant before exposure to an oxidizing atmosphere.

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