

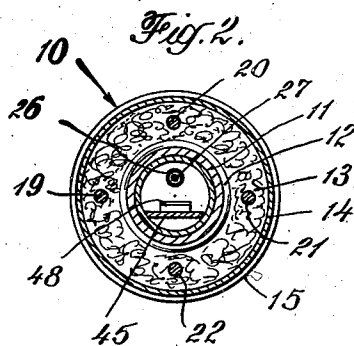
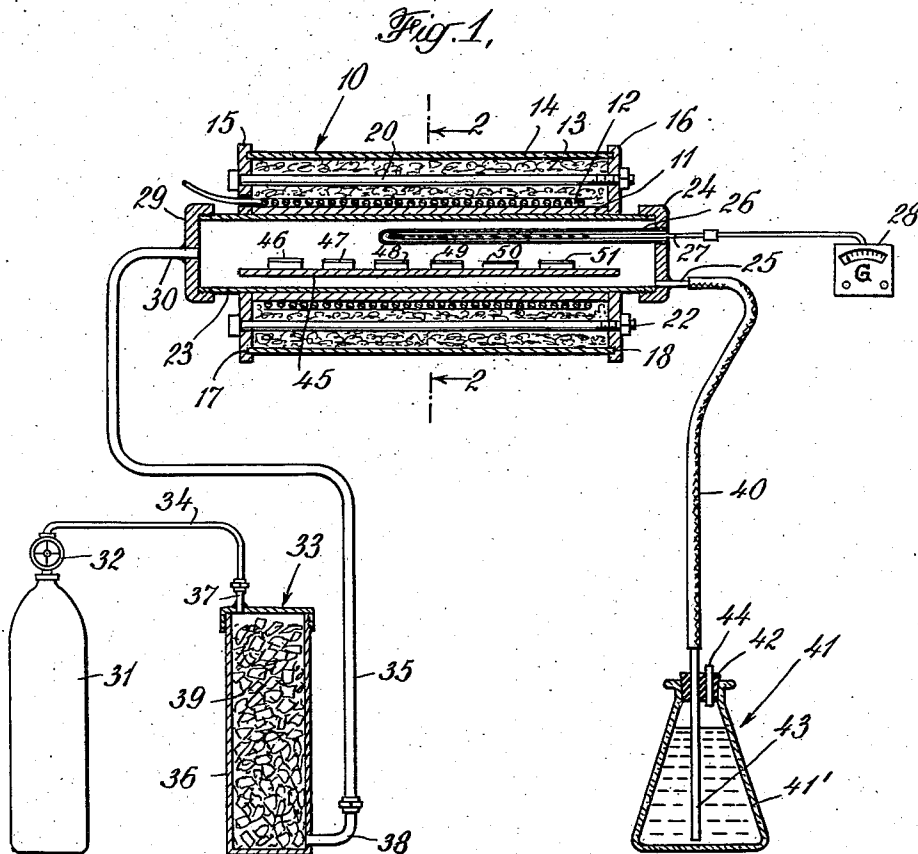
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MANUFACTURE OF COMPOSITE BEARINGS

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MANUFACTURE OF COMPOSITE BEARINGS

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This invention is concerned with the manufacture of composite bearings and the like having a layer of bearing metal strongly bonded to a metallic backing or reinforcing strip and particularly with the manufacture of composite bearings in which the bearing layer is especially durable. Preferably the bearing layer contains at least two metals, for example, copper and lead.

Conventional white metal bearings, for example babbitt, are inadequate in the conditions of service imposed in modern internal combustion engines and the like. It has been proposed heretofore to substitute copper-lead alloys for babbitts, etc., in such service and such alloys are valuable bearing materials because of the relatively low cost of their principal constituents and because they combine the advantages of high tensile and compressive strengths, high thermal conductivity, low coefficient of friction and high fatigue strength. However, general adoption of copper-lead bearings has been hampered heretofore by manufacturing difficulties, especially in the case of the so-called "insert" or composite bearings in which a relatively thin layer of copper-lead is attached to and backed by a reinforcing member of steel or the like.

The manufacturing difficulties have been caused, at least in part, by the lack of mutual solubility of copper and lead in the solid state and the great difference in specific gravity between the two metals. Although molten copper-lead mixtures containing up to 38% copper are completely miscible, nearly pure copper crystals separate from such a molten mixture on passing through the temperature range bounded by 1083° C. (melting point of copper) and 954° C. (monotectic temperature), while the remaining lead solidifies at 327° C. The liquid phase of nearly pure lead tends to coalesce into relatively large masses during solidification and the aggregate shows marked segregation of lead at room temperature, this tendency for segregation being more pronounced the higher the lead content. Segregation of the lead into large masses is, of course, undesirable because it tends to produce non-uniform bearing surfaces.

The production of satisfactory joints is also difficult with lead-rich copper alloys as compared with ordinary babbitt, because of the high coefficient of thermal expansion of such alloys, their high solidification temperature and rapid rate of oxidation. This makes it difficult to affix copper-lead alloys containing a large percentage of lead to steel backings and the like, and although

this may be overcome in part by increasing the copper content of the alloy, the increased copper content at the bearing-backing interface inevitably is accompanied by an increase in copper content at the bearing surface where a high lead content is desired.

As a result of my investigations, I have discovered a method whereby the aforementioned difficulties in the manufacture of copper-lead bearings and the like may be overcome and which offers outstanding advantages in the manufacture of composite bearings in general. In accordance with my invention a porous lining of metal of relatively high melting point is bonded to a reinforcing metal back by sintering a powder of the metal in situ on the back. Thus, a layer of powdered or granular metal (for example, a non-ferrous metal such as copper) is spread or otherwise substantially uniformly distributed in a substantially uncompacted condition on a metal backing (for example, a ferrous alloy such as steel). The resulting coated backing is heated to a temperature below the melting point of the backing and the granular metal but at which diffusion welding occurs, and the heating is continued until the powder particles or grains have been welded together to form a porous lining or matrix and the matrix has become welded to the backing. In other words, the uncompacted grains "sinter" or bond together and to the backing and the interstices between the grains become pores. A layer of coated metal powder particles (the coatings and cores of which are dissimilar and selected from the group consisting of the metal of the porous lining and a metal having a substantially lower melting point) is compressed against the porous lining and while thus compressed is heated to a temperature intermediate the melting points of metals of the coated powders until the metal of lower melting point impregnates the porous lining. In this way there is formed a bearing layer which is affixed firmly to the backing sheet and in which the impregnant is sufficiently well distributed to afford an excellent bearing.

Preferably, the coatings of the particles correspond to the metal of the lining (say, copper) and the cores of the particles are of the metal of substantially lower melting point (say, lead).

My invention will be more thoroughly understood in the light of the following detailed description taken in conjunction with the accompanying drawing, in which

Fig. 1 is a schematic elevation, partly in sec-

tion, of apparatus adapted to the practice of the invention; and

Fig. 2 is a section through the muffle of Fig. 1, taken along the line 2—2.

Referring to the drawing, the apparatus comprises a muffle assembly 10 having a cylindrical inner refractory heat conductive wall 11 disposed in a substantially horizontal position, around which is wound an electrical heating coil 12 of high resistance wire arranged to be connected to a current source, not shown. Around the heating coil is disposed an annular mass 13 of heat insulating material such as "Sil-O-Cel," and this in turn is enveloped by a cylindrical metal sheet 14 for protection purposes. The ends of the muffle are closed by a pair of annular end pieces 15, 16, of heat insulating material which extend from the inner refractory wall to beyond the metal shell. The metal shell fits in annular grooves 17, 18, cut respectively in the end pieces, which are clamped together by connecting bolts or tie rods 19, 20, 21, 22, passing through the annular mass of insulation.

A cylindrical heat resistant metal tube or muffle 23 adapted to slide easily into the refractory cylinder 10 is provided for heat treatment purposes. The rear end of the tube is closed by a cap 24 threaded or welded to said end and provided with an outlet nipple 25 welded to a lower portion thereof and a pyrometer well 26 which likewise is welded to the cap, extends horizontally throughout the greater portion of the tube, and is closed at its inner end. A thermocouple 27 is slidably disposed in the well and is connected to a galvanometer 28 of conventional type for measuring temperature. The front end of the muffle is threaded and is provided with a screw cap 29 which has a concentrically disposed inlet nipple 30.

A cylinder 31 of reducing gas under pressure, for example hydrogen, is connected to the inlet nipple through a reducing valve 32 and a dryer 33 by means of tubing 34, 35. The dryer is in the form of an upright closed cylinder 36 having an inlet nipple 37 at the top and a side outlet nipple 38 at the bottom and is packed with activated (i. e. dehydrated) aluminum oxide 39.

The outlet nipple 25 on the muffle is connected by a tube 40 to a trap or liquid seal 41 comprising a flask 41' with a two-hole stopper 42 into which projects a long tube 43 which extends below the level of liquid, preferably sulphuric acid maintained in the flask. A short tube 44 extending through the stopper from above the liquid level serves as an exit for gas from the system.

A boat 45 of alundum or the like may be placed in the muffle when the front cap is taken off and serves to carry the bearing strips 46, 47, 48, 49, 50, 51 during their heat treatment.

Manufacture of copper-lead composite bearings in accordance with my invention may be conducted as follows:

Flat clean metal backing sheets of steel, bronze or copper and of appropriate size and shape are coated with a thin but substantially uniform layer of dry copper powder having relatively clean surfaces. The coated sheets on the alundum boat are placed in the muffle and there heated in an atmosphere of dry hydrogen to a temperature of about 1000° C., that is to say, to a temperature below but within a hundred degrees of the melting point of copper for a period of at least one hour. During the heating period a

stream of hydrogen originating in the pressure cylinder and dried by passing through the filter is continuously passed through the muffle and bubbles out through the liquid seal at the end of the system. This hydrogen serves to reduce any oxidation products on the surface of the particles of copper powder and assures that the surfaces shall be clean and hence amenable to diffusion welding.

After the heat treatment as described above, the pieces are allowed to cool in the muffle in the non-oxidizing or reducing atmosphere maintained by the hydrogen, the hydraulic seal serving to prevent the ingress of air. When the pieces are cooled to about room temperature, they are withdrawn for further treatment.

The heat treatment of the loose layer of copper powder on the backing as described above results in the formation of a porous copper mixing or sponge bonded firmly to the backing. At the temperature of treatment diffusion welding couples the copper particles firmly to each other and to the backing but leaves voids or pores.

These voids may now be impregnated with molten lead or other substances capable of giving the desired bearing surface. Thus, a layer of copper-coated lead powder may be compressed against the backing. While thus compressed, the assembly is replaced in the muffle where it is heated in an atmosphere of dry hydrogen or other non-oxidizing and preferably reducing atmosphere to a temperature above the melting point of lead (but below that at which the copper sponge is melted or otherwise substantially damaged) for a considerable period of time. Under such conditions the lead melts or sweats into the porous matrix as a result of capillary attraction aided by gravity and thoroughly impregnates the mass. Following this second heating step the mass is again permitted to cool within the muffle so that it is protected from oxidizing influences, and then withdrawn. There results a laminated sheet comprising the backing to which is welded securely a copper sponge or matrix impregnated with lead and having excellent bearing characteristics.

The laminated sheet may be subjected to bending, pressing, stamping or other mechanical working to form it into a finished bearing without rupturing the bond between the backing and the copper-lead bearing layer. Thus the matrix may be subjected to rolling prior to or following impregnation so as to increase the density of the bearing and improve the bearing surface.

The particle size of the metal powder employed to form the sponge or matrix may be varied depending upon the size and proportion of pores desired. I prefer to employ electrolytically deposited copper powders ranging in particle size from about 40 to about 100 mesh (Tyler scale), but finer powders may be employed if very fine pores are desired.

Powders of metals other than copper may be employed to form the matrix. Thus nickel-copper powder or mixtures of nickel and copper powder may be employed. The nickel aids in bonding the matrix to the backing, particularly if it is of steel. Generally speaking, any metal having a higher melting point than the impregnant and which is not attacked substantially by the impregnant at the temperature of impregnation so as to destroy its porous structure may be employed to form the matrix.

Impregnation should be accomplished at a temperature considerably below the melting

point of the matrix so that there is no danger of damaging the latter's spongy or porous structure. In the case of a copper matrix, exposure to lead at 700° C., even though it be prolonged for a considerable period, does not damage the spongy structure substantially. As hereinbefore indicated, impregnation may be conducted by covering the surface with lead-coated copper powder or copper-coated lead powder, compressing, and heating to a temperature where sweating of the lead and consequent impregnation results. I have found that by compressing a loose layer of copper-coated lead powder against the matrix and heating the aggregate while maintaining the pressure, sweating of lead occurs when the layer is heated to a temperature of 750° C. in contact with a porous copper matrix for a period of about an hour so that the copper-coated lead particles become firmly anchored thereto and to each other and form an excellent bearing surface. For example, when a loose layer of copper-coated lead particles containing as little as 12.5% lead is pressed against a porous copper matrix (formed as described hereinbefore on a backing sheet) and while thus pressed is maintained at 750° C. in a reducing atmosphere for a period of one hour or more, the lead sweats and impregnates the matrix without damaging it. With higher proportions of lead in the powder the temperature of impregnation may be considerably lower and approaches the melting point of lead.

Treatment of the porous matrix by heating a mass of fine copper-coated lead particles in contact therewith to a temperature above the melting point of lead and while subjecting the mass to compression so as to squeeze molten lead out of the particles and cause it to enter and impregnate the matrix, as described hereinbefore, is a desirable aspect of my invention in that it permits a close control of the distribution and proportion of lead and copper at the bearing surface irrespective of the size and proportion of pores in the matrix. By employing very fine copper-coated lead powder in this manner the distribution of copper and lead at the bearing surface becomes very uniform and segregation of lead is inhibited. By varying the proportions of lead to copper in the powder the proportions of these two metals at the bearing surface can be controlled. The copper coatings on the particles tend to weld together and to the matrix and form an addition thereto, while the lead penetrates throughout the whole bearing layer.

Lead alloys and other metals or alloys of relatively low melting point may be employed as impregnants for the matrix. Thus hard lead alloys containing appreciable quantities of antimony, etc., may be used.

Unless metal powders with absolutely unoxidized surfaces are available, and this is seldom the case in practice, heat treatment in a reduc-

ing atmosphere is essential. Other reducing gases, such as those obtained by cracking ammonia, may be employed instead of hydrogen. In any case, the presence of water vapor should be avoided insofar as possible during heat treatment, and I have found a dessicator (of the type illustrated in the drawing) containing activated alumina to be satisfactory. Periodically such a dessicator should be revived by removing it from service and blowing air through it while hot.

The matrix may be formed advantageously on a rough electrically deposited metal surface, for example, the rough surface which obtains upon a copper cathode. Such a surface offers an admirable base for the bearing.

I claim:

1. A method of making a composite bearing which comprises placing powdered substantially solid copper on a metal back to form a substantially uncompact coating, heating the back thus coated to a temperature below the melting point of copper but within a hundred degrees centigrade thereof until the copper powder particles bond to each other and to the backing to form a porous matrix welded to the backing, compressing a layer of copper-coated lead powder against the porous matrix and while thus compressed heating it to a temperature intermediate the melting point of copper and of lead until the lead sweats and impregnates the matrix.

2. A method of making a composite bearing which comprises forming a porous lining of metal of relatively high melting point bonded to a reinforcing metal back by sintering a powder of the metal in situ on the back, compressing against the porous lining a layer of coated metal powder particles, the coatings and cores of which are dissimilar and selected from the group consisting of the metal of the porous lining and a metal having a substantially lower melting point, and while thus compressed heating the layer to a temperature intermediate the melting points of metals of the coated powders until the metal of lower melting point impregnates the porous lining.

3. A method of making a composite bearing which comprises forming a porous lining of metal of relatively high melting point bonded to a reinforcing metal back by sintering a mass of powder of the metal in situ on the back, compressing a layer of coated metal powder particles against the lining, the coatings of the particles corresponding to the metal of the lining and the cores of the particles being of metal of substantially lower melting point, and while thus compressed heating the layer to a temperature intermediate the melting points of the metals of the cores and coatings until the metal of the cores sweats and impregnates the porous lining.

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