May 20, 1947. C. M. LAFFOON, JR 2,420,886

APPLICATION OF SOLID LUBRICANT COATINGS TO SURFACES

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Fig. 1.

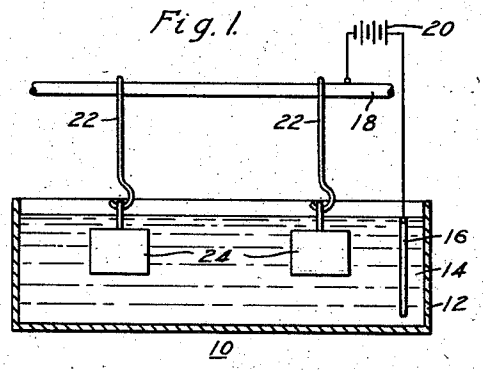
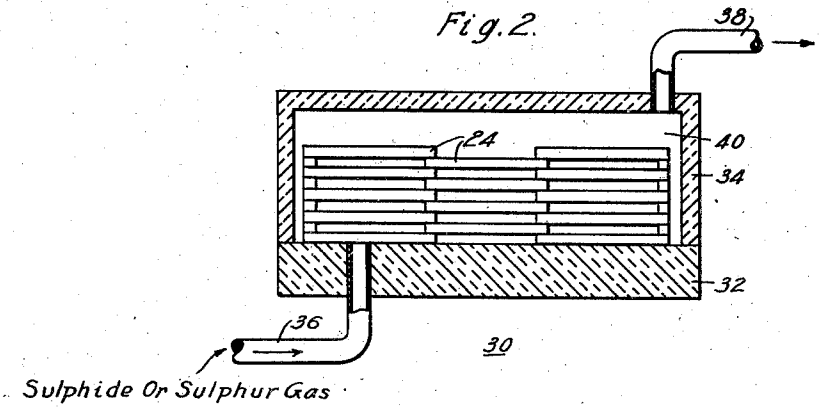


Fig. 2.



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APPLICATION OF SOLID LUBRICANT COATINGS TO SURFACES

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2 Claims. (Cl. 204—37)

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This invention relates to a method of providing tenaciously adherent coatings of solid lubricating materials to surfaces of members.

It has been discovered that certain compounds exemplified by molybdenum disulphide have exceptional lubricating properties if applied to the surfaces of the members under appropriate conditions to provide for a tenacious adherence to the surfaces. Unless applied in such a manner that the compound adheres to the surface, the lubricating property thereof is not the optimum available.

For the purpose of this invention, the compound molybdenum disulphide will be referred to specifically, but it is intended to include therewith similar compounds such as tungsten disulphide, molybdenum selenide, molybdenum telluride and tungsten telluride. These compounds and others are characterized by flat crystals which cleave to form very fine scales of the compound. The crystals are believed to possess a physical structure wherein the metallic atoms of the compound are disposed as a layer in one plane while the nonmetallic atoms are attached to the metallic atoms in equal number as layers on either side of the metallic atoms. The exterior layers of the nonmetallic atoms in each crystal have very weak attraction for other nonmetallic atoms, so that when the crystals approach one another under heavy pressure, the coefficent of friction therebefore is exceedingly low. However, the nonmetallic atom layers possess a great affinity for metal surfaces whereby the nonmetallic atoms, under appropriate conditions, will adhere tenaciously to the metal. It has been found that the crystals, when once adherently attached to metal surfaces, cannot be removed therefrom except by abrading the metal surfaces.

The optimum antifriction properties secured by the application of molybdenum disulphide are obtained when the molybdenum disulphide is so applied to the metal surface that a tenaciously adherent coating is obtained. Such coating forms bearing surfaces characterized by a very low coefficient of friction. These coatings exhibit lubricating properties even under extreme conditions. For example, bearings coated with the molybdenum disulphide will function satisfactorily at elevated temperatures of the order of 500° C. in high vacuum. Rotating anode X-ray tubes have been satisfactorily lubricated with the compound, whereas liquid and other solid lubricants, such as graphite, were inoperative or detrimental in most cases. The molybdenum disulphide has been found to give exceptionally low

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coefficient of friction at extreme pressures of the order of 500,000 to 600,000 pounds per square inch where its coefficient of friction is one-third or less of that of the best available liquid and solid lubricating materials.

The object of this invention is to provide for producing adherent coatings of solid lubricant exemplified by molybdenum disulphide on electroplatable members.

A further object of the invention is to provide for treating bearing surfaces to produce thereon adherent coatings of solid lubricating compounds such as molybdenum disulphide to provide for the best antifriction properties.

Other objects of the invention will, in part, be obvious, and will, in part, appear hereinafter. For a fuller understanding of the nature and objects of this invention reference should be made to the following drawing, in which:

Figure 1 is an elevation view, partly in section, of an electroplating arrangement, and

Figure 2 is a vertical cross-sectional view through a heat-treating oven.

Some difficulty is encountered in applying molybdenum disulphide to surfaces of members. The compound as such has been applied to members by causing the molybdenum disulphide to be impacted against the surface for a prolonged period of time and thereafter the impacted layer of molybdenum disulphide has been heat-treated in order to assure a tenacious adherence of the compound to the surface. While this procedure is satisfactory for ball and roller bearings of most types, it is not feasible for treatment of instrument pivots, internal surfaces of bores of small diameter, and similar fragile or difficultly available surfaces. A further objection to this treatment is the length of time that is required to achieve a satisfactory adherent coating. Unless an adherent coating is obtained, the molybdenum disulphide does not behave as a lubricant but is simply churned about or displaced by the movement of the bearing surfaces.

According to this invention, members having bearing surfaces to be provided with a solid lubricant of the type of molybdenum disulphide are electroplated with the metal constituent of the compound, the metal being deposited either as the pure metal, metal oxide, basic metal oxide, or any combination thereof. Thereafter the surface with the metal deposited thereon is heat-treated in an atmosphere containing sulphur or sulphide gases, or selenide or telluride gases in order to convert the adherent electroplated metal to the corresponding disulphide or other lubricating

compound. This procedure is rapid, gives satisfactory results and may be applied to many members without detriment to the surfaces being processed, no matter their size or fragility.

Referring to Fig. 1 of the drawing there is illustrated a form of apparatus 10 suitable for electroplating molybdenum metal, for example, upon members. The apparatus 10 comprises a tank or receptacle 12 for an electrolyte 14. The electrolyte 14 may, for example, consist of an aqueous solution consisting of 25% concentrated ammonium hydroxide and 20% molybdic acid by volume. In some cases the tank 12 may be provided with a cover to prevent evaporation of the ammonium hydroxide. The anode 16 for this particular electrolyte consists of insoluble graphite or platinum members. Current to the anode 16 and a cathode bar 18 is furnished by a source of direct current 20 at about 110 volts. Suspended from the cathode bar 18 are members 24 to be electroplated electrically connected thereto by the conducting hangers 22. For most purposes, the current through the cathode members 24 is approximately 5 amperes per square foot. Only a short period of time is required to deposit a satisfactory thickness coating. A few ten thousandths of an inch or less of molybdenum metal is required.

It will be appreciated that members 24 will be of some electroplatable substance such as a metal, alloy or a coating of electrically conducting composition such as precipitated silver on a material that may be normally nonconductive.

It is believed that the deposit on the members 24 which is produced by the electrodeposition consists of molybdenum metal as such, or as molybdenum oxide, basic oxide, or some combination thereof. It is immaterial for the purposes of this invention as to just what the chemical nature of the coating is, providing the coating is produced as an adherent layer of predetermined thickness over the surfaces of the member 24.

If predetermined areas of the member 24 only are to be electroplated therewith, it is feasible to mask off the areas of the members it is desired not to plate by the use of an insulating paint or compound.

After the members 24 have been electroplated to a predetermined thickness, the members are withdrawn from the bath and are dried. Referring to Fig. 2 of the drawing, there is illustrated the subsequent treatment of the electroplated members by placing the members in the heat-treating oven 30. The oven 30 comprises a heat insulating floor 32 and heat insulating walls 34 constructed as known to those skilled in the art. Preferably the material of the walls 32 and 34 consists of a material or substance resistant to the action of the sulphur and sulphide gases. In some cases, an interior coating of a ceramic or glassy material will be effective for this purpose.

The members 24 are stacked within the space 40 so as to provide for free flow and penetration of the oven atmosphere. The oven 30 is provided with an inlet 36 for introducing a gas capable of converting the metal coating electroplated on the members 24 to the form of lubricating compound disclosed. Sulphur gases, hydrogen sulphide, hydrogen selenide and hydrogen telluride are gases suitable for the purposes of the invention. Other gaseous substances of a corresponding nature may be also employed. The gases are introduced through the inlet 36 in sufficient quantity to drive off through

outlet 38 any oxidizing or atmospheric gases which may inhibit the action of the gases to convert the electroplated metal to the lubricating compound. The oven 30 is heated by any suitable means to cause the temperature of the members 34 to reach from about 600° C. to 1400° C. In some cases resistance elements of a metal capable of withstanding the action of the atmosphere may be applied in the interior of the oven. In other cases the members 24 may be heated by high frequency induction heating elements applied to the oven 30 in known ways. The heat-treatment at a predetermined elevated temperature in the predetermined atmosphere need be conducted for only a few minutes to produce a desirable form of lubricating compound. The conversion of the metal to the lubricating compound is achieved most rapidly at the temperatures of from 1000° C. to 1400° C. The reaction is relatively slow at 600° C.

After the furnace has been cooled to a temperature of below 600° C., the flow of protective gas to the inlet 36 may be discontinued and the members cooled exposed to the atmosphere. Above 600° C. the molybdenum disulphide, for example, when exposed to oxygen, may decompose. The members may be used for their intended purpose as soon as they are cool enough to handle.

It will be found that the heat treated molybdenum disulfide coating thus produced is exceedingly adherent. It will show no tendency to flake off, crack or otherwise fail. The coatings may be lightly buffed or treated to render them more suitable for bearing purposes, but in most cases they may be used at once for their intended purpose.

While the application of the metal to the members 24 is particularly satisfactory by electroplating methods, in some cases a thin coating of the metal may be produced by immersing the members 24 in the bath of the molten metal. It will be appreciated that due to the high melting point of molybdeum and tungsten that this procedure is feasible in a limited number of cases only. Accordingly, coating processes depending on the melting of such metals as molybdenum or tungsten are of limited scope and utility. Electroplating accordingly furnishes the most convenient method of applying the metal to the surface of the member.

It will be appreciated that tungsten may be electro-deposited as a coating on members similarly to molybdenum. It is believed that tungsten metal ordinarily is not deposited as such, but rather as tungsten oxides. The same useful solid lubricating compound will be attained when the coating of tungsten oxides is heat treated in the gas.

Since certain changes in carrying out the above process may be made without departing from its scope, it is intended that all matter contained in the above description shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. The method of applying to a surface of a member composed of a metal other than tungsten or molybdenum a tenaciously adherent coating of a solid lubricant of a metallic compound selected from the class consisting of sulfides, selenides and tellurides of tungsten and molybdenum, comprising electroplating the surface of the member to deposit thereon an adherent electroplate of the metal component of the compound and heat treating the electroplated sur-

face at a temperature of from about 600° C. to 1400° C. in an atmosphere consisting of at least one of the group consisting of sulfur, sulfide, selenide and telluride gases to convert the electroplated metal to produce only the corresponding disulfide, selenide, and telluride to provide for the solid lubricating metallic compound being formed on the surface of the member.

2. The method of applying to a surface of a member composed of a metal other than tungsten or molybdenum a tenaciously adherent coating of a solid lubricant of a metallic compound selected from the class consisting of sulfides, selenides and tellurides of tungsten and molybdenum comprising making the member a cathode in an electroplating bath capable of depositing the metal component of the metallic compound thereon, causing the electrodeposition of a predetermined thickness of the metal on the member, and treating the electroplated member at a temperature of from about 1000° C. to 1400° C. in an atmosphere containing effective amounts of at least one

of the group consisting of sulfur, sulfide, selenide and telluride gases to convert the electrodeposited metal to produce only the corresponding disulfide, telluride and selenide to provide for the lubricating metallic compound being formed.

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