

[54] DRY LUBRICATION

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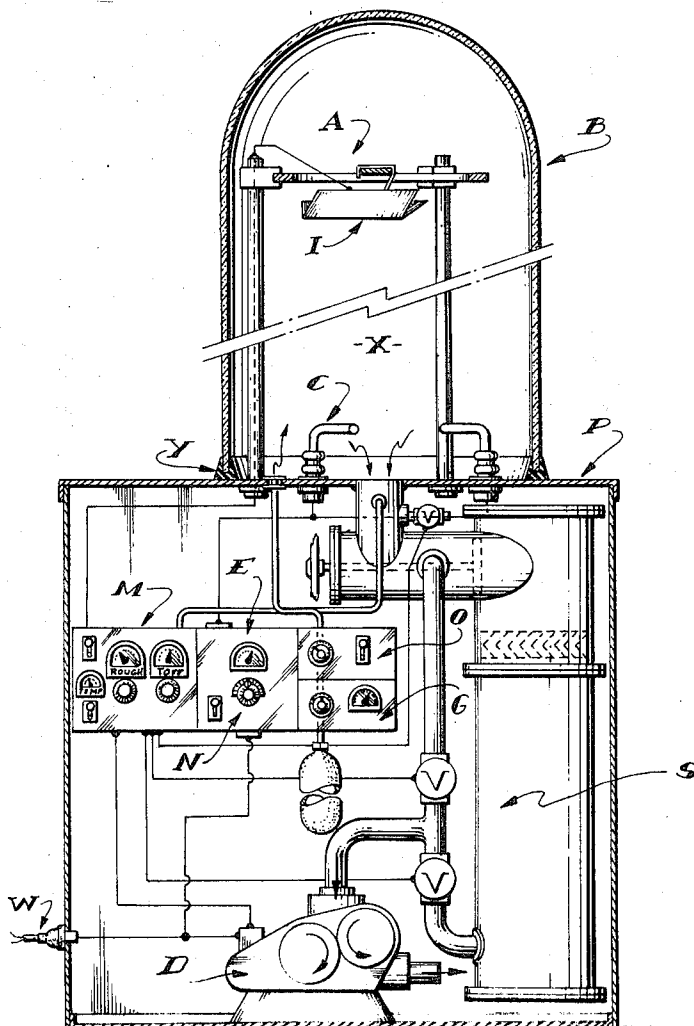
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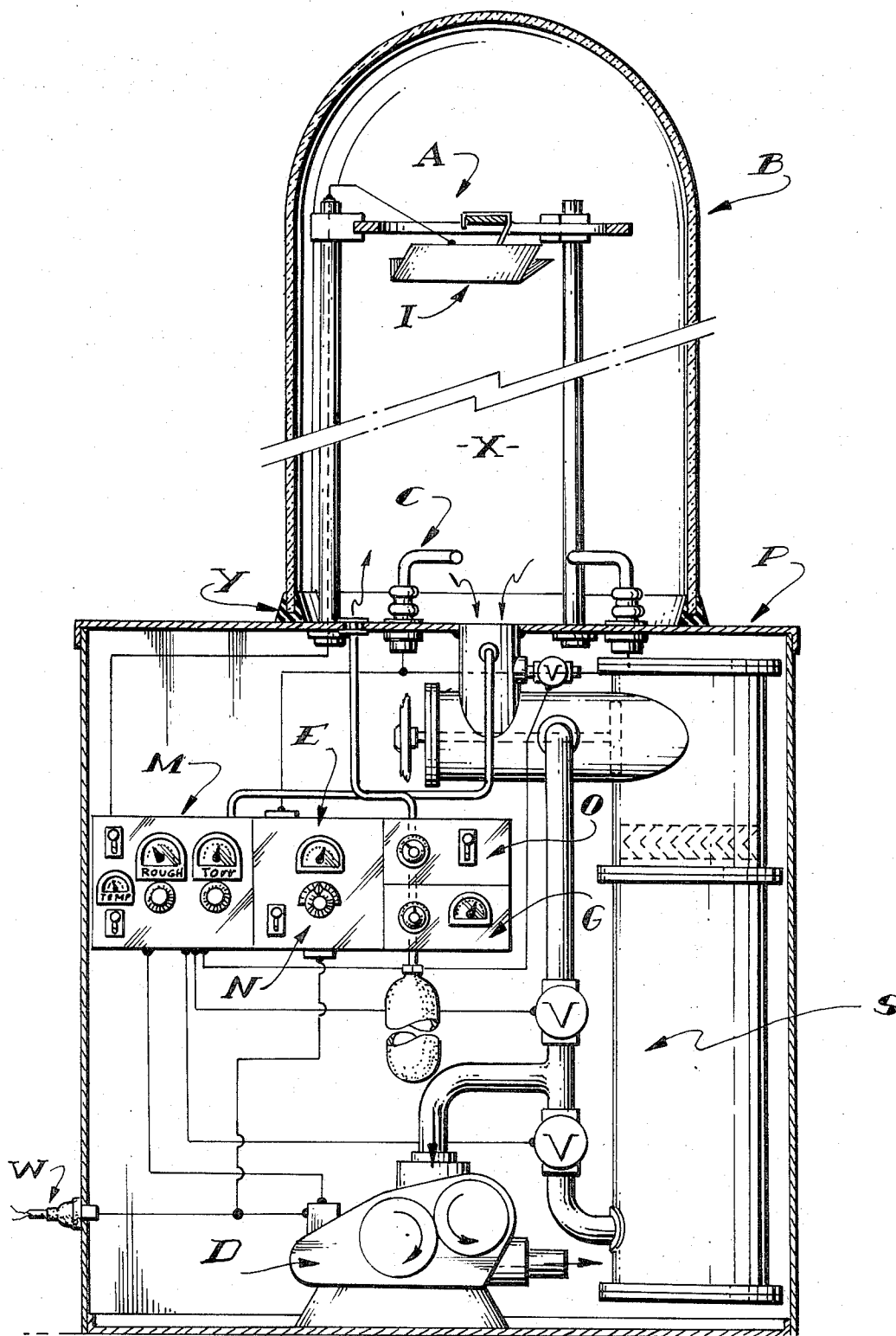
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ABSTRACT

Applying a dry, lubricous, protective coating of polymeric material on the surfaces of parts in a thickness of about 100 A. and in added increments thereof by cleaning the surfaces of the parts by subjecting the parts to ionic glow discharge in a low vacuum atmosphere and then coating the cleaned surfaces of the parts with polymeric material by subjecting the parts to ionic bombardment in an ionized atmosphere of fluorocarbon gas at about 6×10^{-6} Torr.

8 Claims, 1 Drawing Figure





DRY LUBRICATION

This invention has to with the establishment and application of protective and lubricous coatings to parts surfaces and is more particularly concerned with a novel process for applying a thin durable coating of polymerous, organic material to parts surfaces.

Throughout the many arts there is an ever-increasing requirement and need to protect items or parts against wear and/or the deleterious effects of their environments; which requirement and/or use would be best served by a thin coating of polymerous material.

While thin coatings of metallic materials, such as chromium and copper can be established on parts surfaces by electro plating and vapor deposition processes and while thin mineral oxide coatings can be established on parts surfaces by anodizing processes and the like, the prior art has failed to develop and provide a suitable means or process whereby organic, polymerous materials can be lightly or thinly applied to parts surfaces.

In regards to the above, the term "thin" as here used refers to coatings the thickness of which is from .000001 inches to .000010 inches and such that measurement thereof is most often effected by optical means and translated in terms of Angstroms.

It is an object of my invention to provide a novel process which is effective to apply strong, integrated, durable coatings of polymerous material to parts surfaces in uniform thickness of about 100A.

It is another object and feature of my invention to provide a novel process of applying coatings of polymerous material to parts surfaces which coatings are sufficiently thin that they are visually undetectable upon ordinary or normal visual examination and such that parts surfaces can be advantageously coated and protected without affecting their aesthetics.

It is yet another object and feature of my invention to provide a process of the character referred to which enables and makes possible the application of dry, lubricous coatings on bearing surfaces of parts, which coatings are sufficiently thin that normal, established, mechanical working tolerance between related, coated, parts is not adversely affected.

Still further, it is an object and feature of my invention to provide a process of the character referred to whereby protective, dry, lubricous coatings of dielectric polymerous material can be advantageously applied to the surfaces of magnetic and/or electrical components in a sufficiently thin state that they do not electrically insulate or otherwise adversely affect the magnetic and/or electrical characteristics and functions of the components.

It is an object and a feature of the present invention to provide a process of the character referred to which is such that an applied coating of polymerous material on the surfaces of a part conforms to the surfaces of the part and does not migrate and/or flow in such a manner as to fillet corners, peel or otherwise result in undesirable variations in density and/or thickness of the coating.

Still further, it is an object of the present invention to provide a process of the character referred to above which is such that a dry, lubricous, protective, polymerous coating can be advantageously applied to metallic or non-metallic, porous and non-porous surfaces.

The foregoing and other objects and features of my invention will be fully understood from the following

detailed description of this invention, throughout which description reference is made to the FIGURE in the accompanying drawing in which an apparatus suitable for carrying out this invention is diagrammatically illustrated.

The apparatus shown in the FIGURE of the drawing includes a vacuum chamber X defined by a platform P and a downwardly opening bell B engaged on and supported by the platform. Suitable sealing means Y are provided between the platform and the rim of the bell to seal the chamber tightly.

Within the bell B, and projecting upwardly into the upper portion of the chamber X is an anode structure A comprising a post-like structure projecting upwardly from the platform P and a rack-like carrier on the post structure and on which articles of work or parts I, the surfaces of which are to be coated, are secured by clips or the like.

Within the bell B, at the lower portion of the chamber, in predetermined spaced relationship with the carrier of the anode A is a cathode structure C. The cathode structure C is carried by the platform P, in insulated relationship therewith and can be of any suitable design and construction.

In addition to the above, the apparatus includes a high vacuum system S which system includes a pump D, the inlet of which is suitably connected with the chamber X.

In practice, the system S and the pump D thereof can be any one of several available makes and designs of high vacuum pumping means or systems, without departing from the spirit of the invention.

In the drawing I have shown one such high vacuum system in diagrammatic form. Since such systems are well known to those skilled in the art, I will not burden this disclosure with further and unnecessary detailed description of the vacuum system or its operation.

The apparatus next includes suitable control means M for selectively controlling and monitoring the operation of the vacuum system S. The means M includes a switch for putting the pump D into and out of operation, manually or electrically operated valves for controlling the flow of air and gases moved or handled by the system S and pressure and temperature gauges for monitoring and indicating the pressure and the temperature within the chamber X and of the work I and/or the anode substrate of said work. In practice, the means M can include automatic controls and the like which controls can be such that operation of the system S is automatic.

Next the apparatus includes a suitable direct current power supply E. The power supply is connected between a suitable alternating current services W and the cathode structure C.

The power supply E is provided with controls N to accurately control the voltage to the cathode structure. The controls for the power supply can include timing means and servo means related to the timing means and to the system S whereby programmed sequential changes in applied voltage, required in carrying out my process, can be made automatically.

Finally, the apparatus includes gas supply means G for introducing a desired gas into the chamber X, as will hereinafter be described. The means G, like the means M and N can include automatic controls O, related to the means M and N to automate operation of the apparatus.

Since in practice the exact nature and form of the several control means referred to above can vary widely without departing from the spirit of this invention, detailed illustration and description of such means would only serve to unduly burden this disclosure and will therefore be dispensed with.

In the case illustrated, the platform P is established by the top of a cabinet. The system S, power supply E, means G and the controls therefor are suitably related to and can be arranged within the cabinet as indicated in the drawing.

The process that I provide includes two or three basic steps; first, the careful and thorough cleaning of the work or part surface to be coated; second, the application of a base coating on the surface; and third, if desired or necessary, finishing of the base coating.

Since the coating to be applied is extremely thin, being less in thickness than matter left on a surface by engaging it with one finger, that is, less in thickness than a fingerprint, it is imperative that surface to be coated be absolutely clean or free of all foreign matter so as to avoid or eliminate degradation of adhesion of the polymeric coating material to or with the surface.

In carrying out my new process, the surface of a work part I to be coated is first cleaned by glow discharge within the chamber X of the apparatus employed.

To effect glow discharge cleaning of the work part surface, the part is suitably secured to or connected with anode structure A within the chamber X. This is effected by raising the bell B above the platform P to expose and make the carrier of the anode structure accessible, securing the work part I thereto and then lowering the bell to engage the platform and its related sealing means Y, and to thereby reestablish the chamber X.

With the work part thus secured or connected with the anode structure, in spaced relationship above the cathode structure C, the vacuum system S is put into operation and the chamber is evacuated or roughed to at least 40 microns of mercury, for example, to 50 microns of mercury and a suitable direct current voltage is applied to the cathode structure by means of the power supply E.

It is determinable that the surface of the work part is sufficiently clean when the ionic glow generated in the chamber X by the electron flow between the cathode and anode structures diminishes and/or is extinguished.

When the parts are thus cleaned, the power to the cathode is terminated and operation of the vacuum system S is continued until the atmosphere within the chamber X reaches 1 micron of mercury (or to the limit of its roughing mode) and the part is allowed to cool.

It is to be noted that the process of cleaning set forth above and which constitutes the first step of my new process is an old process of cleaning employed in the art of vapor depositing materials and is commonly referred to as glow discharge cleaning.

At this time, and in the carrying forward of my new process, a base coating of polymeric material is applied to the part surface.

The base coating referred to above is applied by putting the high vacuum section or mode of the vacuum system S into operation and evacuating the chamber X further to 6×10^{-6} Torr.

When the atmosphere to which the work part I is exposed reaches 6×10^{-6} a suitable fluorocarbon gas is

introduced into the atmosphere in the chamber X by and from the means G. Sufficient gas is introduced so that the desired and necessary atmosphere or pressure is established in the chamber. For example, an atmosphere at about 6×10^{-3} Torr is established.

Next, direct current is conducted to the cathode structure and a flow of electrons from the cathode to the anode is established. The electron flow ionizes the fluorocarbon molecules in the atmosphere. The negative charged fluorocarbon ions drive toward and impinge upon the surface of the work part. The ions of fluorocarbon molecules, when impinging upon the surfaces, give up extra electrons to become neutral and establish solid polymeric particles, which are welded to the work part surface.

The current directed to the cathode, in establishing the base coat, is controlled and is sufficient to establish and maintain desired ionization of the gas in the atmosphere in the chamber X. The magnitude of the current controls the rate at which the material is deposited and can be visually monitored by the ionic glow generated within the chamber. Since the rate at which the material can be advantageously deposited varies upon the physical characteristics of the surface substrate, temperature parameters and other like factors, no set or fixed current can be set forth.

The current is applied and the noted ion bombardment onto the part surface is continued until the base coating covers the surface of the work part and further, until the temperature of the work part or surface substrate is heated, by the heat generated in the chamber, to a predetermined maximum allowable temperature, which temperature may be less than 100°F , or a temperature substantially greater than that, depending upon the physical characteristics of the substrate.

The base coating thus applied can be about 100A. in thickness but is preferably about 200A. in thickness.

The thin base coating thus applied tends to be a thin agglomerate affording minimal inner or self support and minimal adhesion on or with the surface of the work part. In many instances where the coating is for environmental protection only and is not to be subjected to wear or the like, the base coating is adequate or sufficient by itself.

When the coating is to be subjected to external mechanical forces and in carrying out my process further, the base coating is filled and welded by allowing the part to cool and by repeating the last described step of ionizing the fluorocarbon molecules and bombarding the previously applied base coating with the fluorocarbon ions. The bombardment of the base coat with additional ions of fluorocarbon compacts and fills the conglomerate base coating and builds up the coating to a solid state where it affords substantial or great inner support and greatly enhanced bond strength and/or adhesion to its related surface of the work part.

The ions of fluorocarbon impinging on the base coating compact the material of base coating as they impinge thereon. As they impinge on the base coating they give up their extra electrons and weld with the base coating as they assume a solid state. They further tend to enter and to fill any pores, interstices and the like occurring in the base coat to establish an impervious polymeric coating.

The second ionic bombardment noted above is continued until the work or the substrate of the surface being coated reaches the maximum permissible tem-

perature, whereupon the power is turned off and the part is permitted to cool.

By repeating the last noted finishing step of my process two or more times, the coating can be built up, made more dense and solid and its durability increased to substantially any desired extent within the inherent limitations of the polymeric material.

In practice, the second and third or more finishing steps that I provide tend to build up and increase the thickness of the coating but not to an appreciable extent. For example, a base coat of 200 A. when subjected to three finishing ionic bombardments, each equal in duration and intensity with the bombardment which established the base coat, results in a finishing coat about 600 A. thick, not a coating 800 A. thick as might be expected. The foregoing example appears to be clear indication that subsequent ionic bombardment of previously deposited material compacts the previously deposited material as noted above.

Having described but one typical preferred form and carrying out of my invention, I do not wish to be limited to the specific details herein set forth but wish to reserve to myself any modifications or variations which may appear to those skilled in the art and which fall within the scope of the following claims.

Having described my invention, I claim:

1. The method of depositing an electrically non-insulating, dry, lubricating, protective film of fluorocarbon polymer having a thickness not more than 200 Angstroms in thickness onto a surface of an article which comprises placing the article into a vacuum chamber and connecting the article to a power supply as an anode with the entire surface to be coated exposed, introducing an amount of fluorocarbon gas substantially equal to the amount of polymer in the finished coating, establishing a glow discharge in the chamber between the article and a cathode and exhaustively depositing the fluorocarbon gas onto the surface of the article thereby extinguishing the glow.

2. The method set forth in claim 1 which includes es-

tablishing a glow discharge in the chamber between the article and cathode before introducing the gas to clean the surface of the article.

3. The method set forth in claim 1 wherein the atmosphere in the chamber is established at 6×10^{-6} Torr prior to introduction of the gas.

4. The method set forth in claim 1 which includes establishing a glow discharge in the chamber between the article and cathode before introducing the gas to clean the surface of the article and wherein the atmosphere in the chamber is established at 6×10^{-6} Torr prior to introduction of the gas.

5. The method of depositing an electrically non-insulating, dry, lubricating, protective film of fluorocarbon polymer having a thickness not more than 200 A. in thickness onto a surface of a nonconductive article, which comprises placing the article on an anode support connected with a power supply and within a vacuum chamber and with the surfaces of the article to be coated exposed, introducing an amount of fluorocarbon gas substantially equal to the amount of polymer in the finished coating and which coats the anode, establishing a glow discharge in the chamber between the anode and a cathode and exhaustively depositing the fluorocarbon gas onto the surface of the article and the anode thereby extinguishing the glow.

6. The method set forth in claim 5 which includes establishing a glow discharge in the chamber between the article and cathode before introducing the gas to clean the surface of the article.

7. The method set forth in claim 5 wherein the atmosphere in the chamber is established at 6×10^{-6} Torr prior to introduction of the gas.

8. The method set forth in claim 5 which includes establishing a glow discharge in the chamber between the article and cathode before introducing the gas to clean the surface of the article and wherein the atmosphere in the chamber is established at 6×10^{-6} Torr prior to introduction of the gas.

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