Nov. 27, 1951 H. W. RIMBACH 2,576,362

ELECTROPHORETIC METHOD OF COATING WIRE WITH GRAPHITE

Filed Oct. 8, 1947

Fig. 1.

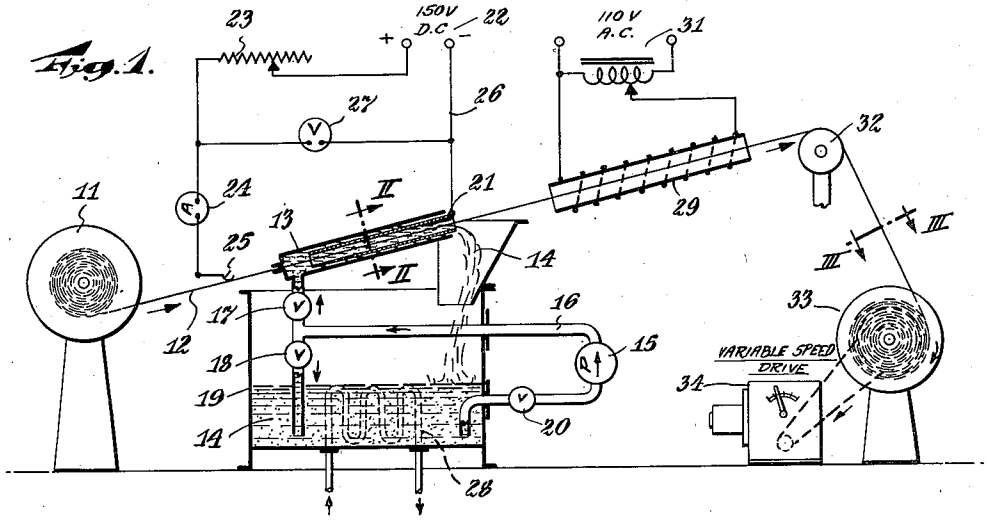


Fig. 2.

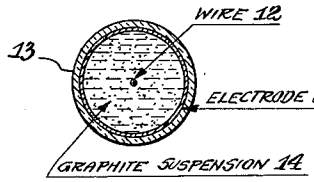


Fig. 3.

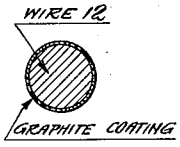


Fig. 6.

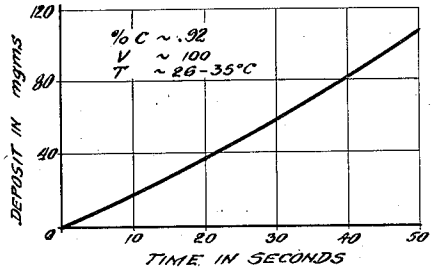


Fig. 8.

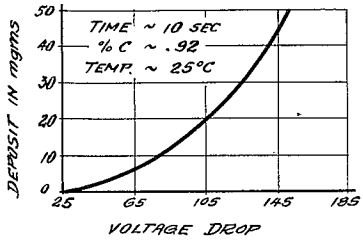


Fig. 4.

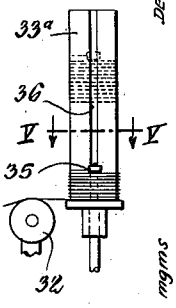


Fig. 7.

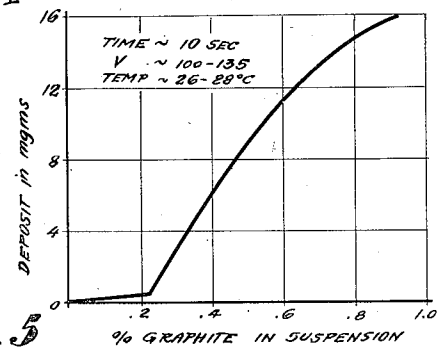


Fig. 9.

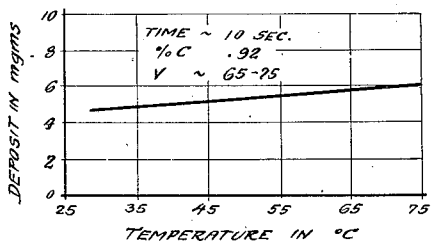
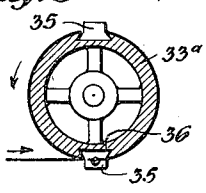


Fig. 5



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ELECTROPHORETIC METHOD OF COATING WIRE WITH GRAPHITE

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Application October 8, 1947, Serial No. 778,703

1 Claim. (Cl. 204—181)

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This invention relates to the lubrication of wire, especially in connection with the drawing thereof, and more particularly to the coating of such wire with graphite.

The principal object of my invention, generally considered, is to coat wire, particularly such composed of molybdenum or tungsten, with a firmly adherent deposit of graphite by electrophoresis, whereby improved results are obtained and the necessity for a binder eliminated.

Another object of my invention is to improve and cheapen the process of lubricating wire, and particularly molybdenum and tungsten wire during the operation of wire drawing, by applying a coating of graphite thereto by electrophoresis, desirably from an aqueous suspension containing a small proportion of a wetting or surface active agent, the graphite being very finely divided.

A further object of my invention is to produce a wire having a smooth dense graphite deposit adhering tightly thereto, whereby it is adapted for being drawn through a plurality of dies without intermediate lubrication.

Other objects and advantages of the invention will become apparent as the description proceeds.

Referring to the drawing:

Figure 1 is an elevational view, partly diagrammatic, of apparatus which may be used in practicing my invention.

Figure 2 is an enlarged sectional view on the line II—II of Figure 1.

Figure 3 is an enlarged sectional view on the line III—III of Figure 1.

Figure 4 is a detailed elevational view of a rewinding reel which may be used as an alternative to that illustrated in Figure 1.

Figure 5 is an enlarged sectional view on the line V—V of Figure 4, in the direction of the arrows.

Figure 6 is a graph illustrating the relationship between the duration of the operation and the amount of graphite deposited on the wire being treated.

Figure 7 is a graph illustrating the relationship between the proportion of the graphite in the suspension and the deposit obtained.

Figure 8 is a graph illustrating the relationship between the voltage drop between the wire being coated and the associated electrode and the deposit obtained.

Figure 9 is a graph illustrating the relationship between the temperature of the graphite suspension and the deposit of graphite obtained.

In the drawing of wire, and particularly such made of tungsten or molybdenum, it has been the practice to apply a coating of graphite to the wire before passing it through a die. The graphite suspension used to coat such wire was of such composition and viscosity that a coating of the lubricant remained thereon. The coating

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is then dried, when binders in the suspension such as agar-agar and brown sugar served to hold the graphite on the wire.

In accordance with my improved method, here disclosed and claimed, graphite is deposited on such wire by electrophoresis, as by passing the wire through a special graphite suspension in a cell containing an electrode which is negative with respect to the wire. Pure graphite is thereby deposited on the wire which is then dried. The character of the deposit is such that it adheres tightly without the use of a binder.

Referring to the drawing in detail, like parts being designated by like reference characters, and first considering the embodiment of my invention illustrated in Figures 1, 2 and 3, there is shown a spool or reel 11 from which wire 12 is drawn, it being assumed in the present instance that the wire is tungsten or molybdenum, but other wire may be so treated as desired. The wire passes through an electrophoretic cell 13, through which a suspension 14 of graphite is being continually circulated, under control of valve 20, as by means of a pump 15 through pipe 16. Valves 17 and 18 may serve to divide the output from said pump between that flowing to the cell 12 and that passing back to the suspension supply in containing tank 19, for the purpose of agitating said suspension and preventing the graphite from settling. Additional or alternative agitating means, such as a pipe from which air bubbles escape, or an impeller rotating in the suspension may be employed if desired.

During the passage of the wire through the cell 13, it is maintained at a potential positive with respect to an associated electrode 21, as by means of a source of direct current 22 connected through a controlling rheostat 23, ammeter 24, and contact brush 25, to the wire at its positive side. Its negative side is connected through the conductor 26 to hollow generally cylindrical cathode 21. A voltmeter 27 may be used to indicate the applied voltage, the variation of which may serve to adjust the amount of deposit on the wire. Because of the fact that the temperature of the suspension increases during the coating operation, a cooling device, such as a coil 28 which is immersed in the suspension contained in tank 19 and through which cold water is circulated, may be employed to maintain the temperature as desired. The rate of circulation of the water in the coil 28 may be controlled thermostatically.

The wire emerges from the cell 13 and passes on through a heater 29, which may be in the form of a tube surrounded by a coil of wire heated to a controlled temperature from a source of potential 31. After being dried, the wire passes over pulley 32 and is rewound on spool or reel 33, the speed of which is controlled by a variable speed drive, 34.

When I first started with my experiments in

electrophorizing graphite to directly coat wire, I used 1% graphite in a mixture of four parts of water and one part of ethyl methyl ketone, to which about 1% of diglycol stearate and 1% of ammonia had been added. I was able to successfully deposit graphite from such a suspension. One disadvantage was that diglycol stearate was codeposited with the graphite. I therefore changed the suspension formula and now preferably employ 1% of finely-divided graphite, in distilled water containing about .3% of a sodium alkyl aryl sulfonate. Other materials of the class known as wetting or surface active agents, such as the alkali metal salts of the alkyl aryl sulfonates and the alkyl sulfonates, may be substituted. Because such graphite is when bought very finely divided, I find that no additional milling is needed. The maximum average particle size of the graphite preferred is 3 microns. Maximum ash content is 1.0%. Other equivalent forms of graphite may be employed.

During the coating operation, the wire preferably leaves the spool 11 under fixed tension. A source of direct current up to 150 volts should be available. The wire desirably passes along the axis of the coating cell and the desirably hollow cylindrical electrode 21 is preferably coaxial therewith and connected to the negative side of the source of power. The electrode 21 may be formed of molybdenum, about ¾ inch in diameter and 5 inches long. The tube furnace 29 heats to a relatively low temperature, merely sufficient for drying before the wire is wound up on spool 33. The speed of winding may vary between 5 feet and 100 feet per minute. With the preferred alkanol suspension mentioned, voltages between 40 and 100 are giving a satisfactory coating at wire speeds of 10 to 35 feet per minute through a 5 inch cell. Under these conditions a graphite deposit in accordance with the accompanying graphs will be obtained.

The chief variables recognizable in the application of the graphite coating are duration of treatment, the effect of which is illustrated in Figure 6; percentage of graphite in suspension, the effect of which is illustrated in Figure 7; applied voltage the effect of which is illustrated in Figure 8; and temperature of the suspension in the cell, the effect of which is illustrated in Figure 9. It will be noted that the weight of the deposit is almost a straight-line function of the coating time and percentage of graphite in suspension. The ratio of weight of the deposit in mgms. to voltage, increased from .05 at 50 volts to .3 at 150 volts. Under the conditions of this test serious gassing was encountered at voltages much in excess of 150.

Temperature variation has little effect on the weight of deposit, but coatings become denser and more coherent as the temperature is increased. The adherence is also improved by the oxide layer formed on the wire during the coating, because of said wire being maintained positive with the consequent liberation of oxygen by electrolysis. A preferred current drawn through the suspension is about 8 amperes per square inch of wire surface.

It will be evident from the foregoing that my method of lubrication possesses considerable flexibility. Voltage adjustment provides a convenient means of controlling the weight of deposit. Further control can be obtained by adjusting the graphite content of the suspension or the length of the coating cell. In cases where the wire is lubricated separately, the speed of the

machine can also be used to vary the weight of coating. However, the wire, as lubricated in accordance with my invention, may be passed directly to a multiple-die machine, as in connection with the cold drawing of such wire through a plurality of dies without intermediate lubrication, as described in the Brush et al. application, Serial No. 699,032, filed September 24, 1946, and owned by the assignee of the present application.

The following is a typical comparison between the performance of Aquadag lubricated wire (see the Benbow Patent No. 1,168,050 as mentioning this lubricant) and wire coated with graphite by electrophoresis in accordance with my invention. The tests were run on a motor-driven tensile strength machine. In both cases the wire was cold 40 mil molybdenum:

Tension—Pounds

Die	Aquadag	Electrophoresis
.036"	93	56
.032"	87	54
.028"	Broke	51
.025"	----------	45
.022"	----------	38
.020"	----------	28

This shows that the application of graphite by electrophoresis greatly decreases the friction of wire-drawing.

Instead of rewinding on a horizontal reel 33, as illustrated in Figure 1, the wire after coating may be wound on a vertical reel 33a as illustrated in Figures 4 and 5. That is, the wire after passing from pulley 32, may be connected to a slider 35 which moves upward freely in slot 36 in the peripheral portion of reel 33a, turned counterclockwise as represented in Figure 5 by any suitable mechanism. As the wire is wound up, that is, from the position represented in full lines in Figure 4 to that represented in dotted lines in the same figure, it passes to said reel at a definite elevation, the elevation of the slider-connected portion of said wire continually changing.

Although preferred embodiments of my invention have been disclosed, it will be understood that modifications may be made within the spirit and scope of the appended claim.

I claim:

The method of coating wire comprising passing said wire through a bath consisting of about 1% of graphite suspended in a solution consisting of water and about .3% of wetting material of the group consisting of alkali metal salts of the alkyl aryl sulfonates and the alkyl sulfonates, and electrophoretically depositing graphite thereon with said wire connected as an anode.

HENRY W. RIMBACH.

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The following references are of record in the file of this patent:

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