Aug. 12, 1947. A. ZAVARELLA 2,425,359

APPARATUS FOR PRODUCING TAPERED ELECTRODEPOSITS

Filed June 16, 1942

Fig-7-

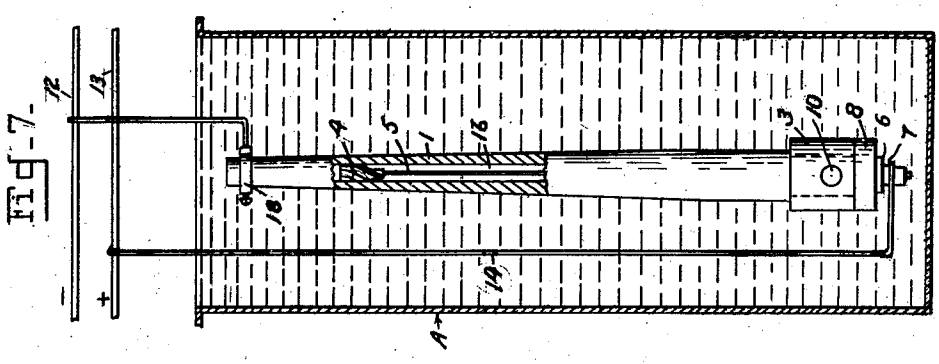


Fig-4-

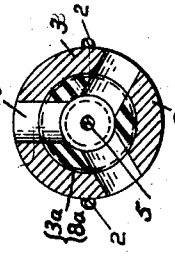


Fig-5-

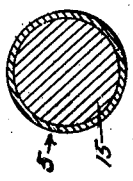


Fig-6-

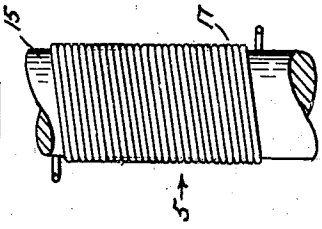


Fig-2-

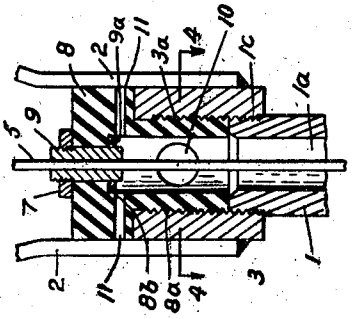


Fig-3-

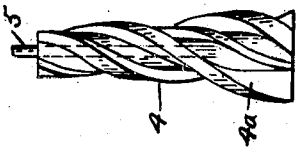
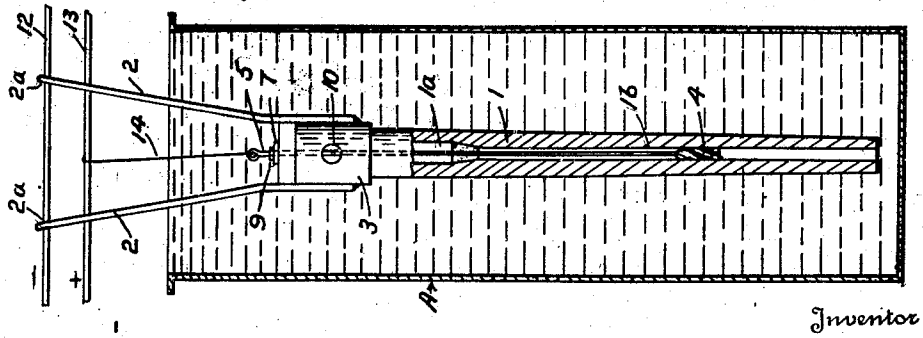


Fig-1-



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# UNITED STATES PATENT OFFICE

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## APPARATUS FOR PRODUCING TAPERED ELECTRODEPOSITS

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3 Claims. (Cl. 204—272)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to electroplating methods and apparatus, particularly for the electroplating of the bore of a gun barrel.

Specialized problems in electroplating arise in the plating of interior surfaces of a gun barrel, particularly the chamber and bore surfaces thereof. For example, it has been found desirable to apply an electroplated coating extending only part of the distance into the bore from the chamber end of the barrel and to have the thickness of such partial bore plating gradually decrease along the bore. Such condition will hereinafter be referred to as tapered plating. Furthermore the extreme conditions of temperature, pressure and stresses to which the bore of a gun barrel is subjected by the firing of a cartridge requires that the absolutely highest quality of electroplated deposit be produced. Surface roughness, porosity and internal stresses in such plated deposit must be avoided. Accordingly the electrolytic solution must be strictly free from suspended matter and hence the anode used must be as insoluble as consistently possible with cost of such anode. The problems of production of a high quality plated deposit and an insoluble anode is of course not limited to plating the interior of gun barrels but is a problem common to many other applications of electroplating.

Accordingly it is an object of this invention to produce an improved quality electroplated deposit. Another object of this invention is the production of a highly insoluble electroplating anode of low cost.

A further object of this invention is to provide methods and apparatus for producing a tapered electroplated deposit upon interior cylindrical surfaces.

It is a particular object of this invention to provide methods and apparatus for producing a high quality tapered electroplated deposit upon the interior surfaces of the chamber and bore of a gun barrel.

The specific nature of the invention as well as other objects and advantages thereof will clearly appear from a description of a preferred embodiment as shown in the accompanying drawings in which—

Fig. 1 is a sectional view of a complete assembled apparatus for producing tapered electroplated deposit on the interior of a gun barrel.

Fig. 2 is an enlarged sectional view of the improved fixture utilized to support the anode with respect to the interior surfaces of the gun barrel.

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Fig. 3 is an enlarged elevational view of the spacer provided to support the inserted end of the anode within the gun barrel.

Fig. 4 is a sectional view taken along the plane 4—4 of Fig. 2.

Fig. 5 is a cross-sectional view of an improved anode.

Fig. 6 is an elevational view of another form of improved anode.

Fig. 7 is an elevational view, partly in section, of the assembled apparatus utilized in an alternative method of producing a tapered electroplated deposit in the interior of the gun barrel.

In Fig. 1 there is shown a preferred embodiment of a plating fixture particularly adapted for the production of a tapered electroplated deposit throughout the chamber 1*a* and the adjacent portion of the bore 1*b* of a gun barrel 1. The fixture comprises a metallic collar 3 provided with interior threads 3*a*. The collar 3 is secured to the end of the barrel 1 by engagement of a portion of the threads 3*a* with the thread 1*c* generally provided on such end of the barrel for engagement with the receiver of a firearm (not shown).

A pair of supporting arms 2 are welded or otherwise conductively secured to the exterior of the collar 3. The ends of the arms 2 are bent into hook form 2*a* and the barrel and assembled fixture are supported within a conventional electroplating tank A by engagement of the hooked ends 2*a* about the cathode bus bar 12. A cap 8, comprising a hollow bolt-like member having exterior threads 8*a* on its shank portion, is screwed into the other end of the collar 3. This cap 8 is preferably made of the material known under the trade-mark "Lucite" but any suitable electrical insulating material which is not affected by the electrolytic solution employed in the electroplating process may be used. The anode utilized comprises a rod 5 which is concentrically mounted within the chamber and bore of the barrel 1. One end of the anode 5 is supported by friction in a bushing 9 which is mounted in the hollow head portion of the cap 8. The bushing 9 is secured to the cap 8 by the provision of a flange 9*a* on its one end, which abuts against the interior shoulder 8*b* of the cap 8, and a nut 7, which engages suitable threads 9*b* provided on the other end of bushing 9. The friction fit between the bushing 9 and the anode 5 should preferably be only tight

enough to securely support the anode 5 against any radial movement and still permit axial movement of the anode within the bushing. The other end of the anode 5 is supported concentrically within the bore surfaces by means of a spacer 4 of suitable electrical insulating material. This spacer is preferably provided with exterior spiral projections 4a (Fig. 3). These projections are of such dimension as to snugly engage the interior surface 1b on the barrel 1 but at the same time permitting ready circulation of electrolytic fluid thru the spiral grooves formed by spiral projections 4a. It would be apparent that with the construction described, the length of the bore to be plated may be readily varied merely by sliding the spacer 4 further down through the bore to any desired length. This is possible by the free sliding support of the other end of anode 5 in the bushing 9.

It will be noted that the general shape of the spacer or guide 4 is that of a taper. As stated, the guide is carried on the free end, or what may be called the muzzle end, of the anode and the taper extends towards the opposite or chamber end of the anode. This feature together with the fact that the spacer has the spiral grooves therein facilitates the ready circulation of the electrolytic fluid into the grooves of the firearm barrel.

That is to say, the taper and grooves cooperate to create more or less of a swirling action of the fluid so that it flows naturally into the grooves of the barrel as contrasted with the action that would result were the guide merely a cylindrical plug having straight grooves. Furthermore, the tapered shape of the guide prevents the plating from being cut off abruptly.

A suitable number of large radial openings 10 are provided in the lower portion of the fixture assemblage. These openings 10 extend through both the insulating cap 8 and the supporting member 3 and communicate with the axial opening thru hollow cap 8 immediately above the end of the barrel. In addition there are provided smaller radial openings 11 in the head portion of the cap 8 also communicating with the axial opening. The openings 10 and 11 perform an important function in permitting free circulation of electrolyte thru the bore. When the tank A is filled with a suitable electroplating solution and the anode 5 is connected to a positive bus 13 of the electroplating tank A by connector 14 and a direct potential applied between the positive and negative buses, then the usual electroplating reaction occurs. Electroplated metal is deposited on the cathodic bore surface and considerable volumes of gas are liberated along the anode surface. This gas naturally tends to rise to the surface of the electrolyte and in doing so exerts a pumping action upon the electrolytic fluid within the bore of the barrel 1. The large radial holes 10 permit the escape and circulation of the electrolytic fluid while the radial holes 11 permit the escape of the gases without interfering with the escape of the electrolytic fluid through the holes 10.

To produce a tapered electroplated deposit within a chamber and bore of the barrel 1, the anode 5 must have certain additional properties. A tapered deposit should be understood to mean one in which the thickness of the electroplated deposit progressively decreases throughout the chamber and the adjacent portion of the bore, reaching a minimum point of practically negligible thickness at the portion of the bore adjacent the spacer 4 on the end of the anode 5. Such



tapered deposit is readily obtained by using an anode 5 having appreciable electrical resistance per unit length. Since the electroplating current is supplied at only one end of such anode, the electrical resistance along the length of the anode will produce a drop in potential along the anode. By selection of an anode having a suitable resistance per unit length, the potential of such anode with respect to the adjacent cathode surface will progressively decrease along the length of the anode and attain a minimum value at the inserted end of the anode such that little, if any, electroplated deposit will be produced on the adjacent cathode surface.

It is obvious that the selection of an anode having a suitable electrical resistance per unit length is dependent not only upon the resistivity of the particular anode material but also upon the cross-sectional area of such anode.

The construction of a suitable anode to produce a tapered deposit in the manner described involves many difficulties. Since the conditions of use of the interior surfaces of a barrel are so severe, it is essential that a very high quality electroplated deposit be produced. Such deposit must especially have a very smooth surface. Accordingly any anode material which would collect a smudge on its surface would be unsatisfactory as the presence of any foreign particles in the electrolytic solution greatly impairs the smoothness of plate obtained. Equally unsatisfactory is an anode which dissolves in the electroplating solution as this action not only destroys the tapered plating property but also limits the number of barrels which can be plated per anode. At the same time such anode material must have sufficient strength to maintain its shape and concentric relationship with respect to the bore surface. Any tendency of such anode to warp or bend would produce a non-concentric variation in a depth of electroplated deposit obtained which would be harmful to the later operation of the firearm.

It has been discovered that the anode meeting the above requirements most satisfactorily, including the necessary electrical resistance per unit length in anode sizes suitable for insertion in small arms barrels, comprises a composite anode 5 (Fig. 5) having a core 15 of high carbon steel and a surface layer 16 of pure iron or lead. Such pure iron surface is conveniently produced by electrolytic deposition. Utilizing an anode thus constructed to produce a tapered electroplated deposit of chromium throughout the chamber and adjacent portion of the bore of a gun barrel, it has been found to possess the necessary physical and electrical properties, to be practically insoluble in the chromium plating solution and to form a negligible amount of smudge upon its surface. Alternatively, an anode comprising a steel core 15 and having a surface of electrolytically deposited lead, may be used. A third alternative form of a suitable anode 5 for electroplating is shown in Fig. 6. Here again the anode 5 is of a composite type having a steel core 15. About this core a platinum wire or ribbon 17 is closely wrapped with the adjacent turns touching. With all these constructions the necessary physical and electrical properties are supplied by the steel core, assuming proper proportioning of the cross-sectional area with respect to the resistivity, while the iron or lead coating or the platinum wrapping, which are practically insoluble in the electrolytic solution, protects the steel core from the action of the solution.

An additional method for aiding the production of a tapered electroplated deposit is illustrated in the arrangement shown in Fig. 7 where like numerals designate similar parts as in Fig. 1. In this arrangement, a fixture and anode similar to that shown in Fig. 1 may be utilized with the exception that the radial holes 11 and the supporting hooks 2 may be eliminated. The barrel is then immersed in the electroplating solution in tank A with the chamber end down. The barrel 1 is supported and electrically connected to the negative bus 12 of the electroplating tank A by means of a clamp 18. Any suitable electrical connection such as the wire 14 may be used to connect the anode 5 to the positive bus of the electroplating tank A. The surface of such connector should be lacquered or enamelled or provided with suitable insulation to protect the metal from dissolution in the electrolyte. With this arrangement the production of the tapered deposit through the voltage drop along the anode is assisted by the action of the gases liberated. It is readily apparent that the concentration of gases in the space between the anode 5 and the bore surface 1b will be much greater at the inserted end of anode 5 than at its chamber end. The effect of such concentration of gases is to reduce the rate of deposit of electroplated metal. Accordingly the gas effect obtained by this arrangement of the barrel in the solution tends to produce a thicker deposit at the chamber end of the barrel than in the bore portion of the barrel, hence aids the production of a tapered deposit.

It is apparent that the methods and apparatus described are not limited to their described application to the electroplating the interior of a gun barrel nor to the plating of chromium only but will be equally effective wherever it is desired to produce a tapered electroplated deposit of any metal upon interior concentric surfaces. Particularly the anode constructions described are not to be construed as limited to the production only of tapered deposits, since they are equally effective wherever a relatively insoluble anode is required for the production of a high quality electroplated deposit.

I claim:

1. Apparatus for producing a tapered depth electroplated deposit on the chamber and adjacent portion of the bore of a firearm barrel comprising a fixture of electrically insulating material engaging the chamber end of the barrel, said fixture having fluid circulation openings, a rodlike anode concentrically supported within the barrel, the chamber end of the anode being supported by said fixture, said anode being formed from electrically conducting material and having a uniform cross-section, the cross-sectional area of said anode being proportioned with respect to its resistivity to provide sufficient electrical resistance per unit length so that a normal electroplating voltage applied to only the chamber end of such anode is reduced by voltage drop along the anode to substantially the threshold electroplating voltage at the other end of the anode, means for supplying electroplating current to only the chamber end of said anode, and means supporting the barrel immersed in an electroplating solution with the chamber end down whereby the gases liberated in the plating operation assist in the production of a tapered depth electroplated deposit on the interior barrel surfaces decreasing in thickness from the chamber end to the muzzle end.



2. An apparatus for producing a tapered depth electroplated deposit on the interior surface of a hollow metallic cylinder comprising a rodlike anode, said anode being formed from electrically conducting material of uniform cross-section, the cross sectional area of said anode being proportioned with respect to its resistivity to provide sufficient electrical resistance per unit length so that a normal electroplating voltage applied to only one end of such anode is reduced by voltage drop along the anode to substantially the threshold electroplating voltage at the other end of the anode, means for supporting said rodlike anode concentrically within the cylinder, means connecting only one end of said anode to the positive terminal of a source of electric current, means for connecting said cylinder to the negative terminal of the source of electric current, and means supporting said cylinder in an electroplating bath in such position that the gas liberated moves along the anode in a direction away from the point of current supply to the anode so as to assist in the production of an electroplated deposit tapering in depth along the length of the interior surface.

3. As a new article of manufacture, an apparatus for producing a tapered depth electroplated deposit on the interior surfaces of a rifled barrel comprising in combination, means supporting the barrel substantially vertically immersed in an electroplating solution including a fixture secured to the top of said barrel, an anode concentrically supported from said fixture and projecting drown into said barrel, and a guide member of insulating material on the lower end of the anode which is substantially cone-shaped in form and tapers towards the opposite end of the anode, said member being provided with a plurality of spiral grooves therein adapted to effect a swirling action of the electroplating solution into the rifling grooves of the barrel.

ARTHUR ZAVARELLA.


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