May 5, 1931. C. P. BROCKWAY 1,803,691

PROCESS AND APPARATUS FOR PLATING WIRE

Filed Nov. 28, 1928 2 Sheets-Sheet 1

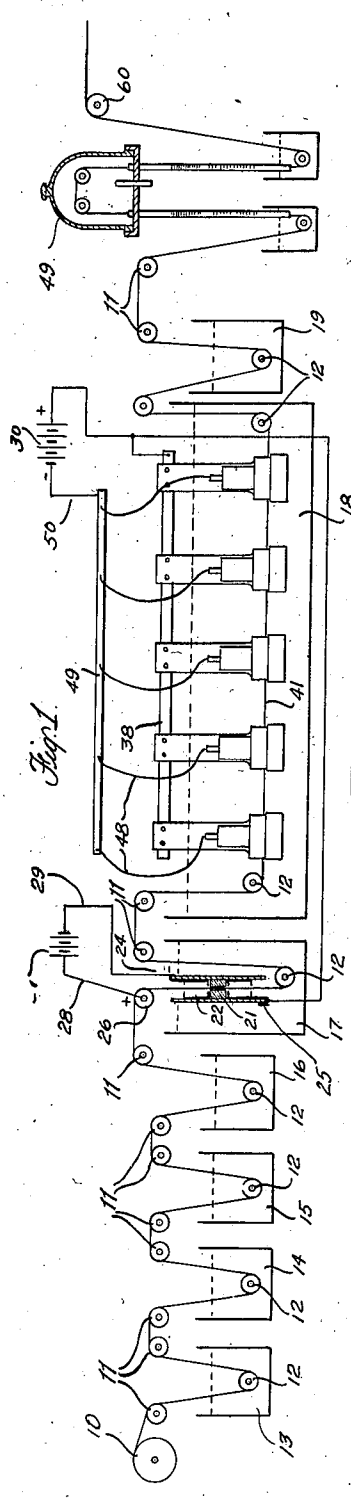


Fig. 1.

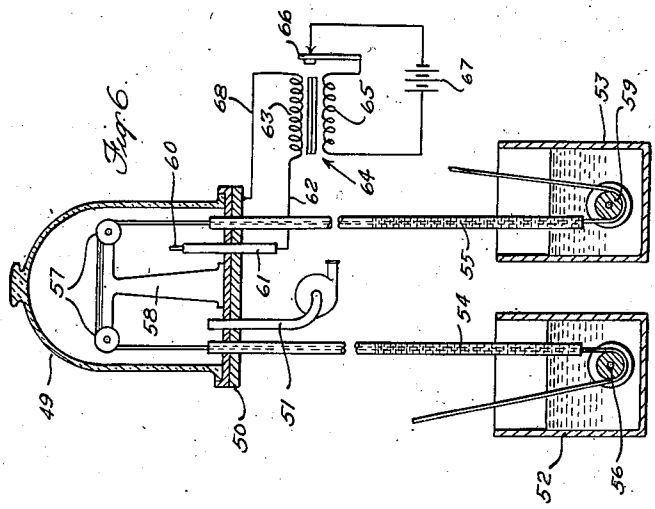


Fig. 6.

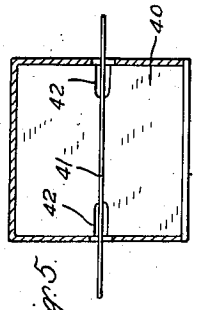


Fig. 5.

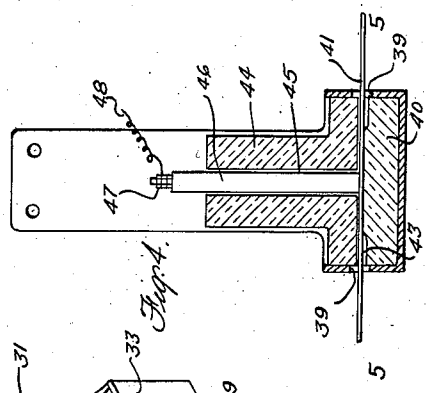


Fig. 4.

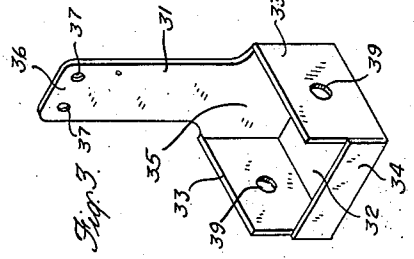


Fig. 3.

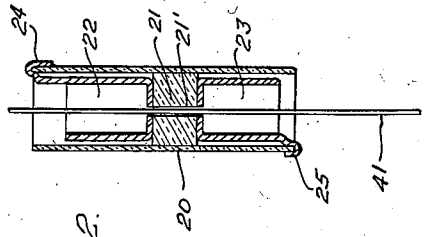


Fig. 2.

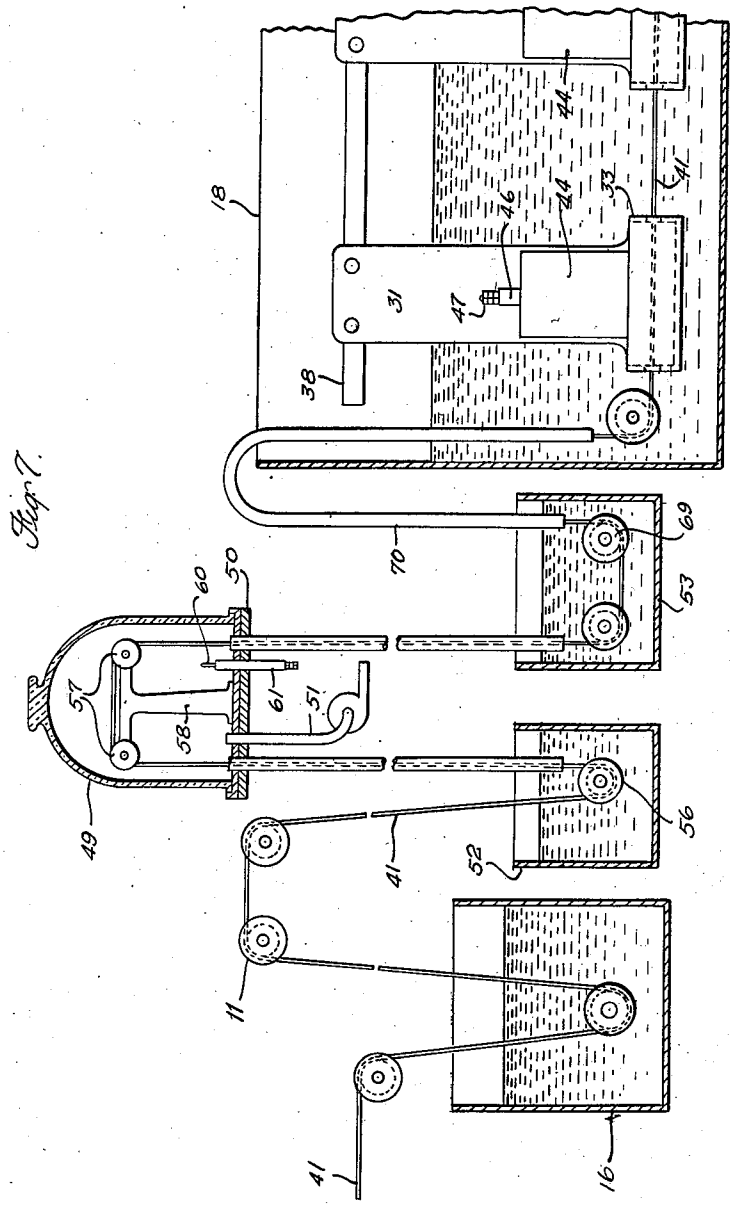
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Fig. 7.



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UNITED STATES PATENT OFFICE

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PROCESS AND APPARATUS FOR PLATING WIRE

Application filed November 28, 1928. Serial No. 322,365.

This invention relates to chromium plating and particularly to a continuous process for chromium plating wire. The invention is illustrated particularly in connection with the process for chromium plating iron wire to be used in a ballast tube for automatically regulating the current flowing through certain electrical circuits. In such a wire the chromium plating forms a mechanical case over the iron wire which prevents deterioration of the wire due to oxidation, and also prevents the evolution and the occlusion of gases. In using such a wire for a ballast or for other desirable purposes, it sometimes becomes necessary to make short bends in the wire and it has been found that ordinary chromium plating on a wire will form such a hard surface that there will be a tendency for the chromium plate to crack whenever a short bend is made. Where the wire is wound in a coil it has been found that the whole surface is covered with a series of minute cracks which tend to permit oxygen to get in contact with the iron wire to cause deterioration, and the wire has been known to burn out beneath such a crack. I have discovered that chromium plate may be applied to a wire in such a manner that the finished coating on the wire is perfectly sound, and yet at the same time the wire may be bent rather abruptly without causing the chromium plate to crack.

It is therefore one of the objects of the present invention to provide a process for plating chromium on a wire whereby the chromium is applied so as to form a more or less flexible coating for the wire.

In chromium plating certain objects it has been found advantageous, immediately before the plating bath, to subject the object to a current of electricity flowing in a reverse direction to that used in the plating, this step in the process being intended to open up the pores of the metal and eliminate any gases which may be held near the surface so that the plating will more closely adhere to the surface of the metal. Several ways of accomplishing this reversal of current have been used heretofore but there have been objections, inasmuch as the additional circuit required for this reversal of current could not be insulated from the main plating circuit, and, therefore, a possible tendency was found for the main circuit to counteract the effect of the reversal circuit. Also it has been found difficult to prevent deterioration of the surface again between the reversal of the current and the beginning of the plating action.

Accordingly, it is another object of the invention to provide a simplified means to reverse the current through the wire, such means affording protection to the wire so that it cannot become affected by outside agencies before it starts the main plating bath.

Another object of the invention is to provide means for placing the electrodes with respect to the wire so that the plating process may be continuously carried on.

Another object of the invention is to provide insulators to separate the electrodes which will stand up under the wear of the wire being drawn across them, and also, will not be affected by the chromic acid solution.

It has also been found advantageous in some instances to subject an object, either before or after the chromium plating is applied, or both to electrical bombardment in a vacuum, so that certain gases will be withdrawn from the surface of the metal, and it is therefore a further object of the invention to provide a means to draw a wire continuously through a vessel containing a vacuum.

The foregoing, and other objects of the invention will be apparent from the following description, taken in conjunction with the accompanying drawings which form a part thereof and which illustrate one embodiment of the invention and in which:

Fig. 1 is a diagrammatical side view of apparatus for carrying out the process of the invention;

Fig. 2 is a sectional view through the reverse current mechanism;

Fig. 3 is a perspective view of one of the electrodes;

Fig. 4 is a sectional side view through the electrode shown in Fig. 3 with the insulators in position and a wire being drawn therethrough;

Fig. 5 is a sectional plan view through the

electrode with the upper insulator removed;

Fig. 6 is an enlarged sectional side view of a portion of that apparatus shown in Fig. 1 which is used for subjecting the wire to a vacuum; and

Fig. 7 is a diagrammatical sectional side view of a portion of the apparatus shown in Fig. 1 and illustrating a modification of the process.

Referring more specifically to the drawings, the apparatus for carrying out the process comprises a series of tanks through which the wire is adapted to be drawn. The wire is held on a spool 10 and is led over a series of pulleys 11 and under a series of pulleys 12 so that it passes through first one tank and then another. In the first tank 13 I provide a solution of caustic soda for the purpose of thoroughly cleansing the wire before it reaches the plating process. In the next tank 14 clear water is provided to remove all traces of the caustic soda solution. In the third tank 15 I provide a solution of hydrochloric acid or other acid, if desired, to aid in removing all impurities from the surface of the wire. Again in the tank 16 I provide clear water to remove all traces of the acid. In the next tank 17 I provide the apparatus for reversing the current through the wire, and this tank is filled with the plating solution, and the next tank 18 is a large tank which is filled with plating solution and which contains the electrodes for producing the plating action. After the wire passes through the plating solution I again wash it thoroughly in a tank 19 filled with clean water. The wire is then passed through the vacuum jar and bombarded with an electrical discharge.

The device for reversing the current in tank 17 comprises a glass tube 20 which is placed in the solution so that it is entirely or almost entirely submerged, and in the center of this glass tube is placed a cylindrical insulator 21 made preferably of lava or other insulating material which is impervious to the action of the plating bath. This insulator is arranged to fit snugly within the glass tube and has a small hole extending axially through it through which the wire may pass as it is drawn down through the tube. Above the insulator 21 is provided an electrode 22 which is preferably cylindrical and has an inturned flange which rests upon the insulator 21, leaving an opening through which the wire may pass without danger of touching the metal of the electrode. In the lower end of the tube below the insulator 21 is placed a similar electrode 23 in a position so that its inturned flange is adjacent the lower surface of the insulator 21. These electrodes may be held in place by clips 24 and 25, respectively, which may also be used to make the connections thereto.

A pulley 26 acting as a guide for the wire directly above the tube 20 is connected to the positive side of an auxiliary battery 27 by a wire 28, the negative side of the battery being connected by a wire 29 to the electrode 22. Thus as the wire is drawn downwardly through the tube 20, current flows through the wire from the pulley 26 and through the plating solution in the upper end of the tube to the electrode 22 and through the wire 29 to the battery again. This direction of current flow is opposite to the normal flow of current during the plating process.

The wire then passes downwardly through the hole 21′ in the insulator 22 and passes the electrode 23 which is charged positively from the main battery 30 which furnishes current for the plating process. As the wire itself is connected to the negative side of this battery 30 in a manner to be later described, current flows from the electrode 23 to the wire, thereby causing a thin film of chromium to be deposited on the wire.

It will be noted that the reversal of current and first plating operation is separated only by the height of the insulator 21, and as the wire passes through the relatively small opening 21′ no opportunity is had for oxidization or the action of gases and other deteriorating agencies between these two steps. The effect of the reversing current, therefore, is in no way impaired, as would be the case where the wire is brought up into the atmosphere before it is subjected to the first step in the plating process.

The wire is passed under a roller at the bottom of the tube 20 and up over other rollers to guide it down again into the main plating bath contained in the tank 18. Here the wire passes under a roller and through a series of electrodes which are similarly constructed and spaced apart beneath the surface of the solution. Each of these electrodes comprises a sheet metal support 31 which is so shaped that it may be bent up to form a box-like container having a bottom surface 32, sides 33, a front 34 which preferably does not extend higher than midway up of the sides 33, and a back 35 which extends upwardly, forming a tongue 36 which is provided with a plurality of holes 37, by means of which the whole container may be attached to a bar 38 in order to rigidly support the electrodes in position in the tank.

The sides 33 of the container are provided with holes 39 through which the wire is adapted to pass and which form the points at which the most concentrated plating occurs. In order to make contact between the wire and one side of the battery 30 I have found it desirable to provide one or more friction plungers to frictionally engage the wire, as merely passing it over rollers does not give a sure enough contact so as to produce an even, uniform plating. Such friction contacts, however, must be insulated from the electrodes

and at the same time be as near as possible to the electrodes so as to maintain the maximum current at the point of plating, which would not be the case if contact were made to the wire at a point further removed from the electrodes, due to the high resistance of the wire. I therefore provide, preferably out of lava, an insulator 40 which is shaped similarly to the bottom 32 of the box-like container 31 so as to easily fit thereinto and which is high enough to extend slightly above the center of the holes 39 passing through the sides 33 of the container. A groove 41 is provided across the upper surface of the insulator 40 just deep enough to permit a wire being drawn straight through the center of the holes 39 and resting in the groove 41. The groove 41 is widened at the ends thereof as at 42, to form cavities 43 which permit some of the solution to surround the wire between the two sides 33 and the negative electrode.

A second insulating member 44 is provided to rest directly upon the face of the insulating member 40. This member I preferably provide cylindrical in form, having an extended flange at its lower end whose diameter is slightly smaller than the opening between the sides 33, and whose upper end has a smaller diameter, as indicated in Figs. 1 and 4. Axially through the center of the insulator 44 I provide a hole 45 into which a friction plunger 46 is adapted to be inserted. The plunger 46 is preferably made of steel and its lower end is hardened to prevent scoring of the plunger by the hard chromium plated surface of the wire. The plunger is also provided with a binding post 47 at its upper end by means of which it may be connected by a flexible wire 48 to a bar 49 which may in turn be connected to the negative side of the battery 30 by means of the wire 50.

As was stated before, a plurality of these electrode members are preferably used, and these are mounted on a bar 38 in such a position that the holes 39 in each of the containers are aligned so that the wire may be drawn straight through the electrodes in succession. The number of electrodes used depends on the speed at which it is desired to operate the apparatus as it is evident that the more electrodes that are provided the less time it will take to deposit a plate of a given thickness.

I have found that where the wire contacts with any surface in the immediately vicinity of the positive electrode that there is a tendency for the plating metal to be built up on this surface, so that if the wire is passed through a hole, for instance, in an insulator and the wire is permitted to contact with the edge of the hole, a few particles of metal may be scraped off against the edge and thereafter become plated until the plating builds up so as to completely close the hole and prevent the wire from going through. To overcome this possibility I have provided the extended portions 42 of the groove 41 through the lower insulator member 40. Inasmuch as the groove 41 is slightly deeper than the diameter of the wire, the insulating member extends up beyond the sides of the wire so that the cavity 43 completely surrounds the wire. As this cavity is full of plating solution, there is a resistance, due to the solution, which will prevent the plating metal from building up at the point where the wire does contact with the lower insulating member, or in other words, the point of contact with the wire is removed far enough from the hole 39 which forms the electrode to prevent the building up of plating metal against the insulating member.

After the wire is drawn through a series of electrodes it passes under a pulley 12 and up out of the tank over the pulley 11, whence it may be drawn downwardly again through a tank 19 of clear water to remove any of the plating solution which may be adhering thereto.

I have found that oftentimes the bath of the plating solution causes certain gases, such as hydrogen, to be occluded on the wire as it passes through the bath, and the wire may be caused to give up this hydrogen or other gases by subjecting it to electrical bombardment in a vacuum. Accordingly, I have provided a bell jar 49, the interior of which is subjected to a vacuum, and means to draw the wire continuously through the bell jar and still maintain the vacuum therein.

This device is shown considerably enlarged in Fig. 6, in which the bell jar 49 is shown mounted on the usual base 50 and has a pump 51 connected to the interior thereof to maintain the vacuum. In order to permit the wire to be continuously drawn through the vacuum I provide a pair of mercury wells 52 and 53, respectively, placed at a considerable distance below the bell jar 49 and communicating with the interior thereof by means of glass tubes 54 and 55, respectively, which extend up through openings in the base 50 of the bell jar. The wire is led down into the well 52 which is filled with mercury, under a roller 56, up through the glass tube 54, into the bell jar 49 over a pair of spaced rollers 57 which are rotatably supported on a bracket 58 attached to the base 50, and down again through the glass tube 55, into the well of mercury 53, under a roller 59, and up again over a roller 60 to a winding drum not shown in the drawing. The mercury in the wells 52 and 53 is drawn up in the tubes 54 and 55 to a height corresponding to the amount of vacuum maintained in the bell jar 49, and the wire may be drawn up through the mercury seal thus formed without in any way impairing the vacuum in the bell jar.

In order to subject the wire in the vacuum

to electrical bombardment I provide an electrode 60 which is sealed in the base 50 through an insulating tube 61 and which is connected by means of the wire 62 to one end of the secondary 63 of an induction coil 64. The primary 65 of this coil is connected through a make and break contact 66 to a source of current such as the battery 67 which furnishes the energy for the operation thereof. The other end of the secondary of the induction coil is connected by means of the wire 68 to the base of the bell jar 50, whereby a connection is maintained to the wire through the bracket 58 and rollers 57, and when a high tension current is produced by operation of the induction coil the discharge in the vacuum causes the whole interior of the bell jar to become luminous and operates to eliminate any of the gases mentioned above which may be held in the plated surface of the wire. If desired alternating current of commercial frequencies may be used for this purpose with good results instead of the high tension induction coil.

In some instances I have found it desirable to bombard the wire with high tension current before the plating process has commenced in order to remove certain gaseous impurities which may be found adjacent the surface of the wire. Hence, I have illustrated in Fig. 7 a modified form of the invention in which the vacuum bell jar is provided immediately prior to the plating operation. I have shown this step in place of the reversed current step as indicated in Fig. 1, although it is to be understood that both of these steps may be used in conjunction, if desired. In the structure shown in Fig. 7 the mercury wells 52 and 53 are provided and the bell jar 49 and associated part similarly to that shown in Figs. 1 and 6, but I have found it desirable to prevent the wire from coming in contact with the air immediately after its treatment in the vacuum and before it reaches the plating solution. To accomplish this purpose I have provided an additional pulley 69 in the mercury well 53 under which the wire may pass, and a U-shaped glass tube 70 extending up over the side of the tank 18 and down into the plating solution contained therein and positioned so that the wire may pass up through one leg of the U and down through the other, the ends of the tube being below the surface of mercury and of plating solution, respectively.

In plating a wire in the manner above specified it will be noted that the wire passes adjacent an electrode which is relatively small but close to the wire so that the point at which the greatest plating action takes place is found at the point nearest to the electrode. However, this point is not the only place where plating occurs, inasmuch as the conductivity of the solution will permit plating to occur at a considerable distance from the electrode. The further a particular point on the wire is from the electrode the less concentrated will be the plating, and hence, as the wire approaches one of the electrodes at any given instant the plating will be formed on the wire at different points on its surface in gradually varying densities depending on the distance of that point from the electrode and the consequent difference in electrical potential between it and the electrode. As the wire is drawn through the electrode, this structure of the plating continues so that actually at any section taken transversely through the wire the same will be provided with a sparsely settled region of chromium adjacent the wire core gradually increasing outwardly to a densely settled concentrated plating and again gradually thinning outwardly to a light sparse coating at the outside of the coating. This particular form of plating will give a resiliency not found in an evenly applied plating, as for example, by a plating applied by an electrode which is equidistant from every point on the surface of the wire. Consequently, such a plating permits the finished wire to be bent or coiled without danger of the plating cracking by virtue of the fact that there is a comparatively soft central area in the coating which acts as a soft cylindrical core for the coating. Where a plurality of electrodes are employed in succession this gradual thickening of the coating and thinning of the coating is repeated outwardly of the wire giving rise to a series of areas resembling layers of dense and thin coating material respectively. This is an important feature of the invention and permits the use of the wire in coils and other arrangements where bending is necessary without the possibility of deterioration due to the admission of oxygen or other gases through cracks formed in the plating shell. The result of this structure of the plating is that the life of the wire is very greatly increased, and the manufacture thereof is more uniform with less tendency to waste.

The above description of the operation of the electrodes in coating the wire is an approximation of the electro-chemical action that actually takes place, and the thickness of the coating and the relative densities at various points throughout the same is determined by a number of factors such as the current potential in the electrodes, the diameter of the wire, the distance of the electrodes from the wire, the distance of the electrodes from each other and the solution employed. In actual practice, however, it has been found that at the precise moment when a particular point on the wire passes directly underneath an electrode, the strength of the current is so great as to cause a cessation of the coating action at this point and a burning of the coating on the surface actually takes place. This burning forms a very thin but flexible solid

membrane at the densest parts of the coating, thereby giving rise to a series of layers of coating material that are readily flexible upon each other.

The plating solution may be any desired solution for electrically performing the process of chromium plating. One such solution having been found satisfactory is composed of 80 pounds of chromic acid, 2 pounds of chromic sulphate, 1.6 pounds of boric acid, and 250 pounds of water. However, a plating solution of any desired composition which will give satisfactory plating may be used without departing from the spirit of the invention.

If desired the tanks 13, 14, 15, 16, 17 and 18 may be supported on a platform which may be raised or lowered at will so that the pulleys and electrodes may be in effect raised out of the solution to make adjustments and insert the wire preparatory to the plating process.

While I have described and illustrated one modification of the invention, it is evident that changes may be made in the process and apparatus without departing from the spirit of the invention, and I do not desire, therefore, to limit myself to the specific modification shown and described, except as limited by the appended claims.

Having thus described my invention, what I desire to claim is:

1. A process for plating objects with chromium which comprises subjecting the object to a relatively low current of electricity in a plating bath and gradually permitting the current to increase until a concentrated plating action takes place, whereby the plate is applied to the object in sectional areas varying in density.

2. The process of plating a wire which comprises passing the wire continuously in close proximity to a hollow positively charged electrode and supplying a negative charge to said wire at a point within said electrode.

3. The process of plating a wire which comprises passing said wire continuously in close proximity to a plurality of positively charged hollow electrodes and providing a negative charge for said wire at a plurality of points within said electrodes.

4. The process of plating a wire which comprises continuously drawing said wire through a bath of plating solution, passing said wire while in said solution in close proximity to a plurality of positively charge electrodes, providing a negative charge for said wire at a plurality of points adjacent said electrodes, and subjecting said wire to electrical bombardment under greatly reduced air pressure.

5. The process of chromium plating an iron wire which comprises thoroughly cleansing said wire, passing said wire through a bath of the plating solution, and simultaneously causing a current to flow from said wire through said solution to an electrode, immediately thereafter causing a current to flow from another electrode through said solution to said wire whereby a coating of chromium is applied to said wire, passing said wire in close proximity to a plurality of electrodes in said plating solution and causing a current to flow from said electrodes to said wire, whereby the coating of chromium is increased on said wire, and subjecting successive portions of said wire continuously to electrical bombardment in a vacuum.

6. The process of applying a relatively resilient plating of chromium to an iron wire which comprises causing the wire to pass a positively charged electrode while submerged in a bath of plating solution, whereby the wire becomes plated with the chromium before it reaches the electrode and thereafter the plating on the wire becomes more dense as it approaches the electrode, whereby a plating is applied to the wire in sectional areas varying in density with the area of greatest density near the surface of the plating.

7. In a continuous wire plating apparatus, a vessel containing plating solution, means to pass the current first in one direction and then in the other through said solution and wire, comprising a tube of insulating material having a restricted opening in the center thereof, an electrode on one side of said opening, means to connect a source of electric current in one direction between said wire and electrode, another electrode immediately on the other side of said restricted opening, and means to connect a source of electric current between said wire and electrode in the opposite direction from the first current.

8. In a continuous wire plating apparatus, a tank containing a quantity of plating solution, an electrode in said solution, means to pass a current between said electrode and the wire to be plated and through said solution in one direction, a second electrode in said solution, means to pass a current between said second electrode and said wire and through said solution in the opposite direction from said first current, and means to maintain said wire submerged between the action of the said two currents.

9. In a continuous wire plating apparatus, a vessel containing a quantity of plating solution, means to guide the wire through said vessel submerged in said solution, a hollow electrode surrounding said wire in said solution and in close proximity thereto, means to charge said electrode positively, and means adjacent and within said electrode but insulated therefrom to negatively charge said wire.

10. In a continuous wire plating apparatus, a tank containing a quantity of plating solution, means to guide said wire continu-

ously through said tank submerged by said solution, an electrode in said solution and surrounding said wire and in close proximity thereto, means to charge said electrode positively, means to charge said wire negatively at a point adjacent said electrode, and insulating means separating said electrode and said last mentioned means, said means being spaced from said wire adjacent said electrode for a portion of the distance between said electrode and negatively charging means.

11. In a continuous wire plating apparatus, a tank containing a quantity of plating solution, means to draw a wire continuously through said tank submerged in said solution, an electrode submerged in said solution surrounding said wire and in close proximity thereto, an insulating member adjacent said electrode and having an opening to permit said wire to be drawn therethrough, said opening being extended at the end adjacent said electrode to prevent said wire from touching said insulating member at any point relatively near said electrode.

12. In a continuous wire plating apparatus, a tank containing a quantity of plating solution, an electrode submerged in said solution surrounding said wire and in close proximity thereto, an insulating member adjacent said electrode and connected thereto and having an opening therethrough to receive said wire, said insulating member also having an opening therethrough at right angles to said wire opening, means to give said electrode a positive charge of electricity, a plunger positioned in the second opening in said insulating member and adapted to frictionally contact with said wire, and means to charge said plunger negatively.

13. In a continuous wire plating apparatus, a vessel containing plating solution, means to pass a current first in one direction and then in the other through said solution and wire, comprising a tube of insulating material having a restricted opening in the center thereof, an electrode on one side of said opening, means to connect a source of electric current in one direction between said wire and electrode, another electrode immediately on the other side of said restricted opening, means to connect a source of electric current between said wire and electrode in the opposite direction from the first current, and means to continuously pass said wire through a vacuum and simultaneously subject said wire to electrical bombardment.

14. In a continuous wire plating apparatus, a vessel containing a quantity of plating solution, means to guide the wire through said vessel submerged in said solution, an electrode surrounding said wire in said solution and in close proximity thereto, means to charge said electrode positively, means adjacent said electrode but insulated therefrom to negatively charge said wire, and means to continuously pass said wire through a vacuum and simultaneously subject said wire to electrical bombardment.

15. Means for continuously subjecting a wire to a vacuum which comprises a vessel containing a vacuum, an inlet tube leading into said vessel from a point considerably lower than said vessel, an outlet tube leading from said vessel to a point considerably lower than said vessel, means to guide the wire up through said inlet pipe and down through said outlet pipe, a mercury seal in each of said tubes, means to connect the wire to one side of a source of electrical energy, and a terminal in said vessel insulated from said wire and connected to the other side of said source.

16. In a device for continuously subjecting a wire to a vacuum, a vessel containing a vacuum, an inlet tube leading into said vessel from a point considerably lower than said vessel, an outlet tube leading out of said vessel to a point considerably lower than said vessel, wells at the lower ends of both of said tubes, a quantity of mercury in each of said wells, means to guide said wire down into said inlet well and up said inlet pipe and down said outlet pipe and up through said outlet well, whereby the weight of the mercury in the tubes maintains the vacuum in said vessel, and means to electrically bombard said wire while it is in said vessel.

17. The process of plating a wire which comprises passing a wire continuously through an aperture in a positively charged electrode, and applying a negative charge to said wire at a point adjacent said electrode.

18. The process of plating a wire which comprises passing a wire continuously and successively through apertures in opposite sides of a plurality of hollow electrodes and applying a negative charge to said wire at a point within said electrodes.

19. The process of applying a relatively resilient plating of a metal to a wire which comprises causing the wire to travel longitudinally in a predetermined path, applying a relatively sparse coating of the metal to the wire at a given point in said path, and applying a dense coating to the wire at a point spaced from said first-mentioned point in the direction of the line of travel of the wire whereby a coating is applied which is denser adjacent its surface than adjacent said wire.

20. The process of applying a relatively resilient plating of a metal to a wire which comprises passing the wire continuously in a longitudinal path, applying a relatively sparse coating of the plating to the wire at a given point in said path and applying an increasingly denser coating to the wire at points removed from said first-mentioned point in the direction of travel of the wire

whereby a plating is applied to the wire which increases in density toward its outer surface.

21. The process of applying a relatively resilient plating to a metal wire which comprises passing the wire continuously in a longitudinal path, applying a relatively sparse coating of the plating to the wire at a given point in said path, and applying an increasingly denser coating to the wire at points removed from said first mentioned point in the direction of travel of the wire, and again applying a relatively sparse coating of the plating to the wire at points still further removed from said first mentioned point in the direction of travel of the wire.

In testimony whereof, I affix my signature.

CARL P. BROCKWAY.