Feb. 19, 1935. A. C. JEPHSON 1,991,678

ELECTROLYTIC DEPOSIT OF IRON

Filed June 30, 1932 2 Sheets-Sheet 1

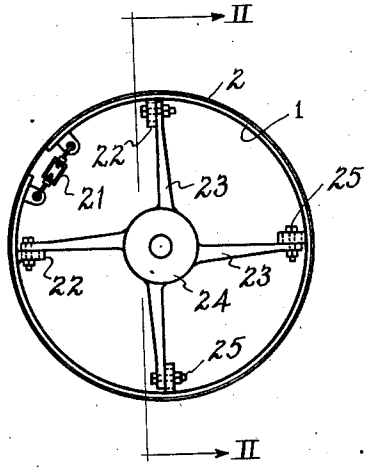



Fig. I

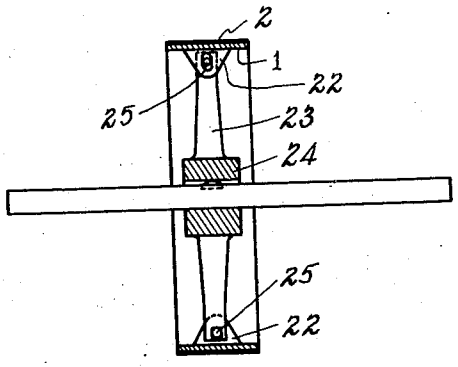



Fig. II

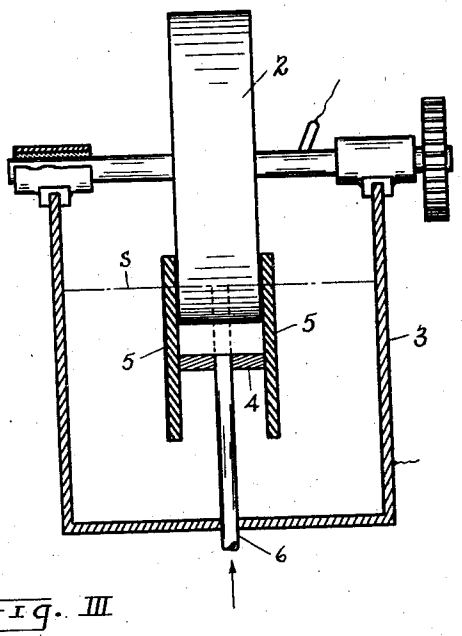



Fig. III

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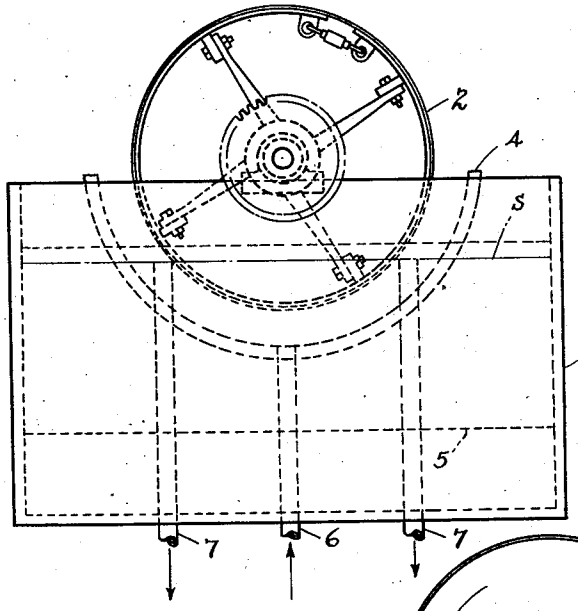



Fig. IV

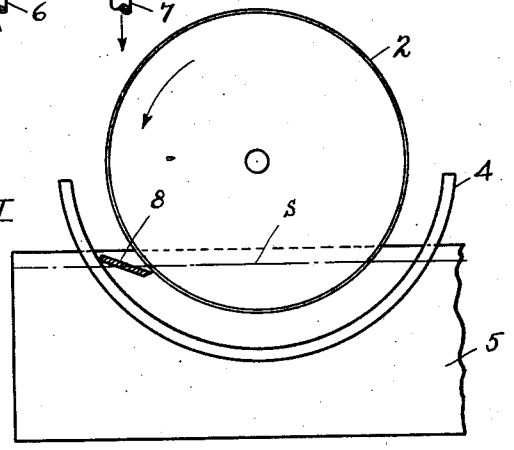



Fig. V

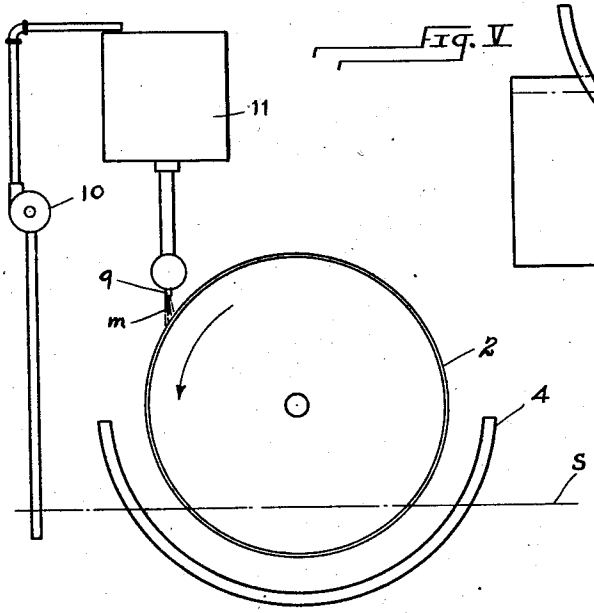



Fig. VI

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# UNITED STATES PATENT OFFICE

1,991,678

## ELECTROLYTIC DEPOSIT OF IRON

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Application June 30, 1932, Serial No. 620,130

5 Claims. (Cl. 204—6)

This invention relates to electrolytic cells, for the deposit of metal in sheet form, and consists in improvements by which the quality of the product and the economy of production may be improved.

In the accompanying drawings, Fig. I is a view in end elevation, showing the cathode of the cell of the invention. Fig. II is a view in cross section, showing the cathode structure on the plane II—II of Fig. I. Fig. III is a view of the cell in vertical section in the plane of the axis of the rotating cathode, and in this view the cathode is shown in side elevation. Fig. IV is a view of the cell in side elevation. Figs. V and VI are fragmentary views, corresponding to Fig. IV, and showing in alternative certain further details of invention.

The invention has been developed in the production of electro-deposited iron strip, and while it will be described in that particular development, it is not limited to the electro-deposition of any particular metal. It is, however, limited to a cell intended for the removal of the formed sheet from the cathode of the cell after it has been deposited. The first feature of the invention concerns cathode structure. The cathode is of cylindrical form, and consists of an expansible and contractible supporting structure, and a removable and replaceable, peripheral, shell, which may be applied to and removed from the expansible and contractible structure.

Referring to Figs. I and II, the cathode will be seen to consist of a supporting structure and a peripheral member. The supporting structure includes a cylindrical band 1 whose ends are interconnected by a turnbuckle 21, so that the periphery of the supporting body may by adjustment be enlarged and diminished in circumferential extent. On the internal face of the band 1 lugs 22 are integrated, the lugs being in such relative positions as to register with the spokes 23 of a hub 24. The otherwise free ends of the spokes 23 are secured, by means of bolts 25, to the lugs 22, and the lugs, conveniently, are so slotted for the reception of the bolts that when the nuts on the bolts 25 are loosened the band 1 may be adjusted to a circumference of larger or smaller size. As suggested above, the turnbuckle 21, advantageously, affords the means for making such adjustment of the band 1. Upon adjustment of the band 1 the nuts may be run home on the bolts 25, rigidly securing the adjusted band 1 to the spokes 23. The peripheral member is a continuous cylindrical band 2 of metal, of fixed and unalterable length. The parts are so proportioned that when the band 1 is contracted, the peripheral member 2 may be slipped to place upon it, and then by the expansion of the band 1 and the tightening of the bolts 25 the peripheral member may be secured in place upon the supporting structure. The supporting structure is so far formed of or inclusive of conducting material that, when the peripheral band member has so been secured in place upon the supporting body, it may be brought into the electric circuit of the cell.

By such provision the necessity is avoided of forming the entire cathode of the relatively expensive material, difficult of fabrication, of which the receiving surface of the cathode is advantageously made. The material for the receiving surface may be chosen without considering limitations which concern the formation of the body of the cathode, and a wider field from which to choose a practical material for the surface is opened. The peripheral band member may be changed and replaced with the greatest facility and economy of time, and the reception surface thus formed as part of the band member may be much more readily and cheaply prepared than could be the case were it the surface of a cathode made of one body of material throughout all its extent. The material for the body of the cathode may be chosen, free of the necessity otherwise imposed of choosing a material susceptible of affording a suitable reception surface, and, therefore, from a wider field of available materials. Preferably it is formed of cast iron, though other material may be employed.

The field of choice of the material for the peripheral band being thus widened, there are particular materials which I have found advantageous to use. One of these materials is cold-rolled steel strip. It is a fundamental requisite in the operation of electrolytically deposited iron in strip form that the strip deposited be in greatest measure possible free of pin-holes, and the commonest cause of pin-holes is blemish upon the surface upon which the iron is deposited. I have found a cold-rolled strip of steel to possess that perfection of surface which affords a deposited strip relatively free of pin-holes. This surface of a cold-rolled steel strip, highly finished with respect to the end I have in view, is, it will be perceived, a surface which is brought to this highly finished condition in a relatively inexpensive manner.

Another possibility which thus is opened to the industry is the employment of a peripheral band formed of steel or iron high in chromium, now commonly spoken of as stainless steel and

stainless iron. This stainless steel (or iron) is a chromium alloy of iron, in which the chromium content ranges from about 8 to 30%, and I mean to include in this definition of chromium steel and iron those steels and irons which, in addition to possessing such a large chromium content, possess also a considerable quantity of nickel. The surfaces of cold-rolled strips of chromium steel not only possess the high surface finish upon which already I have dwelt, but additionally they possess the characteristic that they are highly resistant both to mechanical injury and to chemical corrosion, and so are peculiarly adapted to the conditions and circumstances of the use to which they here are put.

Within this field of choice of materials lies also the possibility of employing as the peripheral band a strip of metal plated with chromium. The chromium-plated strip also possesses such features as those upon which I have dwelt, namely, the retention of high polish and resistance to chemical corrosion.

The next feature of my invention concerns the arrangement of the cathode within the cell, to the ends that the electro-deposit shall in largest measure and in substantially complete degree be limited to deposit upon the intended receiving surface of the cathode, that the supporting body portion of the cathode shall be relatively free of fouling with deposit upon it, that current consumption shall be economized, and that circulation of the electrolyte shall be so controlled as to effect the desired electro-deposit with greatest economy of time and material.

This feature of my invention is illustrated in Figs. III and IV, where the cathode already described is shown to be mounted upon the walls of a cell 3 in such position that, rotating on horizontal axis, its periphery through a portion of its extent dips beneath the surface of a body of electrolyte within the cell. The level of the surface of the electrolyte is indicated by the dotted line *s*. Submerged in the electrolyte within the cell, spaced from the reception surface 2 of the cathode, and preferably extending in parallelism with that reception surface, is the anode 4. It is a segment of a cylindrical shell, and may be understood to be formed conveniently of iron. Alternatively, the anode may consist of scrap iron or iron in other fragmentary form held in place by a suitable perforate screen. It will also be understood that in place of an iron anode, an insoluble anode may, as the art knows, be employed. A typical material for an insoluble anode is graphite.

Two plates 5 of insulating material—of that phenol concentration product, for example, which is known as bakelite or, alternatively, of hard rubber—are assembled with anode and cathode in the arrangement shown in Figs. III and IV. The anode and cathode are concentrically arranged, forming between them, beneath the surface of the electrolyte, a space in the form of a segment of an annulus. This annular space is closed in on opposite sides by the plates 5. The plates are arranged within the cell and between its opposite walls; and extend in planes which are perpendicular to the axis of cathode rotation. They extend adjacent to the opposite edges of cathode and anode, and overlie those edges above and below. Their upper edges rise above the surface of the electrolyte, and their lower edges descend beyond the lowermost extent of the anode. Thus these plates 5 with anode and cathode form beneath the surface of the electrolyte a substantially closed space, within which the body of electrolyte may flow in circulating stream. Through the bottom of the cell and through the body of the anode an induction pipe 6 extends, and at the lever *s* of the electrolyte within the cell eduction pipes 7 are arranged. As best shown in Fig. IV, the induction pipe opens to the annular space formed by and between cathode, anode, and plates, at the lowermost point in the extent of that space, and the eduction pipes 7 open from that space at the surface of the electrolyte on either side. By such provision a flowing stream of electrolyte may be projected upon and caused to stream over the surface of the cathode, throughout that portion of its extent which is submerged. Thus the electrolytic action may be localized and expedited. The passage of electric current is concentrated in, and substantially limited to, the space defined by and between anode, cathode, and plates 5; there is greatest electrolytic action at the point where greatest action is desired; and there is practically no straying of current to effect substantial undesired deposits upon other portions of the cathode structure.

A further feature of invention is illustrated in Fig. V. An electrolytic cell, constructed as above described and lacking those other features of invention which remain to be described, will produce material which is disfigured with pin-holes, and I have discovered that even with such a carefully designed cell the presence of pin-holes may be due to the splashing of electrolyte, which occurs as the operation of electrolysis progresses. It will be understood that in operation the cathode which dips beneath the surface of the electrolyte is in constant slow rotation; that new portions of the surface are constantly being exposed to the action of electrolysis; that, as the cathode surface advances, the deposit is built up upon it; and that constantly the cathode is rising from the electrolyte surface, bearing the deposited material in strip form. In Fig. V, I direct particular attention to the surface of the cathode 2, on the left-hand side. The cathode may be understood to be rotating counter-clockwise, as the arrow indicates, and the left-hand limb of the curve is, as operation progresses, plunging beneath the surface *s* of the electrolyte. Electrolytic action is attended with the liberation of hydrogen, and hydrogen gas escapes in small bubbles at the surface *s*. This slight ebullition of hydrogen has the effect of producing a splashing of the substance of the electrolyte. With Fig. V in view, the surface of the slowly turning cathode, as it approaches the surface of the electrolyte, becomes splashed with small particles of the electrolyte substance. The operation is ordinarily performed at elevated temperature, ranging between 60 and 100° C., and under such conditions (the rotation of the cathode being very slow) particles of electrolyte, so splashed on the exposed cathode surface, dry upon the surface, before submergence. When, then, the cathode plunges beneath the surface of the electrolyte, and electro-deposition begins, those dried particles of electrolyte, not immediately redissolved, so far obstruct the free operation of electrolysis as to give rise to or create a tendency toward the formation of pin-holes in the deposited strip.

My invention includes the provision of a shield 8, arranged at the surface of the electrolyte, at the point where the descending limb of the rotating cathode plunges beneath the surface of

the electrolyte. Preferably, this shield is slightly inclined, and at the end nearer the cathode it extends slightly beneath the surface of the electrolyte. However, it extends transversely to the surface of the cathode, as clearly shown in Fig. V of the drawings, and is so arranged and positioned that it is effective to prevent splashing of the electrolyte upon the surface of the cathode, as the cathode surface approaches the surface of the electrolyte. This shield 8, manifestly, may be mounted upon and constitute a brace structure between the two plates 5, so that the two plates 5 and the shield 8 constitute a unit in structural assembly.

Alternative means for preventing the ill effects of splashing of electrolyte upon the cathode at the point where the cathode surface plunges beneath the electrolyte surface are illustrated in in Fig. VI. Here jets of liquid *m* from nozzles 9 impinge upon the surface of the cathode 2, and spread upon the surface a film of liquid, to the end that there shall be no drying of splashed-on electrolyte.

Mention has been made of the fact that the operation is conducted at relatively high temperature, approaching perhaps the temperature of the boiling of water; and, inasmuch as the electrolyte ordinarily is an aqueous solution, there will necessarily be evaporation at relatively high rate from the surface of the electrolyte. The water thus lost to the bath of electrolyte may wholly or in part be replaced by water so spread upon the surface of the cathode through the nozzles 9. Alternatively, the losses of evaporation being taken care of in some other way, replenishing quantities of electrolyte may be employed, thus to bathe the surface of the cathode. Or, again, replenishment being otherwise taken care of, a pump 10 may be provided, withdrawing constantly a relatively small stream of electrolyte from the bath, and causing it, through the nozzles 9 and over the surface of the cathode, to return again to the body of the bath. And, inasmuch as liberation of gases might otherwise cause a disadvantageous splashing, even at the point where the jets *m* meet the surface of the cathode, it may be found advantageous to provide a tank 11, into which the circulating electrolyte may be pumped, within which gases may make their escape, and from which a stream of electrolyte, free of gases, may descend to the nozzles 9, and spread thence upon the surface of the cathode.

I claim as my invention:

1. A compound rigid cathode for an electrolytic cell including a supporting band shaped to a cylindrical shell and adjustable to conform to a cylinder of varying diameter, and a supported endless band adapted to be applied to a position encircling the supporting band and by adjustment of the encircling band to be secured thereon.

2. In an electrolytic cell for the deposit of metal in strip form, the combination with a cell whose walls confine the electrolyte of a rotating cathode whose cylindrical face constitutes the reception surface, an anode arranged opposite the cylindrical cathode face, two plates of insulating material arranged within the cell and between the opposite walls of the cell, extending in planes perpendicular to the axis of drum rotation, prolonged on opposite sides both of cathode and of anode and enclosing in the space between them both the cathode and the anode and forming with the cathode and the anode and within the bath of electrolyte within the cell a submerged and substantially closed conduit for the circulation of electrolyte, and induction and eduction pipes for electrolyte opening to and from the so formed conduit.

3. In an electrolytic cell for the deposit of metal in strip form the combination with a cell whose walls confine the electrolyte of a rotating cathode whose cylindrical face constitutes the reception surface, an anode arranged opposite the cylindrical cathode face, and two plates of insulating material arranged within the cell and between opposite walls of the cell, extending in planes perpendicular to the axis of drum rotation, prolonged on opposite sides both of cathode and of anode and enclosing in the space between them both the cathode and the anode and forming with cathode and anode and within the bath of electrolyte within the cell a submerged and substantially closed conduit for the circulation of electrolyte.

4. In an electrolytic cell for the deposit of metal in strip form a rotating cathode whose cylindrical face constitutes the reception surface and adapted to stand in partial submergence in the bath of electrolyte within the cell, an anode arranged opposite the cylindrical cathode face and adapted to stand submerged in the bath of electrolyte within the cell, two plates of insulating material extending in planes perpendicular to the axis of drum rotation and extending on opposite sides both of cathode and of anode, and a splash-preventing shield arranged between and carried by the two said plates transversely of and adjacent to the cylindrical cathode face and at the level of the surface of the bath of electrolyte within the cell.

5. In an electrolytic cell a travelling cathode whose reception surface in the progress of cell operation plunges from the air into a bath of electrolyte within the cell, means for preventing the formation of pin-holes in the deposit, such means consisting of a splash-receiving shield extending transversely of and adjacent to the reception surface of the cathode and at the level of the surface of the electrolyte within the cell at the point where the reception surface of the cathode enters the bath of electrolyte.

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