Dec. 2, 1941. N. J. RANNEY 2,264,857

ELECTROLYTIC STRIP PICKLING APPARATUS

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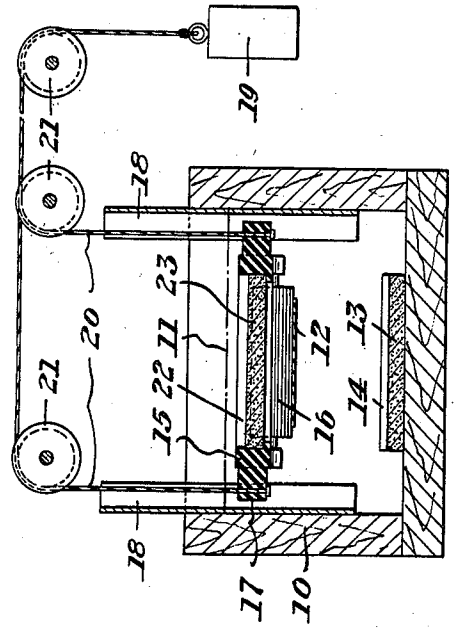


Fig. 3.

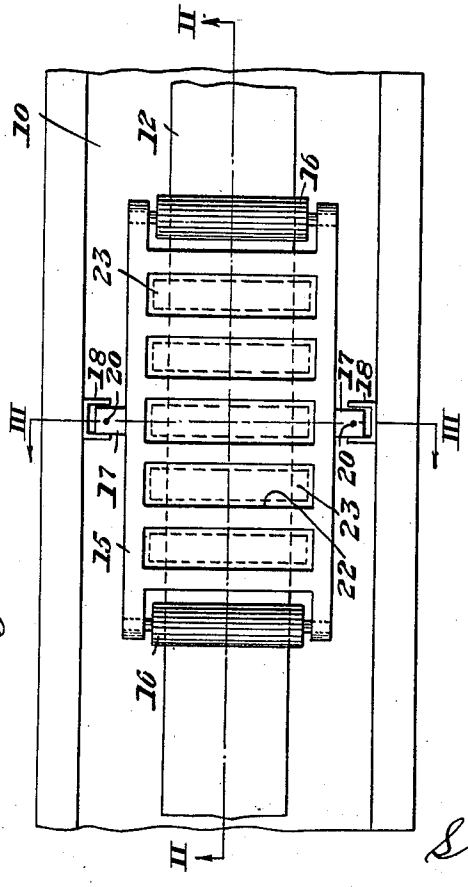


Fig. 1.

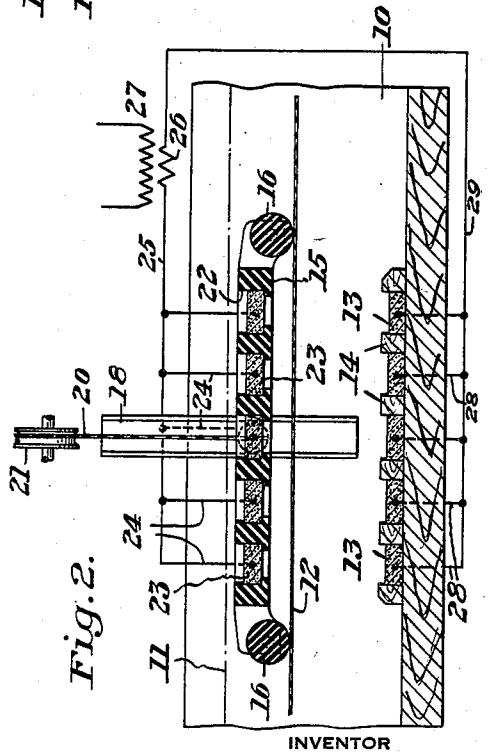


Fig. 2.

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ELECTROLYTIC STRIP PICKLING APPARATUS

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5 Claims. (Cl. 204—206)

This invention relates to the pickling of metal for the purpose of removing scale therefrom and, in particular, to the pickling of sheet metal in the form of long strips although it is applicable to metal in other forms as well.

The pickling of metal in sheet form such as steel sheets or strip has heretofore been performed by immersing the material in an acid solution. In the processing of sheet metal in a continuous manner, however, it has been found that the pickling of strip by the methods heretofore employed requires a definite immersion time. This has necessitated that the strip be passed through the pickling tanks at a speed much lower than that at which other processing operations can be carried on or the pickle tanks must be so long as to be impractical. The pickling operation has thus become a "bottle-neck" in the continuous processing of strip with the consequent reduction in efficiency and production.

I have invented a novel method and apparatus which considerably accelerates the pickling operation and enables it to be carried on at speeds commensurate with those at which other processing operations are conducted, without requiring excessively long pickle tanks. In accordance with my invention I subject strip travelling through a pickle tank to the action of alternating current, preferably by means of electrodes submerged in the pickling solution on opposite sides of the strip. A current is applied only during a certain specific stage of the pickling operation, viz., at the beginning thereof, and relatively high current densities are employed. By means of the invention, it is possible to increase the speed of travel of steel strip through a given pickle tank by 50% or more over that at which ordinary chemical pickling is accomplished, and still produce pickled strip which is the equal in every way of that produced heretofore.

In the method of electrolytic pickling covered by my invention, the usual inorganic acid pickling solution, either with or without an inhibitor, is used. Low voltage alternating current is applied to the steel either by direct connection, or preferably by placing the steel as a series resistance between two sets of electrodes. The method differs from the prior art in that current densities of from 30 to 300 amperes per square foot are used, and that this current is applied to the steel for only the first one-quarter to one-half of the total time during which the steel is being pickled. The remainder of the pickling is accomplished by ordinary chemical pickling without current. The voltage required will depend on the particular application, and will normally fall in the range of from 2 to 12 volts.

Inhibitors may be used to advantage with this method of pickling. One disadvantage of pickling inhibitors is that they tend to slow down the rate of diffusion of the acid through the scale. Under the high current densities used in this method, ordinary inhibitors are ineffective and the diffusion stage of the pickling can proceed at maximum speed. During the chemical part of the pickling operation which follows, when the scale is partially removed and the need for an inhibitor becomes increasingly great, the current is off and the inhibitor is again effective.

The apparatus of my invention comprises in its preferred form, one or more relatively fixed electrodes preferably disposed at the bottom of the pickle tank and one or more movable electrodes supported by means adapted to position the electrode at a predetermined distance from the strip travelling through the tank. The movable electrode is held against movement along the path of the strip but is free to move vertically.

A preferred embodiment of the apparatus for practicing the method of my invention is illustrated in the accompanying drawing. In the drawing:

Fig. 1 is a partial plan view of a pickle tank with my invention applied thereto, certain parts being omitted;

Fig. 2 is a longitudinal sectional view along the line II—II of Fig. 1; and

Fig. 3 is a transverse sectional view along the line III—III of Fig. 1.

Referring in detail to the drawing, a pickle tank 10 may be of any suitable construction and is filled with the usual acid pickling solution to about the level indicated at 11. Sheet metal in strip form such as a steel strip 12 is adapted to be moved lengthwise through the tank 10 by suitable driving means such as pinch rolls, the construction and operation of which are well known and require no detailed description.

Fixed electrodes 13 are disposed in the tank 10 preferably adjacent the end at which the strip enters, and may conveniently take the form of slabs of conducting material such as carbon which is immune to the action of the usual pickling acid. The electrodes 13 may be separated by insulating blocks 14, and, if the bottom of the tank 10 is of conducting material, the electrodes may conveniently be insulated therefrom by a layer of suitable insulation.

A floating frame 15 of suitable material is dis-

posed above the electrodes 13. The frame may be of Micarta, Bakelite, rubber covered steel or the like. Rollers 16 journaled on the frame are also preferably of insulating material and are adapted to bear on the strip 12 thereby positioning the frame relative thereto. The frame has trunnions 17 cooperating with vertical guide channels 18. The channels 18 may conveniently be secured to the sides of the tank 10 as shown. The frame 15 may thus move vertically as the strip 12 rises or falls as the result of tautening or slackening thereof. The weight of the frame 15 is preferably partly counterbalanced by a weight 19 and cables 20 extending therefrom over suitable sheaves 21 to the trunnions 17. The frame 15 is preferably provided with a plurality of pockets or recesses 22 open at the bottom and adapted to receive electrodes 23 similar to those shown at 13. The pockets 22 are open at the bottom to expose the electrodes directly to the surface of the strip 12.

Leads 24 extending from the electrodes 23 are connected by a bus 25 to one terminal of the secondary winding 26 of a transformer 27. The electrodes 13 are similarly connected by leads 28 and a bus 29 to the other terminal of the secondary winding of the transformer. The transformer is designed to have a low secondary terminal voltage, on the order of 20 volts. The primary winding thereof is connected to any convenient source of alternating current of commercial frequency or any other which may be available.

In the operation of the apparatus described, the strip passes through the tank continuously, the trailing end of each end of strip being secured to the leading end of the succeeding length. The portion of the strip 12 between the ends of the tank 10 is maintained at the proper level by suitable control of the speed of the pinch rolls usually disposed at each end of the tank. The uncounterbalanced weight of the frame 15 and the parts carried thereon causes the rollers 16 to ride on the strip, thus accurately positioning the electrodes 23 relative to the portion of the strip subject to the action of the alternating current. The application of alternating current at low voltage and the relatively high current densities (e. g., on the order of 30–300 amperes per square foot) through electrodes immersed in the pickling acid appears to exert an electrolytic action on the adjacent strip which reverses at the frequency of the employed current and which seemingly loosens the scale on the strip at the beginning of the pickling operation to an extent such that the chemical action of the acid during the remainder of the immersion time is greatly accelerated. The frame 15 is permitted to rise and fall with the strip 12, sufficient slack being provided in the leads 24 for this purpose. The frame is held against longitudinal movement by the trunnions 17 fitting in the guide channels 18.

It has been my observation that the accelerating effect of alternating current in pickling is not due to any direct attack of the current on the scale, but rather to the fact that the current penetrates the pores of the scale and undermines it by the electrolytic solution of iron and the evolution of hydrogen gas. The resulting opening of the pores and cracks allows the pickling acid to readily attack the inner ferrous oxide layer of scale, which is the bonding layer.

Application of current after this diffusion has largely been accomplished is undesirable, since it results in excessive attack on the base metal, with attendant waste of iron and acid, and in a poor finish on the surface of the steel. Furthermore, very little further decrease in pickling time results from the continued application of current at this stage, since the pickling rate at this stage is largely determined by the chemical solution of the scale.

The invention is characterized by numerous advantages. In the first place, the acceleration of the pickling speed makes it possible to operate pickling lines at higher speeds than heretofore, thus increasing the production and reducing the unit cost. An increase in the speed of pickling lines as much as 50% over speeds now employed may now be expected with the aid of the invention. The use of alternating current is highly advantageous since the cost of the necessary transformer equipment is much less than that of the motor generator set usually employed to supply electrolytic pickling systems previously proposed. The transformer also has a distinct advantage over the motor generator set from the standpoint of maintenance. No direct electrical contact with the strip is necessary so that sliding or rolling contacts with all their inherent difficulties are eliminated. Accurate positioning of the electrodes relative to the strip is not necessary.

The increased speed of pickling which is made possible by the invention is not accompanied by any increase in the severity of the attack of the pickling solution on the base metal. As a matter of fact, the invention reduces the amount of iron which actually is dissolved by the solution. This gives a superior finish on the pickled material and reduces the acid consumption.

The apparatus shown causes the movable electrode to accommodate itself to variations in the level of the strip and no change in the ordinary means for feeding strip through the tank is necessary. The movable electrode, furthermore, does not interfere with complete removal of the strip from the tank in case of a shutdown but simply rises with the strip above the level of the pickling solution. By maintaining the movable electrode at a predetermined distance from the strip, the maximum electrolytic effect is obtained and the power consumption is kept to a minimum. The cost of the apparatus, finally, is small compared to the net annual savings which may be effected thereby.

From the above, it will be seen that this method is especially suitable for application to continuous strip pickling, where only the first part of the pickle tank or tanks would be electrified. However, it could also be applied to batch pickling. In this case, it might be desirable to electrify one tank and remove the steel to a second tank for the chemical part of the cycle, or the operation could be accomplished in one tank by turning off the current at the proper time, either manually or automatically. As a matter of fact, in applying this method to the pickling of continuous strip, by employing suitable means for positioning the moving strip, a fixed set of upper electrodes could be substituted for the floating electrodes described.

The apparatus covered by my invention is designed primarily to facilitate the application of the above method to the pickling of continuous strip. In addition, this apparatus could be used in connection with D. C. pickling, cleaning and plating processes.

Although I have illustrated and described

herein but a preferred embodiment of the invention, changes in the construction and procedure disclosed may be made without departing from the spirit of the invention or the scope of the appended claims.

I claim:

1. Strip-pickling apparatus comprising a pickle tank through which strip may be drawn for immersion in an electrolyte, an electrode fixed relative to the bottom of the tank below the normal path of the strip and out of electrical contact therewith, connected to one terminal of a source of electric current, a frame disposed above said path, electrodes on said frame connected to the other terminal of said source adapted to be immersed in said electrolyte, said frame having supporting members bearing on the strip and carrying substantially the entire effective weight of the frame and said last-mentioned electrodes, said members also supporting said last-mentioned electrodes out of electrical contact with the strip and at a predetermined distance therefrom, and means guiding the vertical movement of said frame while preventing displacement thereof along the path of said strip.

2. Strip pickling apparatus comprising a pickle tank through which strip may be drawn for immersion in an acid solution, an electrode fixed relative to the bottom of the tank below the normal path of the strip and connected to one terminal of a source of electric current, a frame of electrically insulating material movably supported above said path, pockets in said frame, conducting slabs in said pockets connected to the other terminal of said source and adapted to serve as electrodes when immersed in said solution, and means on said frame engaging the strip effective to space the last-mentioned electrodes from the strip and support substantially the entire effective weight of the frame and its electrodes and maintain the latter out of electrical contact with the strip.

3. Strip pickling apparatus comprising a pickle tank through which strip may be drawn for immersion in an acid solution, an electrode fixed relative to the bottom of the tank below the normal path of the strip and out of electrical contact therewith, connected to one terminal of a source of electric current, a movable electrode above the strip connected to the other terminal of said source, and a holder for said movable electrode having means bearing on the strip and supporting substantially the entire effective weight of the movable electrode and maintaining it at a predetermined distance from the strip and out of electrical contact therewith, whereby the electrode rises and falls as the strip tautens and slacks.

4. Strip pickling apparatus comprising a pickle tank through which strip may be drawn for immersion in an acid solution, an electrode fixed relative to the bottom of the tank below the normal path of the strip and out of electrical contact therewith, connected to one terminal of a current source, a frame movably supported above said path, electrodes on said frame adapted to be immersed in said solution and connected to the other terminal of said source, means for partially counterbalancing the frame and the last-mentioned electrodes, and rollers on said frame adapted to ride on said strip, whereby substantially the entire effective weight of the frame and the electrodes thereon is supported and the electrodes on the frame are constantly maintained at a predetermined distance from and out of electrical contact with the strip as it slacks and tautens.

5. Strip pickling apparatus comprising a pickle tank through which strip may be drawn for immersion in an electrolyte, an electrode fixed relative to the bottom of the tank below the normal path of the strip and out of electrical contact therewith, connected to one terminal of a source of elecric current, a frame disposed above said path, electrodes on said frame connected to the other terminal of said source and adapted to be immersed in said solution, and means on said frame adapted to bear on the strip and support substantially the entire effective weight of the frame and its electrodes with the latter in spaced relation to and out of electrical contact with said strip.

NEIL J. RANNEY.