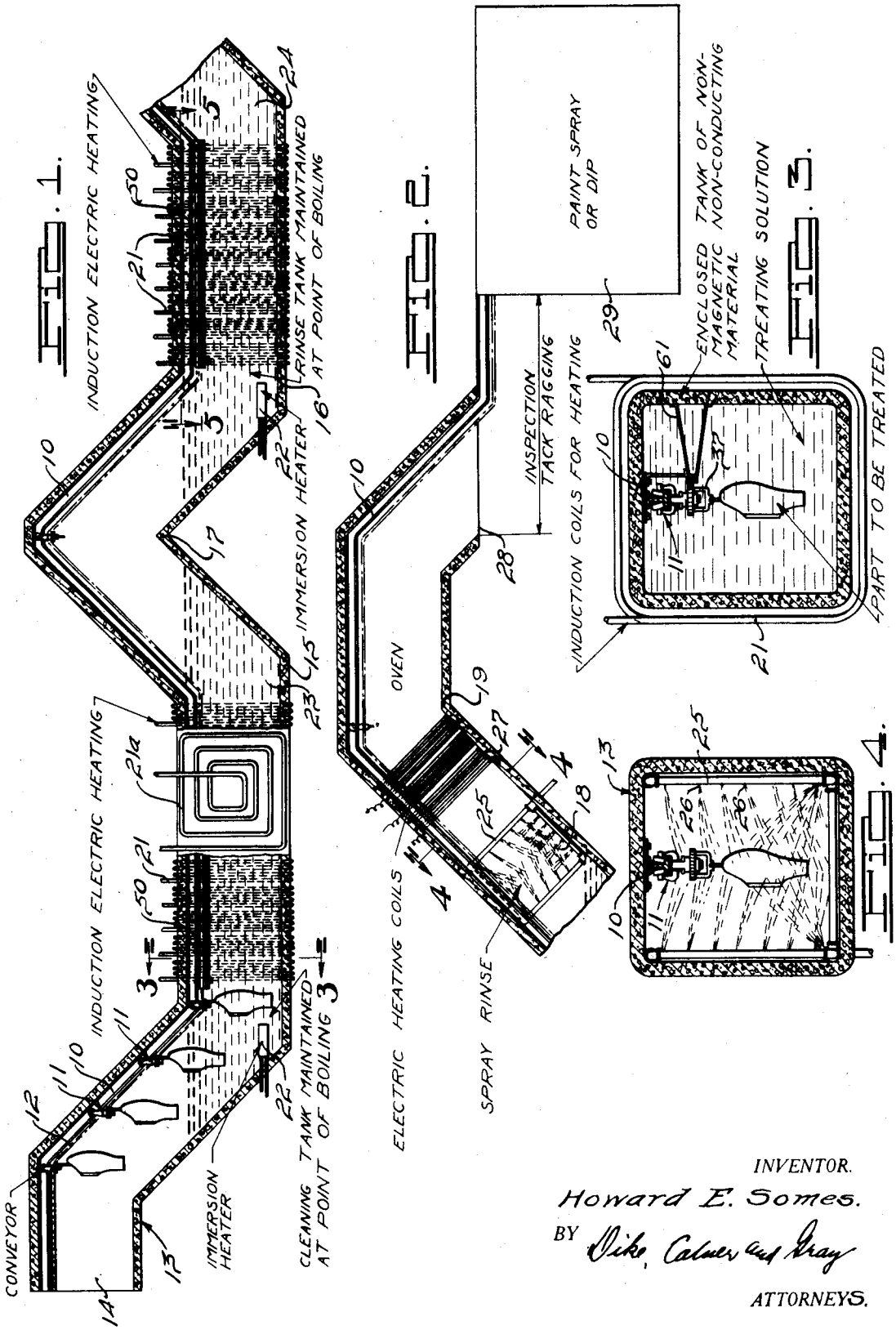
May 24, 1938. H. E. SOMES 2,118,480

METHOD OF TREATING METALS OR METALLIC ARTICLES

Filed Nov. 8, 1934 2 Sheets-Sheet 1



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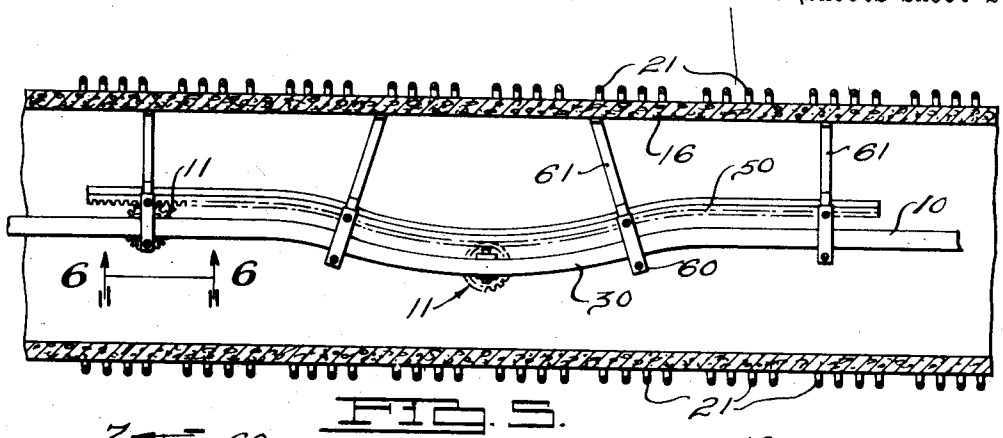

FIG. 5.

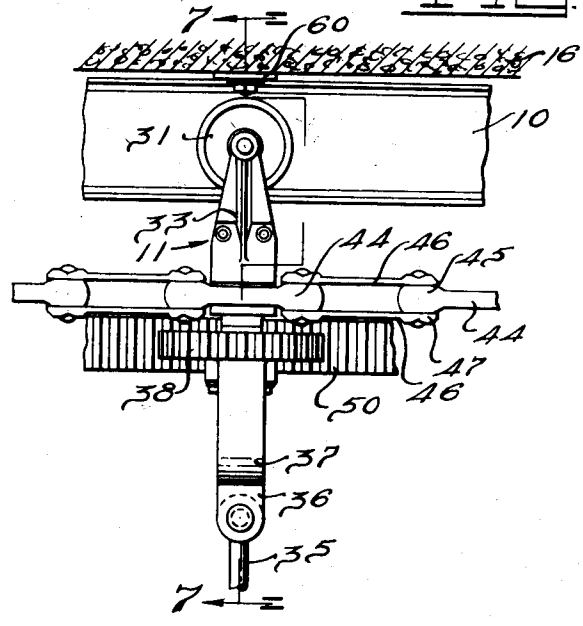

FIG. 6.

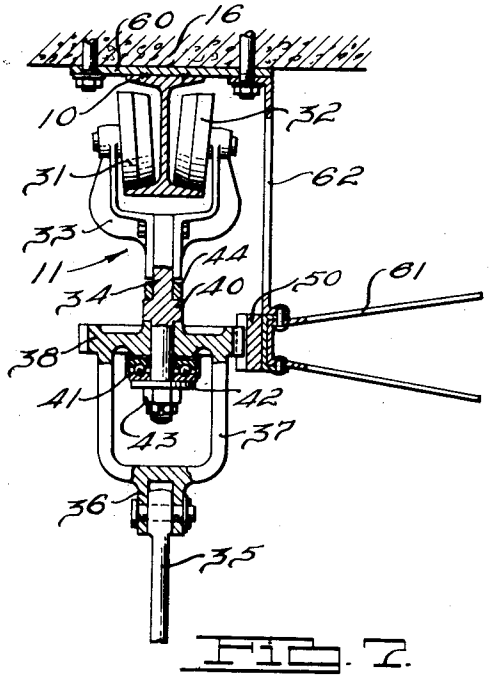

FIG. 7.

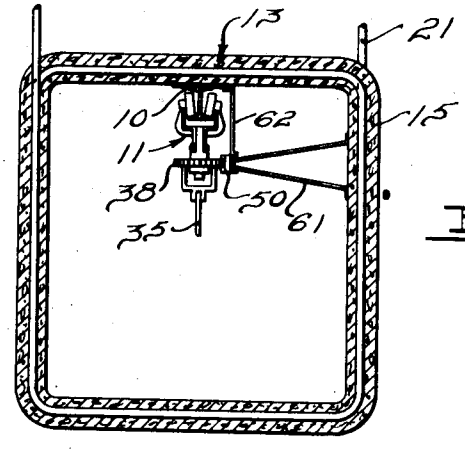

FIG. 8.

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METHOD OF TREATING METALS OR METALLIC ARTICLES

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5 Claims. (Cl. 148—8)

The present invention relates to a method of treating metals or metallic articles in which the phenomenon of electrical heating by induction is utilized in combination with the several features of the invention to effect various treatments thereof.

It is known that when a piece of metal or a metallic article is passed within the field of an induction coil, a flow of electrical current is induced within said metal or metallic article and causes a heating thereof. The present invention utilizes this phenomenon in connection with a suitable treating bath and produces a heating of the metal or metallic article while maintained in a selected treating bath. The invention is particularly though not exclusively adapted for use to effect a cleaning, or degreasing, of the surface of the metal or to effect the removal of rust in the case of iron, scale, corrosion, surface carbon, or the like from the surface thereof. The process also may be used in connection with preparatory metal treatment processes such, for example, as pickling, case hardening or the like. The process may also be used in operations for coating the surface of metal or metallic articles with protective coatings such as water-japan, rust-proofing compositions or the like. The process is effective to produce the desired results either with usual types of metal stock or with either regularly or irregularly shaped metallic articles.

The invention likewise may be used in connection with any treatment of metal or metallic articles in which it is desired to maintain a treating bath at a predetermined temperature which may be different from the temperature to which the metal or metallic article is to be subjected during the treatment thereof. In this connection the invention may be used with metal treating substances in the bath which volatilize or vaporize at normal temperatures, the present invention making it commercially feasible to maintain a sufficiently low temperature in the bath to prevent vaporization or gasification thereof. At the same time the surface of the metal or metallic article is heated by induction to a higher temperature.

The phenomenon of heating metallic articles by induced currents of high frequencies has been utilized prior to my invention to effect the melting of a metallic article and for baking a protective coating thereon. In the present invention this phenomenon is utilized for the first time in combination with selected ingredients of a metal treating bath to achieve new and useful results by heating the metal or metallic article independently of the bath while immersed therein.

It is a principal object of the present invention to provide a process for the treatment of metal or metallic articles which may be controlled during the entire operation thereof and in which induced electrical currents set up within the metal or metallic article are utilized to heat the metal or metallic article to be treated while the same is immersed in a bath of suitable ingredients to effect the desired treatment thereof. Such bath may be in the physical form of a liquid, such as various acid or alkaline solutions, coating compositions or the like, or of a solid such as a salt or combination of salts or the like, or in some instances the bath may be maintained as a vapor or a gas.

It is a further object of the present invention to provide a method of and apparatus for cleaning the surface of a metallic article wherein heat due either to hysteresis or eddy currents is utilized to effect a heating of the metal surface while the article is immersed in a suitable cleaning solution. In this connection the invention effects a thorough mechanical cleaning of the surface of a metallic article and effects economies therein because of the reduced consumption of time and cleaning substances required to effect the desired result.

It is a further object of the present invention to provide a metal treating system in which economies may be effected by the use of lower concentrations of the treating solutions than in the prior methods and in which superior results are obtained while using the same concentrations of such solutions as in prior processes.

It is a further object of the present invention to provide a metal cleaning system in which induced heat due to hysteresis and/or electrical currents set up within the metal to be treated are employed while the metal is immersed in a treating bath to effect the desired treatment of the metal and in which high conductivity of the treating bath is not essential, nor is it necessary to provide separate electrical connections to each piece of metal or each article subjected to treatment in the process.

It is a further object of the present invention to provide a process for treating metal or metallic articles in which the treating bath may be maintained in a liquid phase and thereafter converted to a vapor or gaseous phase directly at the surface of the metal article to be treated and the mechanical energies thus available are utilized at the

surface of the metal to effect the desired treatment thereof.

Other objects of this invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

The process of the present invention preferably, but not necessarily, may be carried out by means of apparatus shown in the accompanying drawings, in which

Fig. 1 is a fragmentary view, partially in elevation, showing a longitudinal section through an enclosed conveyor system adapted for use in the present invention, this view showing particularly the starting of the process and the construction of the treating tanks.

Fig. 2 is a fragmentary view in longitudinal section showing a portion of the enclosed conveyor system adapted for use with the present invention and showing the portions thereof adapted for the rinsing and drying of the object being subjected to treatment.

Fig. 3 is a cross section taken substantially on the line 3—3 of Fig. 1 in the direction of the arrows.

Fig. 4 is a cross section taken substantially on the line 4—4 of Fig. 2 in the direction of the arrows.

Fig. 5 is a fragmentary top plan view taken substantially on the line 5—5 of Fig. 1 in the direction of the arrows and showing a modified form of a conveyor track to effect transverse movement of the trolley while passing longitudinally of the enclosures.

Fig. 6 is an enlarged view taken substantially on the line 6—6 in the direction of the arrows of Fig. 5 showing a trolley which may be used to effect rotation of the article carried thereon while passing longitudinally of the enclosures.

Fig. 7 is a sectional view taken substantially on the line 7—7 in the direction of the arrows of Fig. 6.

Fig. 8 is a view similar to Fig. 3 but showing a modified form of construction wherein the induction coils are embedded within the walls of the conveyor enclosure.

The process of the present invention is essentially separate from any particular form or type of apparatus. It may, however, be utilized advantageously with the apparatus herein shown in the drawings and hereinafter to be described. It is believed that the process steps will be best understood in connection with the apparatus particularly as shown in Figs. 1 and 2, which, while showing an apparatus, also are in effect diagrammatic flow sheets of the process.

The apparatus shown herein consists of a conveyor mechanism of any conventional type such as a single or two strand type, and may be either of the overhead or of the platform type. As here shown the conveyor is of the single strand type having a conveyor track 10 suspended above the trolleys 11 which are movable relative thereto. This type of conveyor is known generally as the overhead type. The trolleys 11 are joined by suitable connecting members 12 which may be, as here shown, a series of joined links. The connection may, however, be of any preferred type so long as it is sufficiently flexible and will effect substantially simultaneous movement of the trolleys 11 relative to the conveyor track 10. The trolleys 11 are connected in such a manner as to form an endless belt and the track 10 is formed with return portions (not shown) so that the trolleys 11 may move in a predetermined path thereon and travel about a predetermined cycle. Such a conveyor mechanism may be particularly adapted for use in the present process by providing trolleys 11 as here shown, which will cause movement of an article carried thereon in a plurality of directions relative to the track 10 so as to expose the article to substantially uniform heating by intersecting the magnetic lines of the induction coils in a plurality of directions while being moved longitudinally thereof.

In order to treat an article carried on the conveyor a selected portion of the conveyor track is enclosed within an enclosure indicated generally at 13 which preferably is formed of any non-conducting non-magnetic material such as concrete, glass, wood, rubber, synthetic plastic substances or the like, which, while forming an enclosure for the conveyor system, also forms a tank or receptacle suitable for holding the bath employed in carrying out the process. The enclosure 13 surrounds the entire conveyor system at predetermined points and is in the general form of an enclosed tunnel which conforms to the rises and falls of the conveyor system. The enclosure 13 preferably comprises an entrance portion 14 and tank portions 15 and 16 separated by dividing walls 17. Any number of tank portions may be provided in the system, depending upon the number of baths which are to be employed in carrying out the process. A spray rinse portion 18 and a heated oven portion 19 are also provided within other portions of the enclosure and may be used in carrying out the present process.

Surrounding the circumference of the enclosure 13 at the tank portions 15 and 16 are a series of induction heating coils 21 which are electrically connected with a suitable source of high frequency electric current (not shown). The high frequency electric current employed in the induction heating coils may be the standard 60 cycle current or this may be increased to any desired higher frequency. Where the piece of metal or the metallic articles to be treated are relatively thick, a relatively lower frequency may be used than for metal or metallic articles of thinner section; for example, an article of twenty gauge metal will require a higher frequency current than an article of eight gauge or ten gauge metal.

The induction heating coils may be helical or flat or of any other desired type. The coils 21 are helical and are placed circumferentially around the exterior of the enclosure 13 as shown in Fig. 1 or they may be embedded within the walls of the enclosure 13 as shown in Fig. 8. The coils 21*a* are coiled flat, preferably placed on the outside surfaces of the walls of the enclosure 13 They may, however, be embedded in the walls similarly to the embedding of the coils 21 in the walls as shown in Fig. 3. In either instance the operation of the coils is substantially the same although the shape of the coils and their placement in the enclosure 13 will determine the direction of travel of the induced currents. The coils 21 or 21*a* preferably are a series of independent coils which are separately controlled either as to frequency or current or both from suitable control mechanism (not shown). This provides a varying range of induced heat in the metal or metallic article which passes inside the coils and this may be regulated and graduated in any preferred manner. This con-

struction, therefore, will permit the use of a range of selected temperatures in the metal or metallic article as it passes through selected portions of the present mechanism which carries out certain preferred steps of the present process.

In general, it will be found that in many operations, such for example, as in rust-proofing processes for ferrous metals, a relatively higher frequency or flux or both is preferred at the beginning of the process than in succeeding steps of the process. Also that the higher frequencies are desirable where the maximum controllability of the field is desired.

Where the objects to be treated are of irregular shapes and varying thickness, it will be found that as a general rule a higher frequency of current is required for the thin articles than where the articles are thicker.

The temperature of the baths within the tanks 15 and 16 is controlled by suitable temperature controlling elements 22 which, as here shown, may be heaters of the electrically actuated immersion type of any conventional design and electrically connected with a suitable source of electrical energy (not shown). In certain uses of the present invention, however, the temperature control elements 22 may be in the nature of cooling coils or the like which in such instance would be operatively connected with suitable refrigerating mechanism to effect the cooling of the bath therein. The purpose of the temperature control element 22 is to effect either a heating or a cooling of the baths 23 and 24 within the tanks 15 and 16 accordingly as may be desired to carry out most efficiently the particular steps of the process using selected ingredients in the baths. It will thus be seen that the temperature control of the baths used is an important feature of the invention which permits the selection of ingredients in the treating baths from a wide variety of solvents or the like, many of which cannot be used in present commercial processes because of the necessity for accurate temperature control within fixed predetermined limits.

The enclosure 13 is provided also with a spray rinse portion 18 formed from a series of pipes 25 joined to form a conduit which extends circumferentially inside the enclosure 13 and surrounds the conveyor mechanism. The pipes 25 are provided with a plurality of jets 26 through which a selected fluid under pressure from a suitable source of supply (not shown) is discharged as a series of sharp needle sprays in a plurality of directions toward an article suspended from the trolleys 11. Thus any substances remaining on the surface of the object to be treated after passing through the baths, may be washed from the surface thereof.

The enclosure 13 is also provided with a heated zone 19 which acts as a drying oven and which may be heated either by induction coils 21 of the type heretofore described or may be heated by the conventional type of resistance heating element 27 as shown in Fig. 2.

The enclosure 13 terminates as at 28 to permit inspection of the articles after passing through the plurality of steps of the process and the conveyor system thereafter may travel into any desired enclosure to effect further treatment of the metallic article, such for example as a paint spray booth or dip tank 29.

The track 10 of the conveyor system is provided with a plurality of rises and falls in the vertical direction as shown in Fig. 1 to cause a dipping of the metal or metallic articles carried on the trolleys 11 in the tanks 15 or 16. The rises and falls in the track 10 are of such an extent as to provide a substantially complete immersion of the metal or metallic article in the baths in the tanks 15 and 16 and thereafter a substantially complete removal therefrom. In certain installations it may be desirable also to provide a bent portion 30 in the track 10, such as shown in Fig. 5, which will effect a lateral movement of the trolleys 11 in a substantially horizontal plane as they pass over these portions of the track. This construction is not essential, however, to the satisfactory carrying out of the present process in many installations. Preferably the curved portions 30 are provided in the track 10 at points adjacent the induction coils 21 so as to cause movement of the trolleys 11 and the object suspended therefrom in a transverse direction while moving longitudinally of the coils. In certain installations particularly for treating metal or metallic articles of irregular contour or irregular thicknesses, this added transverse movement in the substantially horizontal plane effects desirable results in that it causes the article to intersect substantially all of the lines of the magnetic flux flowing from the coils 21 and effects substantially uniform heating of all portions thereof.

The construction of the trolleys 11 is shown in detail in Figs. 6 and 7. As there shown, each trolley 11 comprises conveyor track engaging rollers 31 and 32 mounted on the opposed arms of a rigid U-shaped bracket 33. A depending shaft 34 is secured to the bracket 33. Article conveying means such as a hook 35 is pivotally mounted in a bracket 36 which is formed integrally as a part of a larger bracket 37. The bracket 37 is secured to a toothed gear wheel 38 and extends downwardly therefrom. The gear wheel 38 is mounted for rotation on the shaft 34 and is held in a predetermined position thereon by contact with the shoulder 40 on the shaft 34 which prevents sliding of the gear 38 in an upward vertical direction. The gear wheel 38 is supported on a bearing 41 which is carried by a washer 42 held in place on the shaft 34 by means of the nut 43 screw threaded thereon.

The conveyors are joined together by means of connecting members 12 which may be in the form shown in Fig. 6. As there shown, the connections may be in the form of a plurality of links 44 having opposed ball-shaped ends 45 joined together by means of members 46 having sockets 47 on the opposed ends thereof. In this construction one of the links 44 contacts with a portion of the trolley 11 and effects the movement thereof upon the movement of the connecting members 12.

Rotary movement is imparted to the gear 38 and the article suspended therefrom by means of a toothed rack gear 50 which extends at predetermined points longitudinally of the conveyor and substantially parallel to the conveyor track 10. The rack gear 50 is adapted for contact with the toothed gear 38 on each of the trolleys 11 and causes the rotation thereof about the shaft 34 as the trolleys 11 are moved longitudinally of the track 10. The conveyor track 10 may be held in place in the enclosure 13 by any preferred construction, such for example as shown in Fig. 7 wherein the track 10 is secured as by welding or the like to a plate 60 which is bolted or otherwise secured to the top portion of the enclosure 13. The rack gear 50 is preferably supported on a bracket arm 61 which extends

from a side wall of the enclosure 13 at substantially right angles to the center line of the conveyor track 10 to a point adjacent the periphery of the gear wheel 38. The extended end of the bracket 61 is preferably secured to a brace member 62 which is suspended from the top of the enclosure 13. Thus the rack gear 50 extends within the enclosure to the desired point and is rigidly supported therein. All conveyor parts are preferably formed of non-magnetic materials such as 18—8 stainless steel, brass or the like or even non-conducting materials such as bakelite or the like.

The process of the present invention may be carried out with the apparatus as herein shown and described not only to effect cleaning of the surface of the metallic articles but also in connection with pickling operations and also as a process for removing rust from the surfaces of such articles. In other applications of the process it may be used to apply coatings to a metallic surface, such for example as a rust-proofing coating, water-japanning or the like. The process also may be used satisfactorily to effect heat treating or case hardening of the metallic article being passed therethrough.

The common feature of the invention in these various uses is the passing of a metallic article through a treating bath maintained at a predetermined selected temperature while heating the article itself by means of electrical induction. By way of example of the present process, if it is desired to use the process to apply a rust-proof coating to an article of ferrous metal, the article passes by means of the conveyor system into the tank 15 in which the bath 23 is made up of suitable solvents or cleaning substances to remove dirt, rust, scale, grease, or other foreign substances from the surface of the article. As the article passes through the bath, which is preferably maintained in its liquid phase, the cleaning solution penetrates the foreign substances on the surface thereof to a slight extent and then as the object passes within the induction coils 21 the object is instantly heated to a higher temperature than the temperature of the bath and the cleaning solution is rapidly changed from its liquid to its gaseous or vapor phase. The rapid expansion incident to this change from the liquid to the vapor or gaseous phase in effect "explodes" the solution which has penetrated through the foreign substances on the surfaces of the article and causes the foreign substances to be loosed so as thereafter to be readily removed from the article as it passes through the remaining portion of the bath. Where an alkali is used in the cleaning solution it will be found that this intense heating of the article independently of the bath will in effect concentrate the alkali at the surface of the metal and this will effect greater penetration of the alkali into the foreign substance on the surface of the metal. The effect heretofore described of the "exploding" of the particles from the surface of the object creates ebullition within the solution which, as is known, increases the efficiency of the cleaning operation. The rapid movement in the liquid due to the ebullition causes a further washing of the object.

The result of the foregoing is that a more rapid and more thorough cleaning of the surface is available than with other methods heretofore used. If in the bath 23 substances are used which are injurious to the subsequent rust-proofing operation, the article may pass into a rinse tank 16 in which a bath 24 of any desired rinsing solution is placed. The same action occurs here as the object passes through the tank and through the induction coils as has heretofore been described in connection with the passing of the article through the bath 23 and the tank 15. If the rinse tank operation is not sufficient to remove all such substances from the surface of the article it may then pass through a spray rinse and thereafter be suitably dried as by further heating or treatment in an oven. If the object is thoroughly cleaned by the time that it passes from the tank 15 and is at that point ready for the rust-proofing operation, the bath in the tank 16 may be made up of any suitable rust-proofing solution as, for example, a 2% solution of phosphoric acid and manganese dioxide. This solution may be maintained by the temperature maintaining member 22 at a temperature lower than the temperature induced in the metal or metallic article to effect the particular treatment. As the object passes through this bath and within the field of the induction coils 21 the object is instantly heated to the required temperature of reaction to effect the complete rust-proofing thereof.

In other uses of the invention the tanks may be filled with various organic solvents, as for example benzene or trichlorethylene, or with dilute solutions of cleaning alkalies and water. When used for purposes of metal treating, the baths are prepared in accordance with the results desired from the treatment; for example, if the metal is to be pickled, the standard pickling solutions may be used and the temperatures of these solutions and the temperatures created within the article undergoing treatment are regulated according to the preferred practice.

The present invention may also be used satisfactorily in applying protective coatings to metal surfaces, such for example as water-japans or japans containing other diluents. In this instance the water-japanning solution is placed in the tank 16 and the article, after having been cleaned in the bath in the tank 15, passes into the water-japanning solution and through the induction coils at a regulated temperature which is maintained during the entire movement of the object through the tank. After having passed through the water-japanning solution the object would then pass directly into the drying oven without passing through the spray rinse. The present process is superior to conventional processes in water-japanning in that it is here possible to maintain and control the temperatures during the immersion of the object in the japanning solution, thus securing controlled variations of film thickness.

In carrying out heat treating or case hardening or other metal treating processes the object to be treated is immersed in the proper solution at the proper temperatures for a suitable length of time. In nitriding for example, a bath of ammonia vapor could be used. In case hardening the article to be treated can be immersed in a non-metallic container together with the materials commonly used for forming a carbon coat such as charcoal, bone meal or the like. The container is then passed into the field of the induction coils. All of these factors may be regulated in a process of the present invention by controlling the temperature of the baths by means of the temperature control elements 22, the temperatures within the article by control of the current flowing through the induction coils 21,

and by regulating the speed at which the objects pass through the particular treating baths.

From the foregoing it will be seen that the present process provides a process for the treatment of metal objects by means of immersion in baths and creation of a temperature within the metal object different from the temperature of the bath by means of heat resulting from electric currents induced therein. This permits the layout of a progressive series of different operations which will permit the complete control of the operations both as to operation and as to final result from the process. These features are known to those skilled in the particular art.

I do not, therefore, desire to limit the present invention to any particular process or sequence of steps except as claimed in the claims herein.

I claim:

1. The method of improving the cleaning effect of a cleaning solution upon an article of magnetic metal which comprises passing the article through a cleaning solution capable of aiding in the removal of matter to be removed from the article, and subjecting the article while in said solution to a high frequency alternating electromagnetic field of sufficient strength and frequency to heat the article to a temperature higher than that of the solution.

2. The method of cleaning the surface of a metallic article which comprises passing the article through a cleaning solution having an accelerated cleaning effect when heated, and while in said solution heating the article to maintain it at a temperature higher than that of the main body of the solution substantially wholly by high frequency electromagnetic induction.

3. The method of cleaning the surface of an article composed of a metal capable of being heated by high frequency electromagnetic induction, which comprises passing the article to be cleaned through a suitable cleaning solution capable of reacting chemically upon the metal of which the article is composed, and while in said solution passing the article through induction coils energized by high frequency current and thereby subjecting the article to uniform heating to a temperature sufficient to vaporize the solution immediately adjacent the surface of the article.

4. The method of cleaning the surface of an article composed of a metal capable of being heated by high frequency electromagnetic induction which comprises a continuous process of moving the article through a heated cleaning solution capable of penetrating the substance to be cleaned from the surface of the article and while in said solution subjecting the article to the action of induction heating coils energized by high frequency current, to effect heating thereof to maintain it at a temperature sufficient to vaporize the solution immediately adjacent the surface of the article, and thereafter passing the article through a rinsing solution inside a series of similarly activated induction coils.

5. The method of treating a metallic article by a surrounding liquid chemical bath by maintaining the article at a temperature higher than the vaporizing temperature of the bath with minimum vaporization of the bath and accelerated rapidity of vaporization which comprises maintaining the main body of the bath heated but at a temperature below the vaporizing temperature, and heating the article by high frequency electromagnetic induction to maintain it at a temperature higher than the maintained temperature of the main body of the bath, but sufficient only to cause continuous ebullition of the liquid adjacent the surface of the article.

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