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METHOD OF QUENCHING METAL ARTICLES

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Fig. 1.

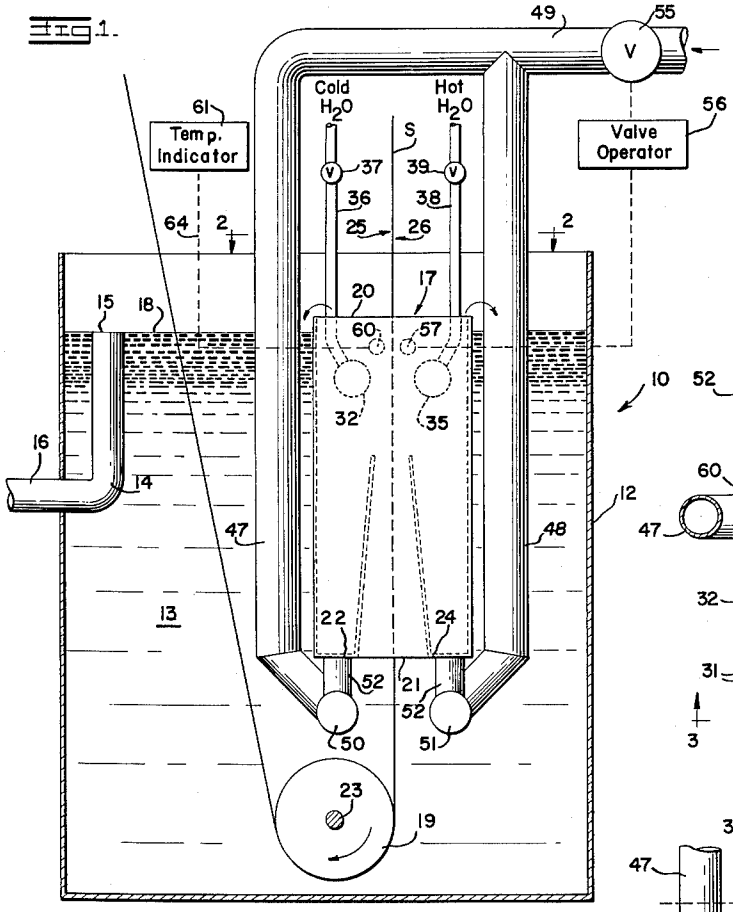
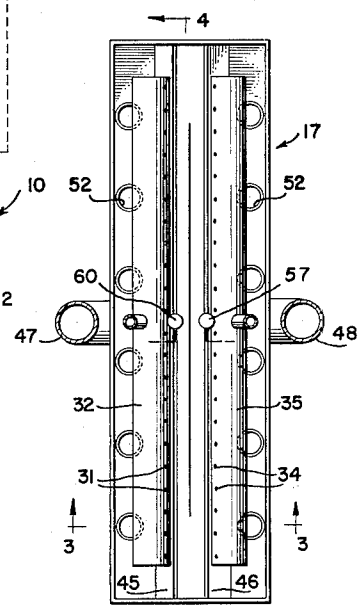


Fig. 2.



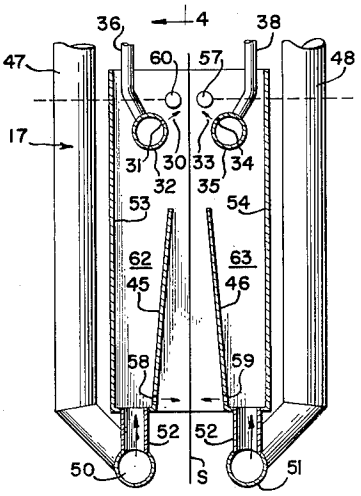


Fig. 3.

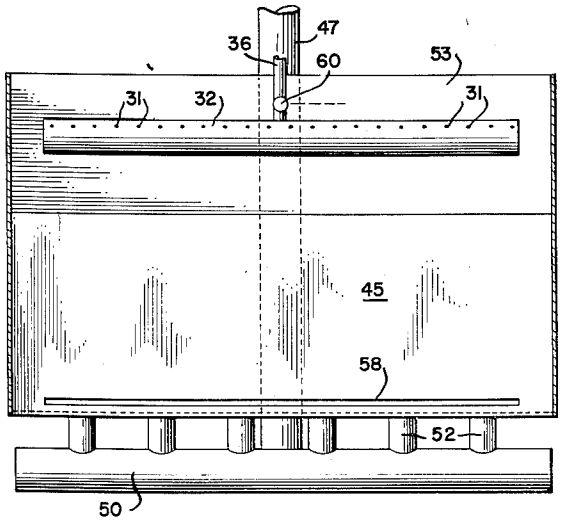


Fig. 4.

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METHOD OF QUENCHING METAL ARTICLES

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The present invention relates to a novel method of quenching metal articles and, in one of its more specific variants, to a novel method of quenching differential electrolytic tinplate.

In the production of electrolytic tinplate, ferrous metal strip such as blackplate is continuously passed at high strip speeds through an electrotinplating line at strip speeds of 500–2000 feet per minute or higher. As the ferrous metal strip passes through the electroplating line, it is electroplated with a coating of tin of desired thickness on either face of the strip. The amount of tin deposited on a given face of the ferrous metal strip is relatively small when compared with tinplate produced by the hot dip process and usually varies from about one-quarter pound to one pound per base box. If desired, it is possible to electroplate a thicker coating of tin on one face of the strip and thereby produce differential tinplate. The tinplate leaving the final electroplating cell in the electroplating line has a dull or matte finish and, normally, the tinplate is washed and passed through suitable flow-brightening apparatus. As the tinplate with the matte surface passes through the flow-brightening apparatus, the tin coating is heated to a temperature above its melting point so that the tin will flow and produce a smooth mirror-bright surface. Preferably, the molten tin is immediately quenched and solidified in a suitable quenching medium. The tinpalte thus quenched has a bright, mirror-like surface and is a more desirable product.

The flow-brightening and quenching steps usually follow shortly after the tinplate leaves the electroplating cell. Thus, the quenching apparatus is normally incorporated as an element within modern electroplating lines and must be capable of quenching the tinplated strip at the given strip speed employed in the line, i.e., at strip speeds up to 2000 feet per minute or higher. However, when quenching tinplate at high strip speeds, the strip often tends to vibrate or oscillate excessively as it passes through the quenching apparatus. As a result, there is often interference with the quenching operation and the function of the quenching apparatus is impaired.

In the production of differential electrolytic tinplate, still other problems are presented. For example, in quenching apparatus where water is the quenching medium, the water which first contacts the tinplated strip having molten tin thereon must be at a critical temperature if quench stains or "snowballs" are to be prevented. The preferred temperature of the water varies with the amount of tin deposited on the strip and therefore differential tinplate presents a unique problem in that one face of the strip must be quenched at one temperature and the opposite face of the strip must be quenched at a substantially different temperature in order to prevent quenching imperfections. Heretofore, there has not been satisfactory apparatus or a method of providing proper quenching medium temperatures for the two faces of the strip when using water or other liquid as a quenching medium and at the high strip speeds normally employed in modern electroplating lines.

It is an object of the present invention to provide a novel method of differentially quenching metal articles.

It is a further object of the present invention to provide a novel method of quenching differential tinplate.

It is still a further object of the present invention to provide a novel continuous method of quenching differential electrolytic tinplate whereby both faces of the tinplate may be quenched without formation of imperfections such as quenching stains or "snowballs."

It is still a further object of the present invention to provide a novel continuous method of quenching differential electrolytic tinplate at the high strip speeds normally employed in modern electrotinplating lines, such as at strip speeds up to 2000 feet per minute and higher.

Still other objects of the present invention and the attendant advantages thereof will be apparent to those skilled in the art upon reference to the following detailed description and the drawings wherein:

FIGURE 1 diagrammatically illustrates presently preferred quenching apparatus constructed in accordance with the invention;

FIGURE 2 is a plan view of the improved quench box of the present invention taken along the line 2—2 of FIGURE 1;

FIGURE 3 is a cross-sectional view taken along the line 3—3 of FIGURE 2; and

FIGURE 4 is a longitudinal sectional view taken along the line 4—4 of FIGURE 2 and omitting a showing of the strip for purposes of clarity.

Referring now to the drawings, the quenching apparatus generally designated as 10 comprises quench tank 12 filled to a predetermined level with water or other suitable liquid quenching medium 13. The level of quenching medium 13 may be conveniently controlled by the height of the upper opening 15 of the discharge pipe 14 or by other suitable means. When the level 18 of quenching medium 13 rises to a sufficient height, quenching medium 13 is withdrawn through opening 15 and flows downward through discharge pipe 14 and is discharged at 16. The height of quench tank 12 and the depth of the quenching medium 13 is such so as to allow quench box 17 to be mounted in quench tank 12 with sufficient clearance for convenient operation of the remaining elements of quenching apparatus 10.

A quench box 17 having a generally rectangular configuration and provided with top and bottom openings 20 and 21, respectively, is mounted in quench tank 12. The top and bottom openings 20 and 21 form an entrance and an exit, respectively, to quench box 17 for metal strip S. The quench box 17 is immersed in quenching medium 13 to a depth which allows upper opening 20 to remain above the level 18. The top of quench box 17 may be open with the top opening 20 extending substantially the entire length and width of the internal dimensions of quench box 17, and bottom opening 21 may have a similar length but a width appreciably less than that of the internal dimensions of quench box 17 to thereby provide for convenient arrangement of other elements. Preferably, the bottom of quench box 17 is partially closed by longitudinally extending bottom portions 22 and 24.

The metal strip S to be quenched, e.g., differential electrolytically tinplated ferrous metal strip from the flow brightener of a prior art electroplating line, may be traveling at high speed such as 1,000–2,000 ft./min. and it is passed through opening 20 into the upper portion of quench box 17 where it is contacted with a body of liquid quenching medium 13. The metal strip S is then passed downward in quench box 17, through bottom opening 21 into quench tank 12, and then under roll 19 mounted in the lower portion of quench tank 12 by means including pin 23. Thereafter, the strip S is passed upward in quench tank 12 and after quenching is withdrawn and passed to drying apparatus or given other desired treatment.

The strip S has a face 25 requiring liquid quenching medium at a low temperature and a second face 26 requiring liquid quenching medium at a relatively high temperature if quenching imperfections are to be avoided.

Therefore, it is essential that some means for differential quenching be provided so as to assume the absence of quenching imperfections on both faces 25 and 26.

The quenching medium 13 outside of the quench box 17 is maintained at a relatively high temperature that is sufficiently elevated to result in the formation of quenching imperfections on face 25. Preferably, the quenching medium is maintained at a temperature high enough to assure proper quenching of face 26. As the strip S to be quenched enters the body of liquid quneching medium 13 within quench box 17, face 26 is contacted by the high temperature quenching medium and for this reason it does not present a quenching problem. Face 25 does present a quenching problem due to the high temperature of the body of quenching medium and, substantially immediately after it enters the quenching medium, jets of cool liquid quenching medium 30 projecting from openings 31 in manifold 32 are impinged thereon across the width of a submerged portion of the strip S. Preferably, the openings 31 are constructed and arranged so as to project the quenching medium upward and onto the strip at a point in the vicinity of its first contact with the quenching medium and shortly after entry into the quenching medium. Similarly, jets of hot quenching medium 33 at a temperature sufficiently elevated to properly quench face 26 projecting from openings 34 in manifold 35 are impinged on a submerged portion of face 26 shortly after entering the quenching medium. The cool quenching medium is supplied to manifold 32 by conduit 36 at a rate controlled by valve 37 while hot quenching medium is supplied to manifold 35 by conduit 38 at a rate controlled by valve 39. The cool quenching medium has a temperature at least as low as is required for quenching face 25 without formation of quenching imperfections. Also, it is impinged on face 25 in a volume whereby quenching medium contacting face 25 as it enters the body of quenching medium is maintained at the temperature required for quenching without formation of quenching imperfections. The hot quenching medium is at a proper temperature for quenching face 26 without formation of quenching imperfections and it may be supplied in about the same volume and pressure as the cool quenching medium to thereby provide equal lateral forces against the strip S and aid in reducing vibration at high strip speeds. Preferably, the hot quenching medium is withdrawn from quench tank 12 and thus it may be at approximately the same temperature.

By operating in the above manner, it has been discovered that it is possible to maintain a localized area of liquid quenching medium in contact with face 25 at the point of entry of the strip which is of sufficiently reduced temperature to provide a proper quenching temperature therefor in spite of high temperature quenching medium in other portions of the quench box 17 and quench tank 12. Surprisingly, this may be accomplished without interfering in any way with the quenching of face 26 at the higher quenching temperature that it requires. It has been further discovered that, after the strip has been initially quench as described above, then face 25 may be passed through the remainder of the quenching medium which is at temperatures up to the higher quenching temperature for face 26 and no adverse effects are noted. Thus, the initial quench as the strip enters the quenching medium has been found to be of extreme importance and, if conducted in accordance with the invention, then the remainder of the quench may proceed at the higher temperature without adverse effect.

Inwardly inclined baffles 45 and 46 are formed along the inner edges of bottom portions 22 and 24, respectively. The baffles 45 and 46 are shown as extending substantially the length of the quench box 17 and upward slightly more than half the height of the quench box 17. The baffles 45 and 46 direct any quenching medium 13 supplied to the bottom of the quench box 17 against the surfaces of the metal strip S as it passes downward. The baffles 45 and 46 should not be inclined to such an extent as to allow contact with metal strip S and thus damage the surface.

The baffles 45 and 46 may be provided with narrow, longitudinally extending slots 58 and 59, respectively. The slots may have a width of about one-eighth inch and may extend to within a short distance of the ends of the baffles. The purpose of the slots is to allow any incoming fresh quenching medium supplied to the bottom of quench box 17 to jet inwardly and toward the metal strip S, thereby providing opposite lateral forces or pressures against metal strip S. This arrangement has been found to be an effective and convenient means for providing opposed forces or pressures against the strip S in the lower portion of quench box 17. Such opposed pressures are desirable for aiding in preventing undesirable vibration or oscillation of the strip when it is traveling at the high strip speeds normally encountered in modern electroplating lines.

Fresh quenching medium 13 under pressure is supplied to feed pipes 47 and 48 from a suitable source (not shown) via supply pipe 49. The feed pipes 47 and 48, in turn, supply fresh quenching medium 13 to manifolds 50 and 51, respectively. Each of the manifolds 50 and 51 is provided with a plurality of spaced conduits 52 leading upward through bottom portions 22 and 24 of quench box 17 and into the lower portion of areas 62 and 63 between vertical walls 53 and 54 of quench box 17 and the baffles 45 and 46, respectively, for the purpose of suplying quenching medium 13 to quench box 17 along substantially its entire length when this is desired. A major proportion of the quenching medium 13 so supplied is directed upward and inward in quench box 17 by baffles 45 and 46 and toward that portion of the strip which is in the upper portion of quench box 17. At high strip speeds approaching 2000 feet per minute, all of the quenching medium is generally dragged out by the strip. However, at low strip speeds or where very large volumes of quenching medium are supplied at high pressure, a portion of the inwardly directed quenching medium 13 continues to flow upward through quench box 17 and overflows the top thereof into quench tank 12. A minor portion of fresh quenching medium 13 thus supplied jets through slots 58 and 59 and inward toward that portion of strip S which is in the lower portion of the quench box 17, thereby providing opposed forces against strip S.

The supply line 49 is provided with valve 55 controlled by valve operator 56 in response to temperature data fed by thermostat 57. Also, a thermostat 60, temperature indicator 61 and an electrical lead line therebetween is provided for the purpose of obtaining temperature data for the quenching medium on the side of face 25. The valve 55 is preferably slightly opened at all times, thereby insuring at least a small flow of cooling medium 13 continuously. The thermostats 47 and 60 should be placed a short distance from incoming strip S so as to insure that the temperature recorded thereby will closely approximate the actual temperature of cooling medium 13 in contact with faces 25 and 26, respectively, of strip S. For example, thermostats 57 and 60 may be placed a distance of approximately one to three inches from the strip and four to six inches below the surface of the quenching medium in quench box 17. In addition, manifolds 32 and 35 may be placed about four to six inches from the strip and a similar distance below the surface of the quenching medium in quench box 17.

The temperature of the quenching medium is of critical importance in the immediate vicinity of the point of entry of the strip into the quenching medium when quenching tinplate from a flow-brightener. If quench stains or "snowballs" are to be prevented when quenching differential tinplate from the flow-brightener with water as the quenching medium, then it is essential that the water first contacted by the strip on each face be at the necessary temperature in each instance to assure the absence

of quenching imperfections. When quenching flow-brightened tinplate with water, the preferred temperature of the water varies with the amount of tin electrodeposited on the strip. For example, when about one-quarter pound of tin per base box is electrodeposited on the surface of the metal strip, the preferred temperature of the quench water is 70–90° F., for one-half pound tin plate about 130–150° F., for three quarter pound tinplate 150–165° F. and for one pound tinplate 150–175° F.

The temperature of the quenching medium first contacting the tinplate on both faces of the strip may be controlled very effectively and easily when operating in accordance with the present invention. For example, the quenching medium in the major proportion of the quench box preferably is maintained at the temperature for quenching face **26** requiring the highest quenching temperature, this temperature being maintained by controlling the total amount of fresh quenching medium supplied to the quench box. The temperature of the quenching medium on the opposite face of the strip requiring a substantially lower quenching temperature is controlled at a lower temperature by supplying fresh quenching medium by means of manifold **32**. Control of the temperature of the quenching medium on the face **25** may be established by visual observation of the strip, with the cool quenching medium being supplied in increasing amounts until quenching imperfections are no longer observed or it may be by means of a thermocouple control to maintain temperatures as indicated above on each side of the strip for given weights of tinplate.

As an example of the foregoing when quenching differential tinplate having one-quarter pound per base box of tin on face **25** and one pound of tin per base box on face **26**, the main body of quenching water may be maintained at 170° F. by controlling the amount of fresh cooling medium supplied. For instance, less than the required amount of fresh quenching medium is supplied by manifold **32** and thermostat **57** supplies temperature data to valve operator **56** which operates valve **55** as necessary to supply the remaining amount of fresh quenching medium needed to maintain a temperature of 170° F. in the main body of quenching medium. When the tinplated strip is about 36 inches in width and traveling at 1700 ft./min., the manifold **32** may impinge cold water (70° F.) under 100 p.s.i. pressure against face **25** at the rate of 30 gal./min. The manifold **35** is operated in a similar manner and also may impinge hot water (170° F.) under 100 p.s.i. pressure against face **26** at the rate of 30 gal./min. This method of operation results in both faces of the strip being quenched initially at the proper temperature and completely eliminates quenching imperfections.

While the quenching apparatus of the invention has been specifically described in connection with its use in a high-speed electroplating line for quenching differential electroplated strip, it will be recognized by those skilled in the art that it is also useful for quenching other types of metal strip or other metal articles in general wherever a differential quenching operation is desirable.

The foregoing detailed description of a presently preferred embodiment of the invention and the illustrative drawings are for purposes of illustration only, and are not to be taken as being limiting to the spirit or scope of the appended claims.

What is claimed is:

1. In a method of quenching a metal article having first and second faces requiring liquid quenching medium at a low temperature and a higher temperature respectively for quenching without formation of quenching imperfections, the metal article being quenched in a body of liquid quenching medium having a temperature too high for quenching the first face without formation of quenching imperfections, the improvement which comprises passing the metal article into the body of quenching medium and substantially immediately thereafter impinging cool liquid quenching medium on an immersed portion of the first face, the cool quenching medium having a temperature at least as low as required for quenching of the first face without formation of quenching imperfections and being impinged thereon in a volume whereby quenching medium contacting the first face as it enters the body of quenching medium is maintained at the temperature required for quenching the first face without formation of quenching imperfections.

2. In a method of quenching a metal article having first and second faces requiring liquid quenching medium at a low temperature and a higher temperature respectively for quenching without formation of quenching imperfections, the metal article being quenched in a body of liquid quenching medium having a temperature too high for quenching the first face without formation of quenching imperfections, the improvement which comprises maintaining the body of liquid quenching medium at a temperature required for quenching the second face of the article without formation of quenching imperfections, passing the metal article into the body of quenching medium and substantially immediately thereafter impinging cool liquid quenching medium on an immersed portion of the first face, the cool quenching medium having a temperature at least as low as required for quenching of the first face without formation of quenching imperfections and being impinged thereon in a volume whereby quenching medium contacting the first face as it enters the body of quenching medium is maintained at the temperature required for quenching the first face without formation of quenching imperfections.

3. In a method of quenching tinplate having first and second faces coated with molten tin that require liquid quenching medium at a low temperature and a higher temperature respectively for quenching without formation of quenching imperfections, the tinplate being quenched in a body of liquid quenching medium having a temperature too high for quenching the first face without formation of quenching imperfections, the improvement which comprises passing the tinplate into the body of quenching medium and substantially immediately thereafter impinging cool liquid quenching medium on an immersed portion of the first face, the cool quenching medium having a temperature at least as low as required for quenching of the first face without formation of quenching imperfections and being impinged thereon in a volume whereby quenching medium contacting the first face as it enters the body of quenching medium is maintained at the temperature required for quenching the first face without formation of quenching imperfections.

4. In a method of quenching tinplate having first and second faces coated with molten tin that require liquid quenching medium at a low temperature and a higher temperature respectively for quenching without formation of quenching imperfections, the tinplate being quenched in a body of liquid quenching medium having a temperature too high for quenching the first face without formation of quenching imperfections, the improvement which comprises maintaining the body of quenching medium at a temperature required for quenching the second face of the tinplate without formation of quenching imperfections, passing the tinplate into the body of quenching medium and substantially immediately thereafter impinging cool liquid quenching medium on an immersed portion of the first face, the cool quenching medium having a temperature at least as low as required for quenching of the first face without formation of quenching imperfections and being impinged thereon in a volume whereby quenching medium contacting the first face as it enters the body of quenching medium is maintained at the temperature required for quenching the first face without formation of quenching imperfections.

5. In a method of continuously quenching tinplated strip having first and second faces coated with molten tin that require quenching water maintained at a low temperature and a higher temperature respectively for

quenching without formation of quenching imperfections, the tinplated strip being passed continuously into a body of quenching water maintained at a temperature too high for quenching the first face without formation of quenching imperfections, the improvement which comprises passing the tinplated strip into the body of quenching water and substantially immediately thereafter continuously impinging cool quenching water on an immersed portion of the first face, the cool quenching water having a temperature at least as low as required for quenching of the first face without formation of quenching imperfections and being impinged thereon in a volume whereby quenching water contacting the first face as it enters the body of quenching water is maintained at a temperature required for quenching the first face without formation of quenching imperfections.

6. In a method of continuously quenching tinplated strip having first and second faces coated with molten tin that require quenching water maintained at a low temperature and a higher temperature respectively for quenching without formation of quenching imperfections, the tinplated strip being passed continuously into a body of quenching water maintained at a temperature too high for quenching the first face without formation of quenching imperfections, the improvement which comprises maintaining the body of quenching water at a temperature required for quenching the second face of the tinplated strip without formation of quenching imperfections, passing the tinplated strip into the body of quenching water and substantially immediately thereafter continuously impinging cool quenching water on an immersed portion of the first face, the cool quenching water having a temperature at least as low as required for quenching of the first face without formation of quenching imperfections and being impinged thereon in a volume whereby quenching water contacting the first face as it enters the body of quenching water is maintained at the temperature required for quenching the first face without formation of quenching imperfections.

7. The method of claim 6 wherein the first face of the tinplate has about one-quarter pound per base box of tin thereon and the quenching water contacting the first face as it enters the body of quenching water is maintained at about 70–90° F.

8. The method of claim 6 wherein the first face of the tinplate has about one-half pound per base box if tin thereon and the quenching water contacting the first face as it enters the body of quenching water is maintained at about 130–150° F.

9. The method of claim 6 wherein the first face of the tinplate has about three-quarter pound per base box of tin thereon and the quenching water contacting the first face as it enters the body of quenching water is maintained at about 150–165° F.

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