July 25, 1950 A. F. HOLDEN 2,516,516

SALT BATH QUENCHING FURNACE

Filed Dec. 10, 1946 3 Sheets-Sheet 1

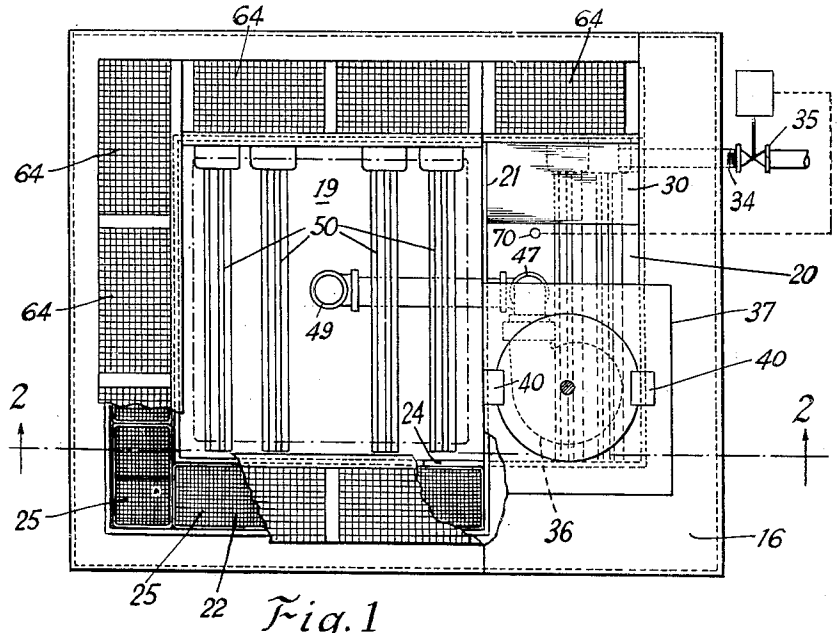


Fig. 1

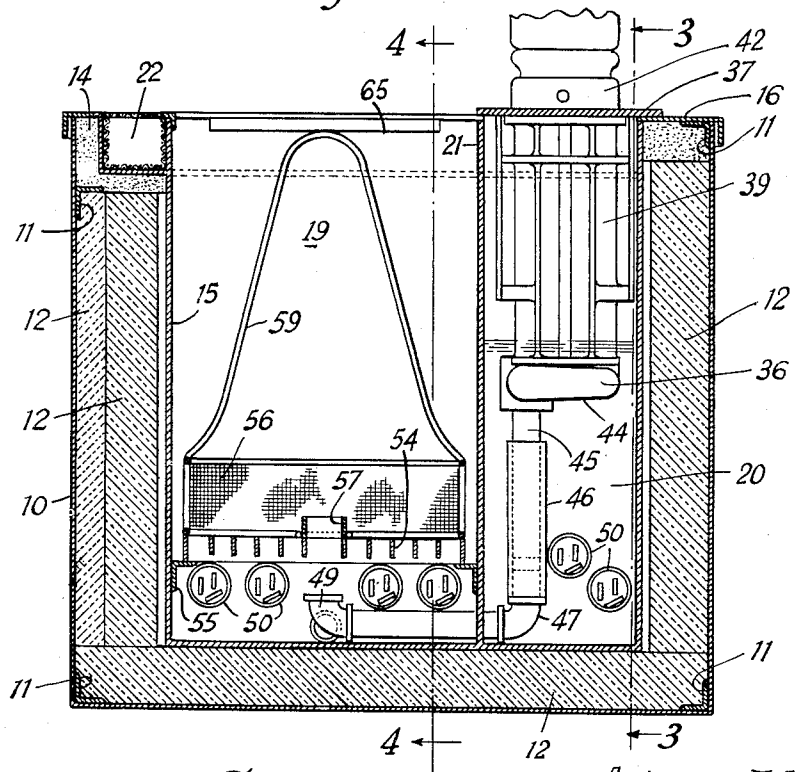


Fig. 2

Inventor

Artemas F. Holden

By

Ramsey, Kent & Chisholm

Attorneys

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SALT BATH QUENCHING FURNACE

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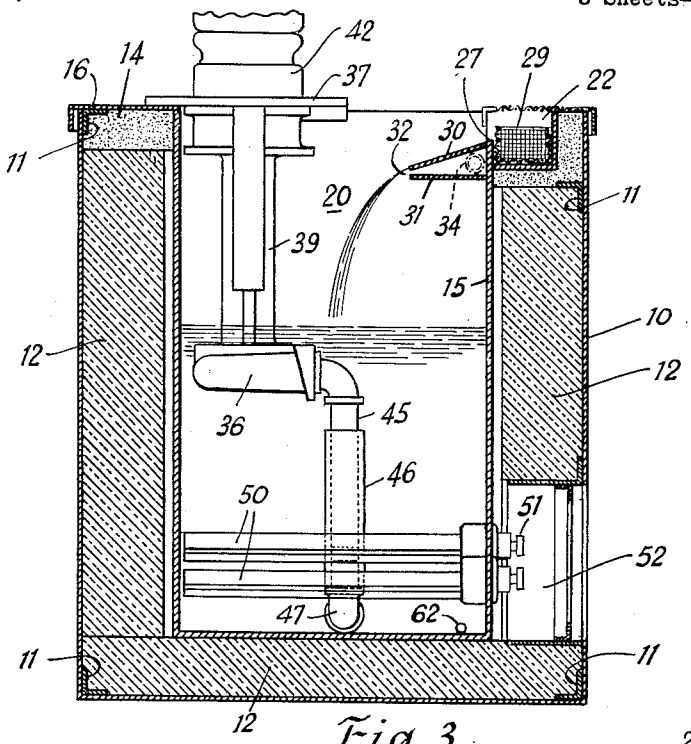


Fig. 3

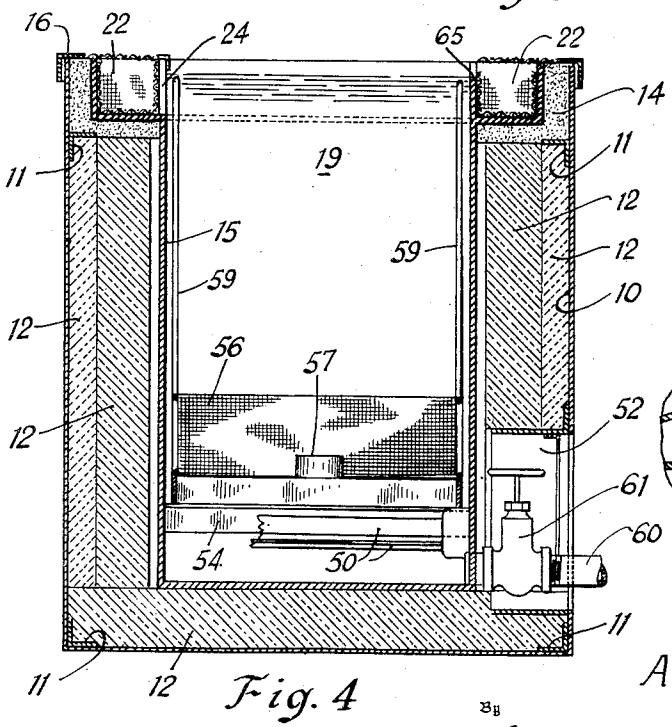


Fig. 4

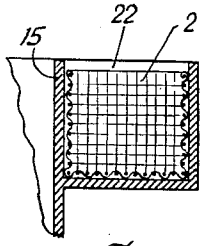


Fig. 7

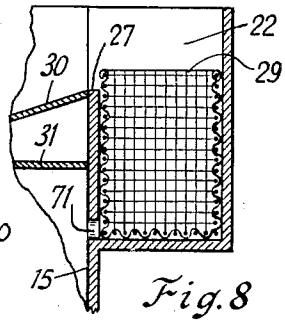


Fig. 8

Inventor

Artemas F. Holden

By

Ramsey, Kent & Chisholm

Attorneys

July 25, 1950 A. F. HOLDEN 2,516,516

SALT BATH QUENCHING FURNACE

Filed Dec. 10, 1946 3 Sheets-Sheet 3

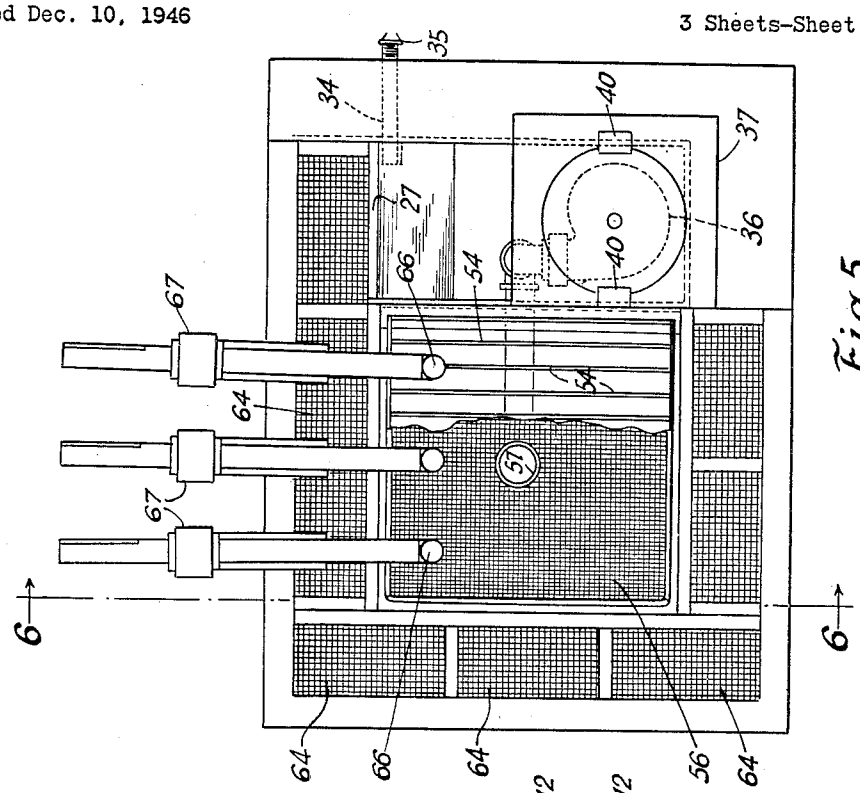


Fig. 5

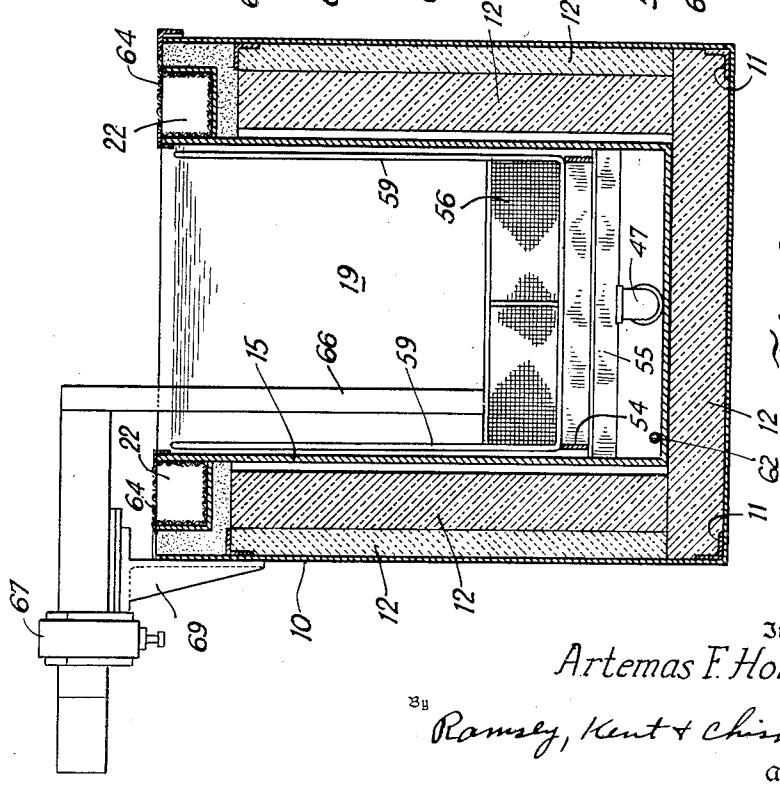


Fig. 6

Inventor
Artemas F. Holden
By
Ramsey, Kent & Chisholm
Attorneys

Patented July 25, 1950

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UNITED STATES PATENT OFFICE

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SALT BATH QUENCHING FURNACE

Artemas F. Holden, New Haven, Conn.

Application December 10, 1946, Serial No. 715,161

7 Claims. (Cl. 13—20)

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This invention relates to salt bath furnaces, and more particularly to quenching furnaces of the salt bath type.

In the form disclosed, the present invention is directed to the provision of a salt bath furnace which is particularly adapted for the quenching of steels to produce martensite or bainite or variations thereof, the purpose of this furnace being to obtain minimum distortion, and equal hardness over similar steel that is subjected to conventional quenching in oil, water or brine.

A salt bath quenching furnace must have provision for cooling the bath in order to dissipate the heat supplied thereto by the articles quenched therein, as well as provision for heating the furnace during its idle time to replace normal heat losses and to fuse the salt bath and bring the furnace to operating temperature when starting up. In addition, the furnace should be adapted for the maintenance of a relatively uniform temperature throughout the working area thereof in order to produce a uniform quenching action on the metals introduced therein and minimize distortion of the quenched metals. Further, the over-all temperature of the working area of the furnace, when in operation, should be held to within a range of about plus 5° F. or minus 5° F. in order to secure the desired quenching action.

In the form shown, this invention, which meets all of the above requirements, comprises a pot or container which is open at the top and is divided into two chambers by a partition, thus forming a working area and a sump area. A channel or trough which is disposed around the periphery of the working area communicates the top portion of the working area with the sump area. The pot is nearly filled with a salt bath which may be maintained during the idle periods in molten state at the desired operating temperature of the furnace by suitable heating means. The molten bath is circulated between the sump area, the working area and the connecting trough by a pump, this circulation tending to agitate the salt bath within the working area so as to produce a more uniform temperature therein and circulate the hot upper layers of the salt bath through the channel and into the sump area, the bath being cooled during its flow cycle.

An object of the present invention is to provide a salt bath quenching furnace in which the bath is positively circulated so as to maintain a nearly uniform temperature throughout the working area of the bath.

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Another object of the invention is to provide a salt bath quenching furnace having provision for either heating or cooling of the bath in order to attain and maintain a desired operating temperature.

Another object of the invention is to provide such a furnace in which impurities introduced into the bath with articles to be quenched are promptly removed from the circulating bath to prevent contamination of the bath.

Another object of the invention is to provide air cooling means for preventing overheating of the bath due to heat introduced therein by the quenched articles.

A further object of the invention is to generally improve a salt bath quenching furnace of the type disclosed.

Further objects and improvements relating to details of structure and economies of manufacture will more definitely appear from the following description.

My invention is clearly defined in the appended claims. In the claims, as well as in the description, parts are at times identified by specific names for clarity and convenience, but such nomenclature is to be understood as having the broadest meaning consistent with the context and with the concept of my invention as distinguished from the pertinent prior art. The best form in which I have contemplated applying my invention is illustrated in the accompanying drawings forming part of this specification, in which:

Fig. 1 is a top plan view of the salt bath quenching furnace, portions of the structure being broken away for clarity of illustration.

Fig. 2 is a vertical section of the furnace taken on the line 2—2 of Fig. 1.

Fig. 3 is another vertical section of the furnace, taken on the line 3—3 of Fig. 2.

Fig. 4 is another vertical section of the furnace, taken on the line 4—4 of Fig. 2.

Fig. 5 is a top plan view of a modified construction in which the heating of the bath is accomplished by electrodes.

Fig. 6 is a vertical cross sectional view of the modified furnace taken on the line 6—6 of Fig. 5.

Fig. 7 is a fragmentary vertical section showing the wire baskets in the channel of the furnace.

Fig. 8 is a fragmentary vertical section of a modification of the furnace shown in Figs. 1 to 4 inclusive.

Referring to Figs. 1, 2 and 3, the quench fur-

nace includes a shell 10 which is preferably rectangular in shape and formed of heavy gauge sheet steel. The shell 10 may be reinforced by angles 11 positioned at the edges of the shell. The shell 10 is lined with a layer of refractory heat insulating material 12. The upper margin of the heat insulating material 12 may be covered with a layer of heat resistant cement composition 14 in order to reinforce and protect the insulating material.

A container or pot 15 is placed within the insulating material 12 and is preferably rectangular in shape and formed of steel or alloy plate which may be welded or otherwise formed into the shape shown. A nickel steel alloy, stainless steel, or other corrosion resistant steel may be used. A sheet metal flange or cover 16, formed of material similar to that used for the shell 10, serves to cover the space between the shell and the pot 15 and also to support guard screens, to be described.

The pot 15 is divided into a working chamber or area 19 and a sump chamber or area 20 by a vertically positioned plate 21 which is preferably formed of metal of the same composition as the pot. The plate 21 may be secured within the pot 15 by welding or otherwise and forms a substantially imperforate partition within the pot between the two areas.

A relatively shallow channel or trough 22, which is open to the atmosphere, serves to communicate the upper portion of the working area 19 with the sump area 20. This channel runs along the periphery of the working area 19 as shown in Fig. 1, about the external walls of the pot 15 and along one side of the sump area 20. A portion of the wall of the pot 15 is cut away to form an inlet opening 24 extending down to the level of the bottom of the channel 22 along the end portion of the channel in order to permit passage of liquid from the upper portion of the working area into the channel, as shown in Figs. 1 and 4.

The bottom surface of the channel is level throughout its length and at intervals has a rectangular wire mesh basket 25 extending across the channel and upward from the bottom wall thereof to trap scale and other solid and semisolid matter contained in the circulating liquid. This basket may have an additional intermediate vertical wire screen 26 to facilitate trapping and removal of solid and semisolid matter, the baskets 25 fitting snugly within the channel 22 and being of rectangular form open at the top and towards the inlet opening end of the channel.

A weir 27 is formed by cutting away a portion of the top wall of the pot 15 along the side of the sump area 20 as shown in Fig. 3. This weir serves as the outlet for liquid flowing through the channel.

A basket 29, generally similar in shape to baskets 26 and extending for the full length of the weir 27, is positioned within the channel 22 adjacent the weir to serve as a further trap for solid and semisolid matter. Each of the baskets or screens previously described may readily be removed from the channel 22 for removing the trapped matter, after which it may be replaced.

An inclined plate 30 extending for the full width of the sump area and immediately beneath the weir 27, as shown in Fig. 3 serves as a spillway to direct the liquid flowing through the weir into a thin sheet form falling through the midportion of the sump area 20. A horizontal plate 31 is located a short distance below the plate 30 and together therewith forms the upper and lower walls of a chamber terminating in a narrow slot 32 extending for the full width of the sump area and immediately below the lower edge of the plate 30. An air inlet pipe 34 serves to supply air under pressure to this chamber, the air issuing in a sheet through the slot 32. A control valve 35 serves to regulate this supply of air.

A centrifugal pump 36 is supported within the sump area 20 by a mounting plate 37 supported upon the flange 16 and the top edge of the partition plate 21. The mounting plate 37 engages an elongated shaft housing 39 of the pump, suitable clamps 40 serving to retain the housing in position on the mounting plate. An electric motor 41 is mounted on top of the housing 39 and serves to drive the pump 36. A water cooled lower bearing 42 for the motor 41 may be used in which cool water is circulated through a chamber about the bearing in order to minimize transfer of heat to the motor.

The pump 36, which is located about midway of the height of the sump area 20, has a central inlet 44 and a peripherally located discharge line 45 projecting vertically downward from the pump. The line 45 is adapted to telescope within a sleeve 46 of slightly greater diameter, this sleeve being in turn telescoped over a vertically upwardly projecting line 47 which leads through the plate 21 and terminates in a vertically upwardly projecting leg 49 centered within the working area 19. The sleeve 46, which is not threaded, serves to facilitate withdrawal of the pump 44 from the pot 15 for maintenance or other reasons. It is unnecessary to provide a completely fluid tight seal at this joint inasmuch as any slight leakage from the discharge line merely returns the liquid to the sump area 20.

Heating elements 50 of the electrical resistance type are positioned in the lower portion of the pot 15 within both the working area 19 and the sump area 20, these elements being suitably sealed in the side wall of the pot 15 and having terminals 51 located in a recess 52 formed in the insulating material 12, for connection with a suitable source of electric power. The heating elements 50 are of the ordinary immersion type the resistance element being encased in a sheath and electrically insulated from the contents of the pot 15. The heating capacity of the elements 50 is sufficient to heat a salt bath contained within the pot 15 to the operating temperature of the furnace which, for the furnace herein described, is between 350° F. and 900° F. A metal grill or guard 54 is supported immediately above the heating elements 50 within the working area 19 in order to protect the elements from impact of parts being quenched, this grill being supported by angles 55 secured to the inner faces of opposite walls of the pot 15.

A large wire basket, best shown in Fig. 2, rests upon the grill 54 and serves to trap solid and semisolid material settling out from the salt bath within the working area 19, such materials comprising principally oxide scale and high temperature salts introduced into the furnace with the parts to be quenched. The basket 56 is rectangular in shape and has a central flanged opening 57 positioned directly above the upwardly projecting leg 49 of the line 47. Upwardly projecting bails 59, 59 are provided to facilitate removal of the basket 56 from time to time for re-

moval of the deposited matter therefrom, after which the basket may readily be repositioned.

A drain line 60 communicates with the bottom of the working area 19, this line projecting through the recess 52 and having a manually operated valve 61 for closing the line. The sump area 20 may be drained by the provision of a small hole 62 at the bottom of the plate or partition 21, this hole being of small area compared with the volume of flow through the discharge line of the pump 36 so as to permit the return of fluid therethrough to the sump at a negligible rate compared with the flow rate through the pump discharge line 45. This arrangement permits any liquid trapped within the sump area 20 and below the pump 44 to flow into the working area 19 for drainage through the drain line 60.

The channel 22 is covered by coarse wire mesh guard screens 64 which are supported upon the flange 16, these screens preferably being formed in sections, as indicated in Fig. 1, for easy removal. The screens 64 serve to protect the furnace operator from coming in contact with molten salt bath flowing through the channel 22, and at the same time permit atmospheric circulation across the top surface of the molten salt bath within the channel and permit radiation of heat from the salt bath, thus effecting a considerable cooling of the bath in its course through the channel.

A portion of the upper edge of the pot 15 between the working area 19 and the channel 22 is cut away near the weir 27 to form an overflow opening 65 for the working area. This overflow opening will function during operation of the furnace to prevent overflow of molten salt bath from the furnace in the event that the channel 22 should become partially or completely blocked between the inlet opening 24 and the overflow opening 65. If the liquid level of molten salt within the working area reaches the level of the overflow opening 65, the liquid will flow directly into the channel 22 near its outlet end and then across the weir 27 into the sump area 20. This action of the overflow opening will become more completely apparent in connection with the description of the operation of the furnace.

In the operation of the above-described furnace, the pot 15 is filled with material such as a salt bath or other composition which will be completely liquid at the operating temperature of the furnace. Such a bath may be formed of sodium and potassium hydroxide, preferred percentages being 50% sodium hydroxide and 50% potassium hydroxide for the ordinary range of quenching temperatures, as disclosed in my copending application Serial No. 541,281, now Patent No. 2,477,561, issued August 2, 1949, or nitrate-nitrite compositions.

Sufficient bath is added to the pot 15 so that, when in its liquid state, it will completely fill the working area 19, partially fill the channel 22 and fill the sump area 20 to a level well above the central inlet 44 of the pump 36, as indicated in the drawings. The furnace is initially charged with salt bath or other composition in the liquid or solid state, it being understood that the levels indicated in Figs. 1 to 4, inclusive, obtain only when the pump 36 is in operation. During idle standby periods of the furnace, it is preferable not to operate the pump 36 in order to conserve heat within the bath, at which time the channel 22 will almost completely drain and the level will become equalized between the working area 19 and the sump area 20.

After placing the bath within the pot 15, it is brought to proper operating temperature for quenching the metal to be treated therein by means of the heating elements 50. This temperature varies with the particular chemical composition of the metal, as well as the type of heat treatment desired. The furnace herein described is particularly designed for the quenching of steels to form martensite, bainite or mixtures of the two structures which have been heated to a temperature in excess of 1350° F. to obtain the austenitic crystal state of the steel. Such a quenching bath may be operated at a temperature between 350° F. and 900° F. depending on the particular composition of the steel treated. The heating elements 50, acting alone, will serve to uniformly heat the salt bath within the pot 15.

Upon obtaining the desired working temperature of the bath within the working area 19, which may be determined and controlled by a pyrometer such as a thermocouple, not shown, the bath is ready for the quenching of the metal parts therein. During this quenching, the pump 36 is maintained in operation in order to aid in maintaining the temperature of the bath within the working area 19 uniform, as well as to circulate the bath in order to cool it, and uniformly and rapidly cool the parts being quenched.

During operating periods, the bath within the working area 19 is heated by contact with the steel parts being quenched, which will result in an elevation of temperature of the bath adjacent the parts. Heated portions of the bath, being somewhat less dense than the cooler portions thereof, will tend to collect at the top of the bath as they are displaced by the cooler and more dense portions of the bath. This thermal circulation is further aided by the discharge from the upwardly-projecting leg 49 of the line 47, the discharge of which raises the level of the liquid materials within the working area 19 so as to cause the hot upper layer of the liquid to flow through the inlet opening 24 into the channel 22, the liquid level in the sump area 20 dropping accordingly. The hot liquid flows through the channel 22 where it is cooled, as above mentioned, and across the weir 27 into the sump area 20. By projecting the stream of liquid into the sump area in a thin, flat stream flowing through the atmosphere, increased transfer of heat from the bath is effected. This transfer may be selectively increased by passing air through the slot 32 by means of the air inlet pipe 34 so as to increase the cooling rate of the flowing liquid. It has been found that to maintain a relatively even temperature of the bath within the working area 19 and effect sufficient cooling of the bath during its circulation, it is desirable to circulate the bath at a flow rate equal to the volume of the working area every two to four minutes. To obtain this rate of flow, two or more circulating pumps 36 may be used operating in parallel. In addition, it has been found desirable to supply air to the air inlet pipe 34 at about 16 ounce pressure, the air supply being automatically regulated in connection with the cooling requirement by the control valve 35.

In order to maintain a more constant temperature within the working area 19, it may be necessary to add heat to the bath even during quenching operations if the heat introduced into the bath does not exceed the heat transferred from the bath. Accordingly the pyrometer, not shown,

already mentioned may control in a conventional manner the electric energy supplied to the heating elements 50 to maintain the bath at the proper temperature. In addition, it has been found that better operation is obtained if the bath within the sump area is maintained at a temperature about 10° F. cooler than the bath temperature within the working area. Accordingly, a temperature sensitive element 70 within the sump area 20 controls the operation of the automatic air control valve 35 to control the supply of cooling air in accordance with cooling requirements.

It will be found that oxide scale and solidified and partly solidified salts from previously used high temperature salt baths will be carried into the liquid within the furnace by the parts being quenched, as well as the fixtures supporting such parts. Such matter that settles out will be caught within the large wire basket located near the bottom of the working area 19, when the pumps are not operating. Other such matter, as well as high temperature salts which start to solidify during the cooling of the liquid within the channel 22, will be retained by the baskets 26. In addition, the weir 27 and basket 29 will serve as a final trap for such matter before the flowing bath enters the sump area 20. All these baskets are readily removable for cleaning, thus aiding in preventing undue contamination of the bath.

A modified form of furnace is shown in Figs. 5 and 6. This furnace is in general similar to that already described, and is similar in its operation, the only difference being that molten salt bath contained within this furnace is heated by electrodes positioned within the working area 19 of the furnace. A plurality of electrodes 66 may be positioned along the rear wall of the pot 15, projecting downwardly into the salt bath contained within the working area. These electrodes are supported in the usual manner by electrode clamps 67 and electrode supports 69, the electrode supports being mounted on the shell 10 of the furnace. These electrodes may be connected to a supply source of power in any well-known manner, or, in larger furnace units, four to six electrodes may be used. The electrodes heat the salt bath contained within the pot 15 by the heating effect of electric current passing through the bath between the electrodes. In the furnace shown, it has been found unnecessary to position the electrodes within the sump area 20, but additional electrodes could be positioned in such area if required. In addition, the furnace could be heated by other known means such as external heating by gas.

Although a cover has not been shown or described in connection with this furnace, a conventional cover could be used and would be of some advantage during idle periods while the furnace is being maintained at quenching temperature in order to minimize the heat losses therefrom. During operation, such a cover would be detrimental in that it would decrease the desirable heat loss from the furnace.

Fig. 8 discloses a modification of the furnace shown in Figs. 1 to 4, inclusive, in which the channel 22 is made considerably deeper and somewhat wider, the level of the inlet opening 24 and weir 27 not being substantially changed. The particular advantage of such a modification is that when starting up the furnace, a better transfer of heat from the working area 19 to the solidified salt bath contained within the channel 22, is obtained due to the fact that this solidified salt is below the level of the bath within the working area 19 so as to obtain heat directly therefrom through the wall of the pot 15. In this modification it is desirable to provide a relatively small hole 71 in the wall of the pot 15 at the bottom of the channel 22 under the weir 27 in order to equalize the level of the bath in the channel 22 with the level in the remainder of the furnace during idle periods when the pump 36 is not in operation.

I claim:

1. A salt bath quench furnace comprising, an open-topped container for holding a molten salt bath, a partition extending completely across the container and dividing it into a working area and a sump area, an open, substantially level, shallow, elongated passage in contact with the container and leading from the top portion of the working area to the sump area, and a pump communicating with the sump area and having a discharge line leading to the working area, for circulating the salt bath from the sump area to the working area and through the passage back to the sump area.

2. A salt bath quench furnace comprising, a container adapted to hold a molten salt bath, a partition within the container dividing it into a working area and a sump area, a shallow, substantially level channel open to the atmosphere, extending around a portion of the periphery of the working area in contact with the container and providing communication between the top portion of the working area and the sump area, and a pump having an intake from the sump area and a discharge to the working area for circulating molten salt from the top of the working area through the channel into the sump and returning it to the working area.

3. A salt bath quench furnace comprising, a container adapted to hold a molten salt bath, a partition within the container dividing it into a working area and a sump area, a shallow, substantially level channel open to the atmosphere, extending around a portion of the periphery of the working area and communicating the top portion of the working area with the sump area, an overflow weir and spillway for aerating the salt bath in its passage into the sump area, and a pump for circulating the salt bath from the top of the working area through the channel into the sump area and back to the working area.

4. A salt bath quench furnace comprising, a container adapted to hold a molten salt bath, a partition within the container dividing it into a working area and a sump area, a shallow, substantially level channel open to the atmosphere, extending around a portion of the periphery of the working area and communicating the top portion of the working area with the sump area, an overflow weir and spillway for aerating the salt bath in its passage into the sump area, a pump for circulating the salt bath from the top of the working area through the channel into the sump area and back to the working area, and electric heaters within the working area for heating the salt bath.

5. A salt bath quench furnace comprising, a container adapted to hold a molten salt bath, a partition within the container dividing it into a working area and a sump area, a shallow, substantially level channel open to the atmosphere, extending around a portion of the periphery of the working area in contact with the container, and having one end communicating with the

sump area, and a pump having an intake from the sump area and a discharge leading to the bottom of the working area for circulating molten salt bath from the top of the working area through the channel into the sump area and upwardly through the working area.

6. A salt bath quench furnace comprising, a rectangular container adapted to hold a molten salt bath, a partition extending across the container generally parallel to one side and dividing it into a working area and a sump area, a shallow substantially level channel open to the atmosphere, extending around the three walls of the container adjacent the working area and in contact with the container, and having one end communicating with the working area and the other end communicating with the sump area, and a pump having an intake from the sump area and a discharge leading to the bottom of the working area for circulating molten salt bath from the top of a working area through the channel into the sump and upwardly through the working area.

7. A salt bath quench furnace having a working zone and a separate sump zone for containing salt bath, a pump for circulating the salt bath between the working zone and the sump zone, a passage leading from the working zone to the

sump zone and terminating in a weir for discharging a stream of molten salt through the atmosphere into the sump zone, and means for directing a current of air against the molten salt stream to effect cooling of the bath.

ARTEMAS F. HOLDEN.

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