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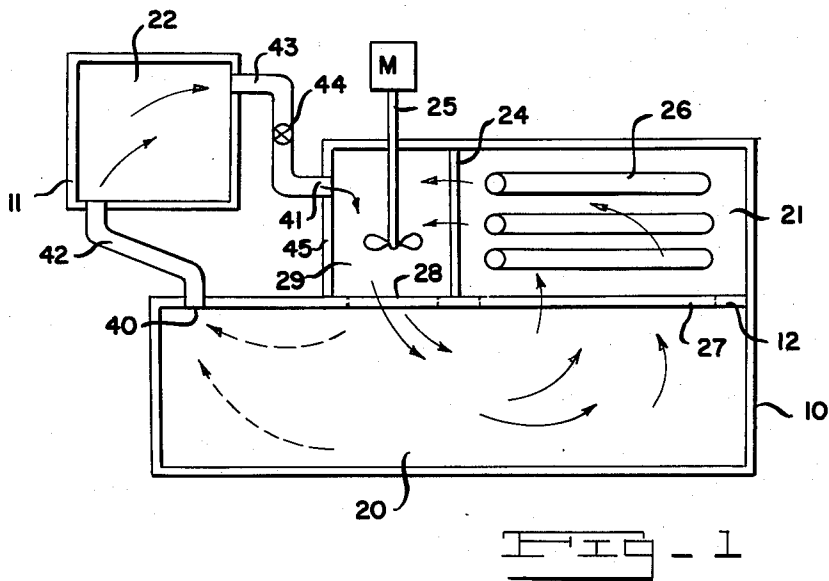
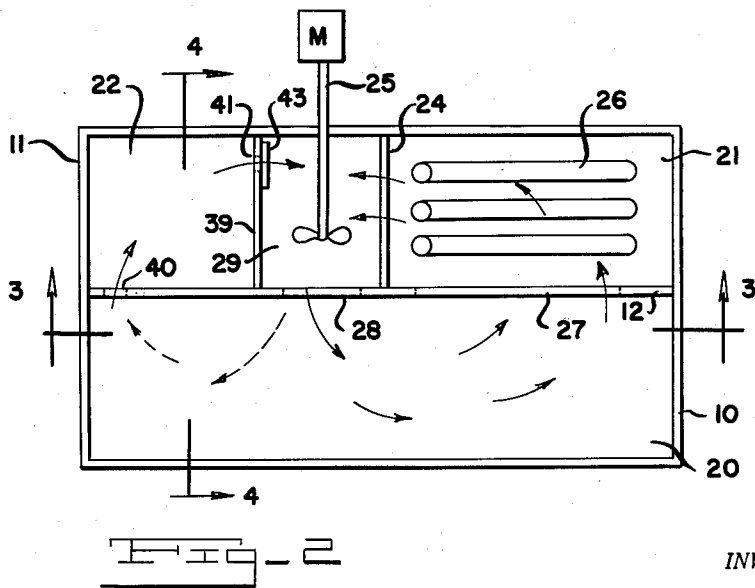
R. H. SHOEMAKER ET AL

2,967,530

APPARATUS AND METHOD FOR CLEANING METAL WORK PIECES

Filed July 5, 1957

2 Sheets-Sheet 1



INVENTORS

BY JOHN A. FALER
ROBERT H. SHOEMAKER
Cullen & Cantow
ATTORNEYS

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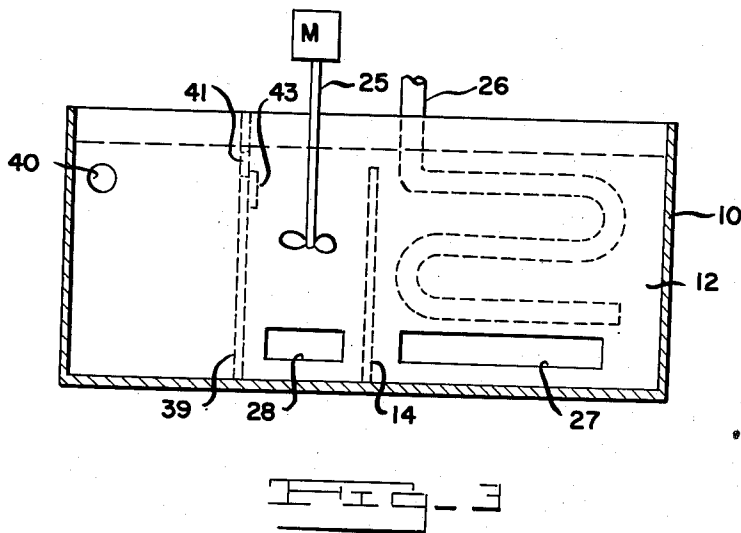
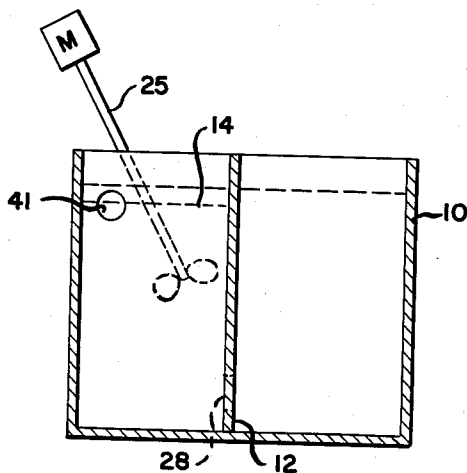
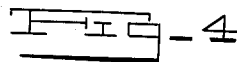
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INVENTORS

JOHN A. FALER
BY ROBERT H. SHOEMAKER

Cullen & Cantor

ATTORNEYS

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APPARATUS AND METHOD FOR CLEANING METAL WORK PIECES

Robert H. Shoemaker and John A. Faler, Detroit, Mich.,
assignors to Kolene Corporation, Detroit, Mich.

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7 Claims. (Cl. 134—13)

This application relates to molten salt bath apparatus used for cleaning metals, and is a continuation-in-part of our prior application of January 10, 1955, Ser. No. 48,862, now Patent No. 2,863,465. Like that prior application, this application specifically relates to the problem of removing contaminants, sometimes known as "waste" or "sludge" from the bath.

A molten salt bath, as the term is here used, is a chemical reaction bath. It is exemplified by the bath shown in Webster Patent No. 2,458,661 of January 11, 1949, or Webster Patent No. 2,468,006 of April 19, 1949. These patents show baths containing molten sodium hydroxide, sodium nitrate, sodium chloride, and possibly other alkali metal compounds as desired, such as aluminate, fluoride, etc. Workpieces to be cleaned are immersed in such baths and cleaned by the chemical reactions of the baths on such workpieces.

Such bath chemically reacts with the surfaces of the workpieces to transform ingredients of such surfaces into members soluble in the bath. An example would be the transforming of sand into sodium silicate. This silicate enters the bath and becomes a contaminant. It thickens the bath, forms an objectionable sludge in the work area, and so saturates the bath as to change the bath formula appreciably and impair the effectiveness of the bath to react chemically with other workpieces later introduced in the bath. For example, a bath intended to contain no silicates (the nitrate-hydroxide-chloride bath of Patent No. 2,458,661; the hydroxide-chloride-aluminate-fluoride bath of Patent No. 2,468,006) becomes contaminated by the addition of silicates to it because of reaction of the bath with sand in the workpiece surface. When a large proportion of such silicate is added to the bath and the bath formula thus changed, the effectiveness of the bath to form silicates from newly added workpieces is reduced and the cleaning operation thus impaired. The silicates contaminant thus not only impairs the bath physically, as a sludge, but also changes its formula, impairing the bath chemically.

Now an elementary bath comprises nothing more than the bath itself, arranged to provide a work zone for the workpieces being cleaned.

However, as shown in our prior application, Ser. No. 480,862, now Patent No. 2,863,465, we include other zones, separate from the work zone, such as a heating zone and a settling zone. For example, we place to one side of the work zone a heater zone in which the molten salt is heated by heater tubes and the molten salt thus heated is freely and rapidly circulated into and out of the work zone and the heater zone and serves as a heat transfer medium to the workpieces as well as maintaining itself heated and molten. Likewise, we provide a settling zone where the contaminant or reaction product formed by removal of impurities from the workpieces is settled out of the molten salt and removed from the settling zone by any mechanical means.

In addition, we include in the bath an agitator means for agitating the molten salt and circulating it to whatever zones are provided.

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In this application, we disclose a bath comprising not only the aforesaid three separate zones, but in addition, an arrangement of controls for the paths communicating these various zones whereby superior functioning of the bath is assured.

One of the advantages is that the contaminant will not settle out of the molten salt in either the work zone or the heating zone, this being assured by the fact that these two zones communicate with each other through large area high and low level openings whereby there is free communication between these two zones and thus free flow of molten salt at high velocity and in large volume freely in and between these two zones in a rather well defined path and in which there is no settling out of contaminant. In this way, contaminant will not settle on any of the work in the work zone nor upon the heater tubes in the heater zone. We observe here that if contaminant were to settle on the heater tubes in the heater zone it would seriously impair the efficiency of these heater tubes and likewise set up corrosive conditions which would seriously shorten the life of these tubes.

Likewise, we have provided another path of circulation of molten salt, a path between the settling zone on the one hand and the other two zones on the other hand, and in such path we provide high level small area openings which provide controlled and restricted communication between the settling zone and the other two zones and permits only a low velocity small volume unagitated or quiet flow of molten salt, not freely but restricted, in and between the two zones and the settling zone. Thus, in the settling zone which is a very quiet zone in a second path completely separate from the first path, the small volume low velocity quiet flow of molten salt in the settling zone will cause a settling of the contaminant in such zone before the molten salt which has moved into such zone with contaminant, moves out of such settling zone back into the other two zones and into the first named path.

Hence, it is a primary object of the present invention to provide a multiple zone multiple path apparatus for cleaning metals comprising a molten salt bath arranged as described above to provide the functions that we have here set forth.

In one embodiment, the settling zone may be remote from the other two zones and connected by piping or the like to the other two zones. In the preferred embodiment, however, the settling zone is incorporated with the other two zones in one large tank, there being suitable partitions which separate the settling zone from the other two zones.

The two embodiments above described have been disclosed in the appended drawings:

In these drawings:

Fig. 1 is a plan view showing a bath divided into three zones with the settling zone quite remote from the other two zones;

Fig. 2 is a plan view of an apparatus showing the settling zone incorporated in one tank with the other two zones and shows the preferred embodiment;

Figs. 3 and 4 are section views as if on lines 3—3 and 4—4 of Fig. 2.

Fig. 1 shows a multiple zone multiple path apparatus for cleaning metals comprising a molten salt bath created by tanks 10 and 11. The bath is a chemical reaction bath exemplified by those previously mentioned.

Tank 10 is divided by a longitudinal partition or wall 12 into two zones namely, a work zone 20, and a heater zone 21. Tank 11 provides a third zone 22, the settling zone.

Heater zone 21 includes a baffle 24 which separates an agitator means 25 from the heater tubes 26. The agitator is a typical propeller type agitator driven by a motor M.

Heater tube 26 is of any conventional and well-known form.

Large area openings 27 and 28 in wall 12 and formed by large slots at the lower part of such wall freely communicate the work and heater zones 20—21 and enable a high velocity large volume agitated flow of molten salt freely in and between these two zones in one path shown by full line arrows. It will be observed that wall 24 has its upper edge below the upper edge of wall 12 and of the tank 10 so that molten salt flows freely through the heater zone 21 and the compartment 29 occupied by the agitator 25. Compartmentation of the agitator 25 by the provision of the wall 24 is desirable to improve the functioning of the agitator means and wall 24 does not in effect separate the heater zone 21 from the agitator compartment 29 particularly because of the free flow of molten salt from the heater zone 21 into the compartment 29 over the upper edge of the transverse wall 24.

The difference in level between openings 27—28 and the upper edge of wall 24 also improves the completeness of movement.

Small area openings 40 and 41 at the upper parts of the walls of tanks 10 and 11 together with pipes 42 and 43 provide controlled and restricted communication between the settling zone 22 on the one hand and the zones 20—21 on the other hand, and permit only a low velocity small volume unagitated or quiet flow of molten salt, not freely, in and between zones 20—21 and zone 22 in a second path indicated by the dotted line arrows. Control for such flow is established not only by the fact that openings 40 and 41 are small openings, both at the upper part of the tanks 10 and 11, but also by the provision of a valve means 44 which could be positioned anywhere in the second path but which is illustrated for convenience as being a valve in pipe 43.

The construction here shown functions in such a way that contaminant will be carried in suspension in the freely and fast moving large volume of molten salt in the full line arrow path shown in the two zones 20 and 21 and will not settle in such zones. Likewise, contaminant will be carried in suspension into the restricted slow moving small volume of molten salt in the settling zone through the opening 40 and pipe 42 and will settle in zone 22 before the molten salt moves out of such settling zone 22 through pipe 43 and opening 41 back into the other two zones 20—21.

The contaminant may be removed mechanically from the settling zone by any suitable means, such as the pans shown in the prior application, Ser. No. 480,862, now Patent No. 2,863,465.

As a matter of illustration, we here indicate that in one installation the construction and particularly the size of the openings are such that whereas 800 to 2000 gallons per minute of molten salt is circulated by the agitator 25 in the first path in zones 20—21, that only four to five gallons per minute are circulated in the settling zone 22, a ratio of one-half of one percent down to as low as one-sixth of one percent.

In the preferred embodiment shown in Figs. 2, 3 and 4 the parts are generally the same as shown in Fig. 1 except that the tank 11 has been integrated with tank 10 to form a unitary integral construction. Thus, Figs. 2 to 4 show tank 10 having a part 11, a longitudinal wall 12, a work zone 20, a heater zone 21, a settling zone 22, a transverse wall 24, a stirrer or agitator 25, heater tubes 26 in heater zone 21, large openings 27 and 28 at the lower part of transverse wall 12, an agitator compartment 29, small openings 40 and 41 connecting the zones 20—21 to the settling zone 22. There is also a transverse wall 39 separating zone 22 from compartment 29.

The valve 43 is here shown as nothing more than a sliding gate, slidably mounted on wall 39 controlling the size of opening 41 by being raised or lowered.

One very important function of this arrangement is the uniform heat obtained. Because the molten salt is con-

stantly flowing over the heated area of the burner tubes, and because the molten salt never is stationary around the burner tubes, there are no hot areas where super-heating might occur.

In previous salt bath heating pots, the conduction of heat away from the burner tubes was dependent upon thermal circulation and the heat conducting properties of the bath salt itself. In the present construction the mechanical movement and circulation of the salt over the burner tube areas constantly and at high speeds eliminates hot spots and maintains uniform heating throughout all areas through which the salt is circulated.

The openings 27—28 and over the upper edge of wall 24 may all be considered as one communication means having lower parts 27—28 and an upper part, over the upper edge of wall 24.

Likewise, openings 40—41 may be considered as one communication means having a part 40 between zones 20—22 and a part 41 between zones 21, 24 and 22.

Opening 41 establishes a flow in two parallel paths, one path including zones 24—22—20. Even with opening 40 omitted there would still be parallel paths. However, if opening 41 were omitted, the paths would be in series, a path through zones 24—21—20, and another path between zones 22—20. While a parallel path arrangement is preferred, the series path arrangement can prove satisfactory to a substantial extent.

Further we point out that while it is desirable that the settling zone communicate directly with the heater zone as well as with the work zone, this is not absolutely essential for it is possible to get substantial results with the heater zone being out of direct communication with the work zone or the settling zone. Thus, the heater may not even be within the bath but may be an outside heating means with suitable arrangements for transferring heat to the bath from the heater. The important thing here is that the work zone and the settling zone communicate with each other either directly or through a heater zone which is in communication with both of them.

Again we here stress that the bath with which we are working is one which involves chemical reactions between the bath and the surface impurities or ingredients of the workpieces. Because of these chemical reactions there are chemical changes in the impurities which produce reaction products and these reaction products contaminate the bath. The invention here is specifically a means for removing these contaminants and thus decontaminating the bath so that it will remain as nearly as possible in its original physical and chemical condition. We propose here to remove the contaminants quickly and continuously as they are formed.

The importance of removing the contaminants is further increased because the bath is used for transfer of heat to the workpieces as well as a means for moving the contaminants away from the workpieces to the settling zone. The loading of the bath with contaminants impairs the functioning of the bath not only for cleaning but also for heat transfer to the workpieces and for movement of reaction products away from the workpieces. If the contaminants are permitted to remain in the bath, they would soon so thicken the bath that it would no longer be effective for heat transfer to the workpieces and for moving the reaction products away from the workpieces.

The settling zone is physically separated from the work zone so that contaminants are effectively settled out of the bath in the settling zone rather than in the work zone.

The contamination effect of the reaction products on the bath is substantial and accumulative and hence it is important in a cleaning bath of the character described to remove the contaminants as quickly as formed and continuously. The contaminant includes the surface material of the workpieces removed by the cleaning action and is a chemical reaction product. In commercial operation the contaminant can amount to as much

as several hundred pounds of contaminant per day where many hundreds of workpieces are cleaned per day. Even in a large bath the addition of several hundred pounds of contaminants per day would soon so change the physical and chemical structure of the bath that it would no longer be considered to be the same bath that was originally specified and would no longer be effective for cleaning, for heat transfer to the work and for moving reaction products from the work.

Considering that several hundred pounds of contaminant per day may be introduced into a typical bath, we can quickly see the importance of quickly and continuously removing the contaminants from the bath by means of the settling action in the settling zone and likewise, the importance of mechanically removing the settled out contaminants from the settling zone by suitable mechanical means. In the specific illustration given here the settling zone is to one side of and physically separated from the work zone and hence the removal of settled out contaminants from the settling zone may be effected without any interruption of work in the work zone.

Again it is important to observe that the contaminant is not merely a surface coating that is removed physically from the work but rather is a chemical reaction product created by the chemical reaction between the workpiece surfaces and the bath. Such contaminant suspends in the bath and will eventually settle out in the bath. By removing the contaminants from the bath in a side zone the effectiveness of the bath is maintained as nearly as possible in its original condition and formula and all this may be done without interrupting the working of the bath for cleaning workpieces.

It may be considered that the invention here is not merely an apparatus such as is here disclosed but in addition embraces a process for cleaning workpieces by a chemical reaction molten salt bath where the process includes the use of the bath to transfer heat from the heating means to the workpieces, the formation of contaminants in the work zone, the use of the bath to transfer such contaminants from the workpieces to a side settling zone, and controlling the flow into and out of the side settling zone so that the contaminant is settled out of the bath in such settling zone as a sludge which can then be removed mechanically from the side zone without interrupting the work being done in the work zone.

Now having described the apparatus and process herein disclosed, reference should be had to the claims which follow.

We claim:

1. The method of cleaning metal from surface contamination, such as oxide and scale thereon, comprising providing a molten salt bath containing a substantial quantity of caustic alkali and salts of alkali metals, said bath being divided into a heating and agitation zone, a metal cleaning zone, and a settling zone, said zones being interconnected to provide molten salt circulation therebetween, heating said molten salt in said heating zone sufficient to maintain the salt continuously fluid in each of said zones, immersing the metal to be cleaned in the cleaning zone of said bath, agitating and circulating said molten salt between the heating and cleaning zones to provide sufficiently large turbulent circulation therebetween to prevent settling of suspended insoluble impurities from said molten salt in either of said zones, said settling zone being interconnected at least with the cleaning zone only near the top of the fluid therein to provide restricted circulation therebetween, thus maintaining the molten salt in the settling zone relatively quiescent, and allowing suspended insoluble impurities to settle therein, and removing settled impurities from said settling zone.

2. The method of cleaning metal from surface contamination, such as oxide and scale thereon, comprising providing a molten salt bath containing a substantial quantity of caustic alkali and salts of alkali metals, said bath being divided into a heating and agitation zone, a

metal cleaning zone, and a settling zone, said zones being interconnected to provide molten salt circulation therebetween, heating said molten salt in said heating zone, immersing the metal to be cleaned in the cleaning zone of said bath, agitating and circulating said molten salt between the heating and cleaning zones to provide sufficiently large turbulent circulation therebetween to prevent settling of suspended insoluble impurities from said molten salt in either of said zones, said settling zone being interconnected with both the cleaning and heating zone near the top of the fluid therein to provide restricted circulation therebetween, thus maintaining the molten salt in the settling zone relatively quiescent, and allowing suspended insoluble impurities to settle therein, and removing settled impurities from said settling zone.

3. Molten salt bath metal workpiece cleaning apparatus comprising a cleaning tank adapted to contain molten salt to substantial depth and receive metal workpieces for cleaning by dipping in the molten salt therein, a second tank comprising a molten salt heating tank adapted to contain molten salt at the same level as the said cleaning tank, said heating tank having heating coils therein adapted to transfer heat to the molten salt by heat supplied to said heating coils, communication means for withdrawing molten salt from said metal cleaning tank and passing the same to said heating tank and communication means for returning heated molten salt from said heating tank to said cleaning bath at a high fluid flow rate, means for turbulently agitating and impelling the said fluid flow between said cleaning tank and heating tank at such flow rate as to prevent precipitation of insoluble contaminants suspended in the molten salt in either tank, and a third tank comprising a molten salt settling tank adapted to contain molten salt at the same level as both of the cleaning and heating tanks, communication means interconnecting said settling tank with said heating and cleaning tanks at a point near the upper level of the molten salt, the latter said communication means having such restricted fluid flow capacity as to prevent transfer of turbulent agitation from either of said cleaning or heating tanks to said settling tank whereby suspended insoluble impurities in the quiescent body of molten salt in said settling tank may settle to the bottom thereof and be withdrawn from the system.

4. Apparatus as defined in claim 3 wherein both the heating and workpiece cleaning tanks are interconnected to said settling tank by said communication means, said communication means having restricted flow capacity and whereby the fluid flow impelling means induces flow from the workpiece cleaning tank to said settling tank, returning therefrom to said heating tank, at such restricted non-turbulent flow as to allow settling of suspended contaminants in the substantially quiescent body of molten salt in said settling tank.

5. Apparatus as defined in claim 4 wherein the communication means has at least one valve, and the restricted flow rate in said communication means is obtained by restriction of the flow rate through said valve.

6. Apparatus as defined in claim 3 wherein each of the said several tanks are subdivisions of a single tank separated into said several tanks by vertical partitioning elements and said communication means comprise large openings in said partitioning elements allowing large flow communication for large fluid circulation between the heating and workpiece cleaning tanks, a relatively small opening in the partitioning element between the workpiece cleaning tank and settling tank, and a relatively small opening in the partitioning element between the settling tank and the heating tank, the latter two openings being of such restricted size as to restrict the fluid flow from the workpiece cleaning tank to said settling tank and then to said heating tank to non-turbulent flow, said smaller openings being located near the upper liquid level of molten salt therein, whereby the liquid only near

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the top of said several baths is circulated through said settling tank.

7. Molten salt metal workpiece cleaning apparatus comprising a rectangular tank adapted to contain molten salt to substantial depth therein, a first vertical partitioning element subdividing said tank longitudinally to form a separate metal workpiece cleaning tank on one side of said partitioning element, the opposite side of said partitioning element being further subdivided by two cross partitioning elements both spaced from each other and placed at right angles to said first longitudinal partitioning element, and forming by the first cross partitioning element and the interrupted portion of the longitudinal partitioning element a rectangular settling tank, the remaining area on the said opposite side of said longitudinal partitioning element being subdivided by the second cross partitioning element into an agitation tank and a heating tank, said second cross partitioning element extending vertically to a height below the normal depth of molten salt in said apparatus, two large openings each cut in the longitudinal partitioning element between the workpiece cleaning tank and the heating and agitating tanks permitting large volume fluid flow therebetween, one relatively small opening in the longitudinal partitioning element positioned to provide small fluid flow communication between the workpiece cleaning tank

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and said settling tank and a second small opening in the first cross partitioning element position to provide small fluid flow between the settling tank and said agitation tank, said small openings being positioned in an upper portion of the said partitions near to but below the normal surface level of the deep molten salt content of said tanks whereby molten salt enters and leaves said settling tank near the top of the molten salt content thereof, heating coils mounted in said heating tank, agitator means mounted in said agitation tank whereby to impart turbulent agitation and induce fluid flow to the salt content, circulating large fluid flow and maintaining turbulent agitation of the molten salt passing from said workpiece cleaning tank through said heating tank, passing over said second cross partition, and returning to said cleaning tank, and low fluid flow from said workpiece cleaning tank through said settling tank and return.

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