

Dec. 7, 1943.

W. MESSINGER

2,336,412

ELECTRIC SALT BATH FURNACE

Filed June 25, 1942

3 Sheets-Sheet 1

FIG.1.

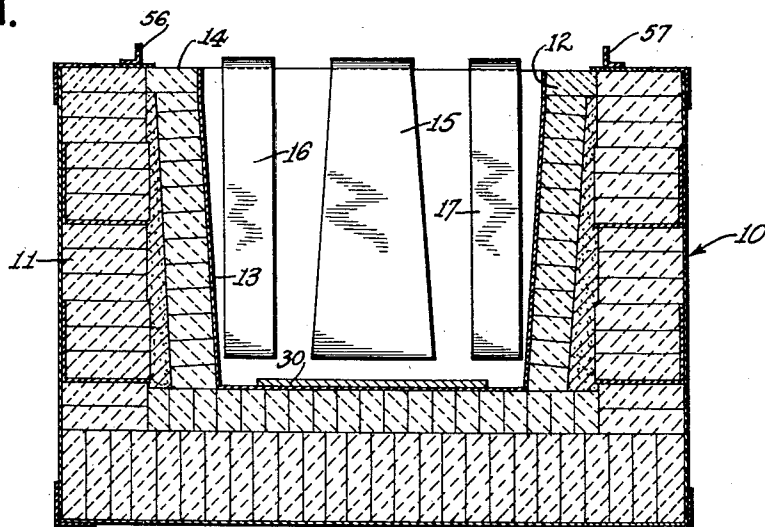
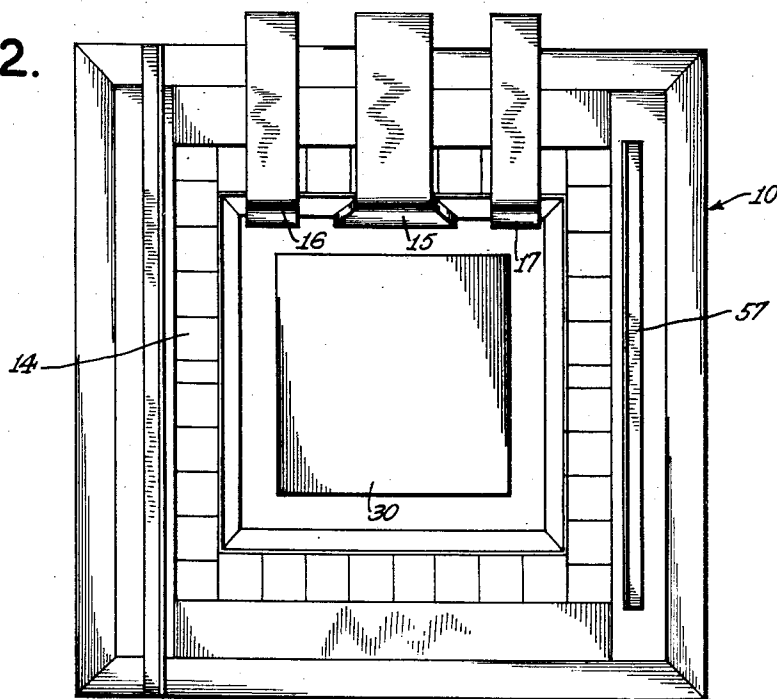


FIG.2.



INVENTOR.

WILLIAM MESSINGER

BY

Joseph H. Lipschitz

ATTORNEY.

Dec. 7, 1943.

W. MESSINGER

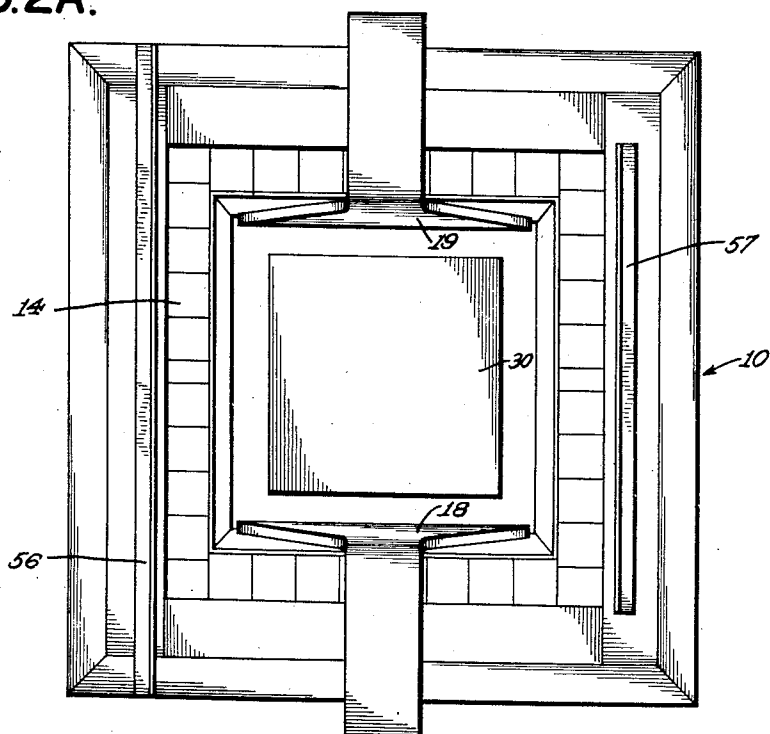
2,336,412

ELECTRIC SALT BATH FURNACE

Filed June 25, 1942

3 Sheets-Sheet 2

FIG. 2A.



INVENTOR.
WILLIAM MESSINGER
BY *Joseph H. Lipschutz*
ATTORNEY.

Dec. 7, 1943.

W. MESSINGER

2,336,412

ELECTRIC SALT BATH FURNACE

Filed June 25, 1942

3 Sheets-Sheet 3

FIG. 3.

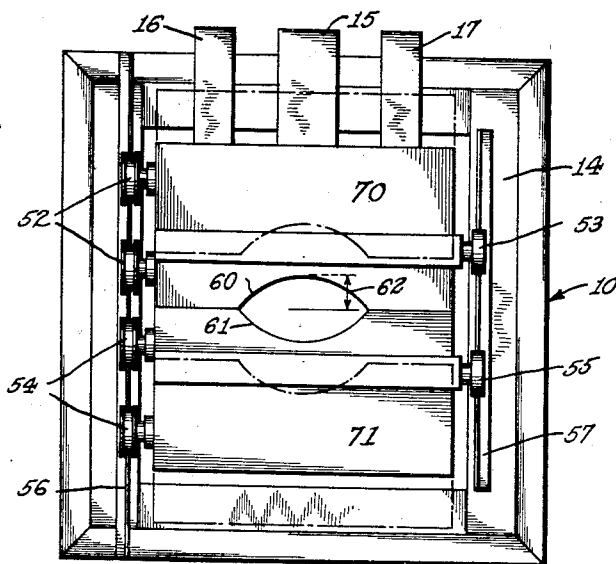


FIG. 4.

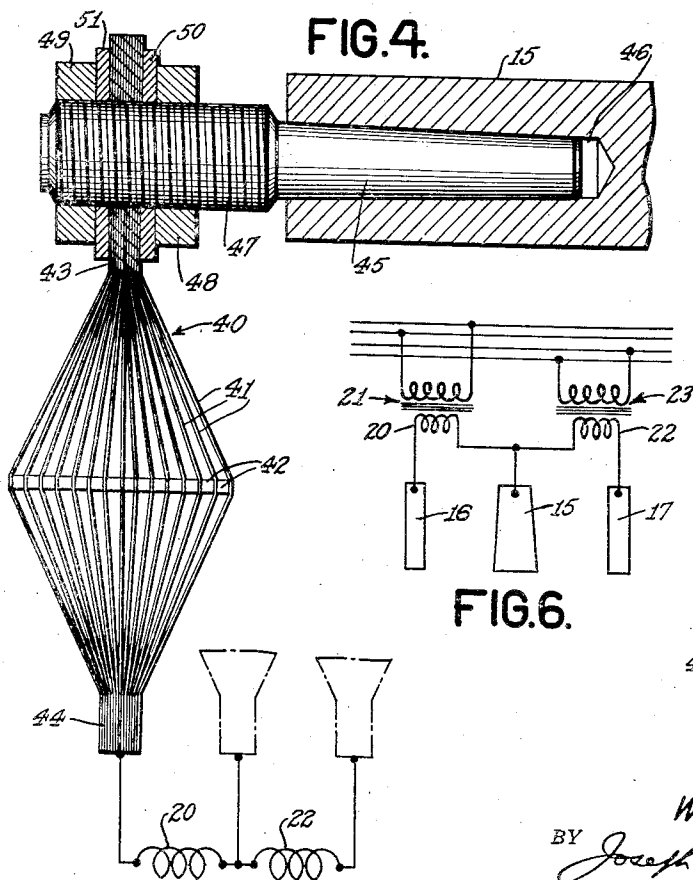
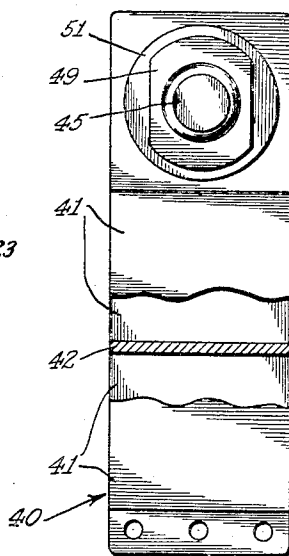


FIG. 6.

FIG. 5.



INVENTOR.
WILLIAM MESSINGER
BY *Joseph H. Lipschutz*
ATTORNEY.

UNITED STATES PATENT OFFICE

2,336,412

ELECTRIC SALT BATH FURNACE

William Messinger, Philadelphia, Pa.

Application June 25, 1942, Serial No. 448,397

3 Claims. (Cl. 13—23)

This invention relates to electrically heated salt bath furnaces which are being increasingly used, particularly for the hardening of high speed tool steel. The reason for the increasing use of these furnaces for this purpose is found in the fact that the salt solution when heated by electric current is found to form a very desirable heat retaining medium. A major problem has arisen, however, in the practical employment of such furnaces, which is the maintenance of uniform temperature throughout the bath. This is a fundamental requisite of a heating furnace which is to be practical and successful, as will be understood when it is stated that an error of less than 5° in a temperature of 1300° to 1400° may make a difference between success and failure in the heating of special steel parts. Heretofore it has been proposed to avoid excessive heating of the object in the furnace by positioning a pair of electrodes close together so that the distance between them is less than the distance between the electrodes and the object. The theory underlying this proposed solution was that the current thus would not be deflected by the higher conductivity of the steel as compared with that of the salt, and that it was this deflection of the current by the steel under treatment which caused the steel to be overheated. Practice, however, has shown that this solution failed and that non-uniformity of heating of the salt bath takes place regardless of how much closer the electrodes are to each other than to the steel tool which is being heated. The reason for this is to be found in the fact that not only in the case just described above, but in all known forms of salt bath furnaces, the large current supply is led into the bath by means of electrodes of small cross-sectional area, with correspondingly small perimeter and small contact surface, resulting in a very high current density. The following results attended this prior construction:

1. Excessive heating took place in the electrodes, amounting to several hundred degrees above the rest of the bath. This concentration of heat at very small areas resulted in a continuous temperature difference between the part of the bath adjacent the electrodes and the remaining part. The heat generated in and at the surface of the electrodes was so great that the salt mixture actually became volatilized at the surface of the electrodes which presented the appearance of arcing. The boiling action of the salt in the space between the electrodes created a violent agitation and convection of the salt. This phenomenon was heretofore wrongly attrib-

uted to the existence of a strong magnetic field between the electrodes which impelled circulation of the molten salt, whereas it was simply motion due to the boiling off of vapors and resulted from the thermal expansion of the salt induced by the high temperature of the electrodes. With this agitation and convection going on in the salt solution it was impossible to obtain the fine control and constancy of temperature which the heating process required.

2. The concentration of high current density in the electrodes, amounting to 4,000 to 10,000 amperes per sq. in. resulted in the generation of heat sufficient to cause disintegration of the electrodes, since the quantity of heat generated is proportional to the square of the current; so that in salt bath furnaces heretofore in use, a life of one week was the average for the electrodes. In an attempt to overcome the rapid deterioration of the electrodes, furnace builders have come to use heat-resisting material such as Nichrome or chromium iron. Unfortunately, the electrical resistance of these heat-resisting metals is from 8 to 10 times as great as that of baser metals, so that the passage of the high currents there-through results in the generation of most of the heat in the electrodes and a relatively small percentage of the heat in the salt medium. Furthermore, the heat-resisting metal electrodes are expensive, and this consideration, as well as established practice, led them to use electrodes of minimum cross-sectional and peripheral area. The result was that the area of surface contact between electrodes and salt amounted only to a small number of square inches. Heat generation was thus localized to a small region of the salt bath. Furthermore, while the electrical resistance of the hot salt is comparatively low, the contact resistance between electrodes and salt is relatively high. With insufficient area of contact, all the remaining power which is not dissipated in heating the interior of the electrode by passage of the current, is dissipated in generating a very high temperature at the surface of the electrode by contact resistance with the salt.

3. The high temperature at the electrodes and the high current density caused volatilization of the salt which meant loss of the salt, generation of an excessive amount of fumes, and destruction of the electrodes.

The present invention has solved the major problem which has heretofore existed in salt bath furnaces and has resulted in obviating all of the disadvantages enumerated above. Not only do I obtain absolute uniformity of tempera-

ture throughout the entire bath, readily controllable to within a few degrees even at temperatures as high as 1300° to 1400°, but I accomplish this without the loss of any substantial amount of salt from the bath and without early destruction of the electrodes. As against a life of one week for electrodes in salt bath furnaces heretofore employed, electrodes in the furnaces constituting the present invention have lasted without appreciable deterioration for many months and are still in service.

The key to the solution of the problem stated hereinbefore and which constitutes my invention, consists in providing the maximum distribution of current and obtaining the quickest distribution of heat. For this purpose I propose the following:

1. The employment of electrodes of such area as to give the maximum distribution of current with substantially no temperature difference between the electrodes and the salt.

2. Employing electrodes which have as low resistance as possible.

3. Making the electrode area greater near the bottom of the furnace to draw more current near the bottom and thus liberate more heat in the lower portion of the furnace.

4. Providing conductive material at the bottom of the furnace to divert current toward the bottom.

It is another object of my invention to provide a furnace having an interior surface composed entirely of non-metallic, heat-resisting material. In all types of salt bath furnaces heretofore employed, the interior was formed of iron or other metal. This metal was naturally as hot as the molten salt at the surface which contacts the salt. The level of the salt may be several inches or a foot or more below the rim of the pot. The portion of the pot not in contact with the salt received heat by conduction so that it was quite hot a few inches above the level of the salt. All metals heated to incipient redness or upward become attacked by the vapors which evolve from the molten salt. Salt pots thus scaled and corroded rapidly at the very line of demarcation with the salt where the exposed portion of the pot was hottest. The scale and corroded material from the pot broke off and slipped down through the salt to the bottom of the pot, thus contaminating and spoiling the salt. The electrodes were spaced in close relationship with each other, and unavoidably also with the interior walls of the metal pot. The metal of the pot shunted some of the current passing between the electrodes due to its higher conductivity than the salt medium. That localized portion of the pot which diverted current between electrodes sustained a higher temperature. Arcing occurred between the electrodes and the current-carrying portion of the metal pot, causing local deterioration of the pot. By forming the interior surface and, in one form of my invention, the entire pot, of non-metallic material these disadvantages are avoided.

It is a further object of this invention to provide means for protecting all, or the exposed portion, of the electrodes from the corrosive action of salt fumes.

It is a further object of this invention to prevent damage to the secondary windings of the transformer by the heat which is ordinarily transmitted from the electrodes to which the windings are connected. For this purpose I introduce into the connection between the elec-

trodes and their respective transformer windings a heat radiator of special design.

It is a further object to prevent power losses, especially in the connections between the electrodes and the transformer windings. While these power losses may be small, they are relatively large with respect to the low voltages at which the current is supplied.

It is a further object of my invention to provide the furnace with movable covers having specially designed cooperating openings in the meeting edges thereof to permit uncovering the maximum circular opening by moving the cover parts a very much smaller amount than the radius of the opening.

Still further objects and advantages of this invention will become apparent in the following detailed description thereof.

In the accompanying drawings,

Fig. 1 is a vertical section through the furnace with the cover removed.

Fig. 2 is a plan view of the Fig. 1 device.

Fig. 2A is a plan view similar to Fig. 2 of a portion of the furnace showing a different electrode arrangement.

Fig. 3 is a plan view of the furnace showing the cover parts in position.

Fig. 4 is a view partly sectioned vertically showing the heat radiator connected to the electrode terminal.

Fig. 5 is an end view, with parts broken away, of the Fig. 4 device.

Fig. 6 is a wiring diagram.

Referring to Fig. 1, there is shown a furnace, indicated generally at 10, comprising a pot 14 and specially designed electrodes 15, 16, 17. The pot is constructed entirely of ceramic, diatomaceous, and other earth materials. In this way there is avoided all of the disadvantages of a metal pot, as fully described in the introduction hereto. Thus there may be an outer wall 11 of brick and an inner wall 12 of brick, separated by a cement filling and having an inner lining 13 of cement. Within the furnace pot thus formed there is placed the melt consisting of a mixture of salts which is adapted to melt when subjected to the heating action of current passing therethrough. The walls of the furnace converge downwardly to allow the melting and expanding mass of salt to lift vertically and thus obviate any tendency to crush and disrupt the side walls.

Either alternating or direct current may be supplied to the salt bath mixture through electrodes of special design and positioning. In the forms shown in the drawings, alternating current is supplied to transformers the secondary windings of which are connected to the electrodes. Two or more electrodes may be employed. As shown in Fig. 2A, two electrodes 18 and 19 are employed, the electrodes being connected to direct current or single phase alternating current. In Figs. 1, 2 and 6, an odd number of electrodes such as three are employed which will permit one of the electrodes 15 to cooperate with each of the other two, 16 and 17, thus giving the same result as can be accomplished by several pairs. Electrodes 15 and 16 may be connected to the secondary winding 20 of a transformer 21, while the central electrode 15 and the outer electrode 17 may be connected to the secondary winding 22 of a transformer 23. Transformer 21 may be connected to one phase of an A. C. supply while the transformer 23 may be connected to an A. C. supply of a second phase. The three electrodes, or any multiple of three, may be arranged for

energization from 3-phase alternating current.

As stated in the introduction hereto, the problem which furnaces of this type present arises mainly from the high current density in the electrodes heretofore employed, resulting in a high temperature difference between the electrodes and the salt, rapid destruction of the electrodes, and uneven heating of the salt bath mixture with consequent lack of constancy of temperature of the object being heated. My solution of the problem consists in providing electrodes of relatively large surface area to yield low current density. Thus, as shown in Fig. 2A, the electrodes 18 and 19 each occupy substantially the entire area of one wall of the furnace, while in Figs. 2 and 3, the electrodes 15, 16 and 17 occupy substantially the entire area of one wall of the furnace. The total area of the electrodes is determined by the following formula: The total electrode area is such as to make the current density so low that there results substantially no temperature difference between the electrodes and the salt adjacent thereto. As an example it may be stated that whereas in prior devices the energy density was 500 watts per sq. in., I use, in the furnace shown, only 100 watts per sq. in. As a result of making the electrodes of the specified area, there is no such concentration of high temperatures at the electrodes as was heretofore the case and there is obtained the maximum distribution of current with the quickest distribution of heat throughout the furnace. The electrodes are made of material having low resistance to facilitate this transfer of energy.

In order to improve the uniformity of heat distribution throughout the salt bath mixture, I provide for the generation of more heat at the bottom of the furnace than at the top. It is for this reason that at least one of the electrodes is formed, as shown in Fig. 1, tapering outwardly toward the bottom to give a progressively larger electrode area toward the bottom of the furnace. More heat will thus be generated toward the bottom of the furnace, which means a better radiation of heat throughout the entire salt bath mixture and therefore a greater uniformity of temperature. While one of the electrodes has been shown as tapering outwardly toward the bottom, two or all of the electrodes may be so formed. In the Fig. 2A form, both electrodes taper outwardly toward the bottom. To facilitate further this process there may be provided at the bottom of the furnace a metal plate 30 which will also serve to draw some of the current to the bottom of the mixture and thus assist the distribution of heat throughout the bath. The plate 30 also serves to protect from mechanical injury the fire cement facing and bricks underlying it when the bottom of the furnace is scraped to withdraw accumulated scale from the heat treated ware or to fend the impact of a piece of steel which may be dropped to the bottom.

The high temperatures generated in the furnace will necessarily result in the electrodes withdrawing a considerable amount of heat from the salt bath, and normally this heat would flow into the secondary winding of the transformer and cause a dangerous rise in temperature. I have provided a structure which prevents such transmission of heat from the electrode to its respective secondary winding. This structure takes the form of a radiator 40 interposed between the outer end of each electrode and the secondary winding of the transformer. The radiator may comprise a plurality of flat strips 41

spaced apart at an intermediate point by a spacer block 42 and clamped together at their ends 43 and 44 to make flat contact members. The end 43 may be connected to the respective electrode by means of a long tapered plug or pin 45 extending into a correspondingly shaped socket 46 in the outer end of the electrode, this plug having a threaded outer end 47 which passes through an opening in the end 43 of the radiator. The long tapered connection between plug 45 and socket 46 will prevent loss in voltage. This loss, while small, has an appreciable effect on the power consumed since the furnace operates at low voltage. Thus, even a loss of .1 or .2 volt will seriously affect power consumption in the present system operating at 6 to 12 volts, whereas such losses would not be material in a system operating at the usual 110 v. or 220 v. The connection between pin 45 and the radiator may be made by lock nuts 48, 49 screwed on the threaded end 46 of pin 45 and engaging opposite sides of washers 50, 51 engaging the opposite faces of the end 43. The opposite end 44 of the radiator may be electrically connected to the secondary winding by any usual electric connection.

Each of the strips 41, shown in end view in Fig. 5, has a large radiating area, and the total area of all of the strips is sufficient to prevent any dangerous amount of heat sufficient to cause damage from being transferred from the electrodes to the respective secondary windings. A similar radiator is interposed between each electrode and its connection to the corresponding transformer secondary winding.

The portion of each electrode between the surface of the salt mixture and the connection to the radiator withdraws considerable heat from the furnace, sufficient to heat this portion to redness. In this state, it is subject to attack by the salt fumes rising from the salt bath, resulting in deterioration of the electrode material. To prevent this condition, I provide for coating either the entire electrode or the portion of each electrode from a point about one inch below the salt bath mixture to its outer end with a heat and chemical resisting coating, such as enamel.

The furnace may be provided with movable covers designed not merely to retain the heat within the furnace but also to support the object which is being heated. For this purpose the furnace covers are shown as consisting of several relatively movable parts 70, 71, the part 70 being supported by rollers 52 and 53, while the part 71 is supported by rollers 54 and 55 riding upon rails 56 and 57 on the upper surface of the furnace. The cover parts 70 and 71 are provided with cooperating segmental cutout portions 60 and 61 designed to give an elliptic opening of sufficient size to permit supporting rods which hold the object to be heated to pass therethrough. The segmental portions 60 and 61 are each part of a circle of greater diameter than the depth 62 of the segments. As a result, it is only necessary to move the covers apart a distance equal to the radius of the circle of which 60, 61 is a part, less the distance 62, in order to obtain an opening which is twice the radius of the segmental portions. Thus, for instance, if the segments 60, 61 are parts of circles of radius 11 inches, and the segmental depth 62 is $4\frac{1}{2}$ inches, then by moving each cover part outwardly the difference between 11 and $4\frac{1}{2}$ inches, or $6\frac{1}{2}$ inches, there is obtained an opening 22 inches in diameter with a movement of each cover part of only $6\frac{1}{2}$ inches.

In accordance with the provisions of the patent statutes, I have herein described the principle and operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other equivalent means. Also, while it is designed to use the various features and elements in the combination and relations described, some of these may be altered and others omitted without interfering with the more general results outlined, and the invention extends to such use.

Having described my invention, what I claim and desire to secure by Letters Patent is:

1. A salt bath furnace comprising a plurality of electrodes for passing current through the salt and adapted to be connected to a source of current supply, the effective area of the electrodes being such that the current density is insufficient to cause substantial temperature difference be-

tween the electrodes and the salt adjacent thereto.

2. A salt bath furnace comprising a plurality of electrodes for passing current through the salt and adapted to be connected to a source of current supply, the electrodes being formed with increasing area toward the bottom of the furnace and the total effective area of the electrodes being sufficient to reduce the current density to the point where there is substantially no temperature difference between the electrodes and the salt adjacent thereto.

3. A salt bath furnace comprising a plurality of electrodes for passing current through the salt and adapted to be connected to a source of current supply, the effective area of the electrodes being such that the current density is insufficient to cause substantial temperature difference between the electrodes and the salt adjacent thereto and the electrodes being formed of material having low resistance.

WILLIAM MESSINGER.