Oct. 29, 1968 J. R. GIER, JR 3,408,470

INDUCTION FURNACE EMPLOYING HIGH PURITY ATMOSPHERE

Filed April 4, 1966 2 Sheets-Sheet 1

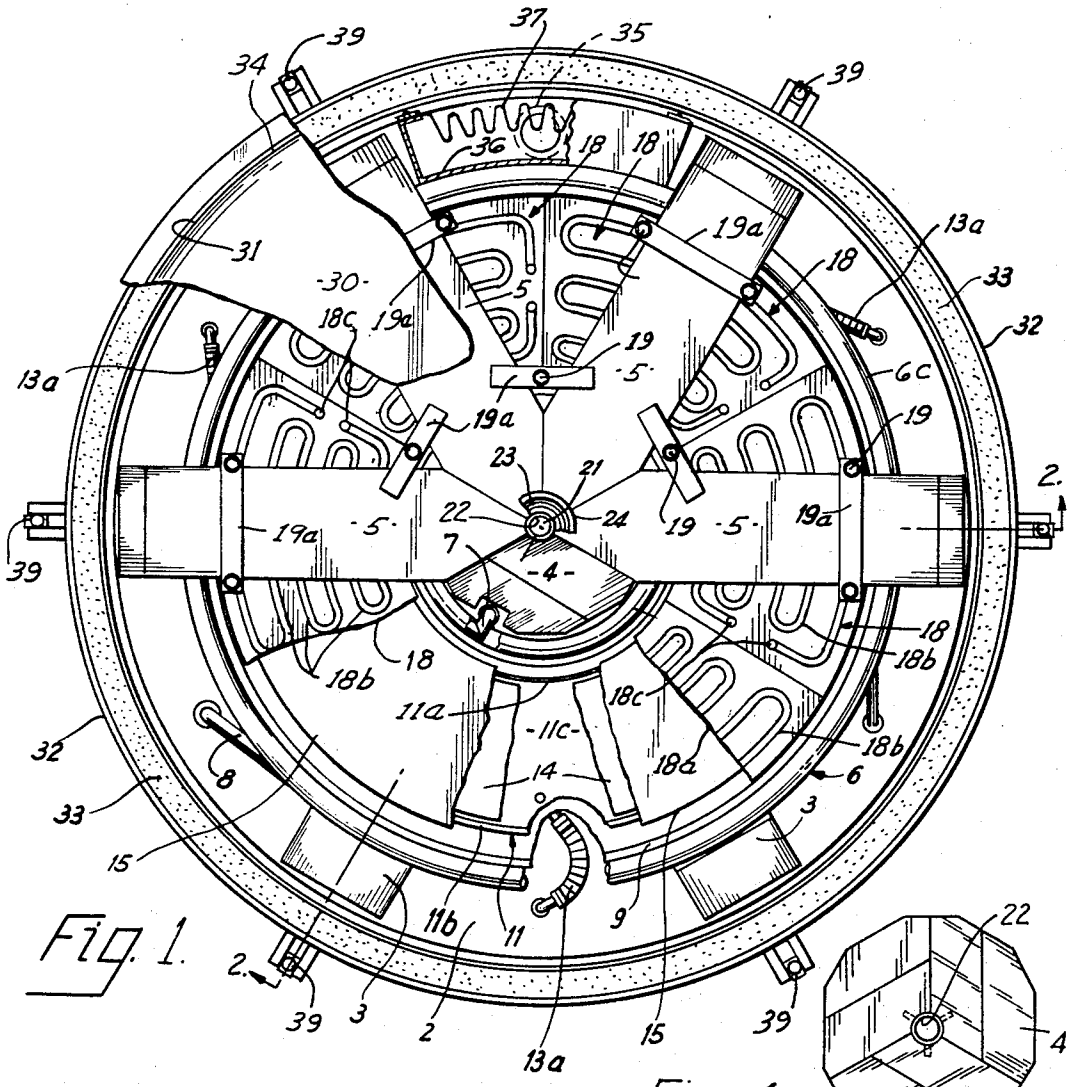


Fig. 1.

Fig. 3.

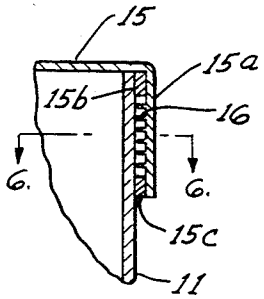


Fig. 5.

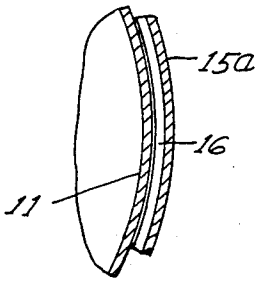


Fig. 6.

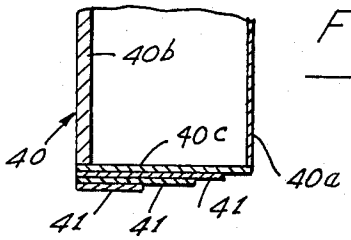


Fig. 4.

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INDUCTION FURNACE EMPLOYING HIGH PURITY ATMOSPHERE

Filed April 4, 1966 2 Sheets-Sheet 2

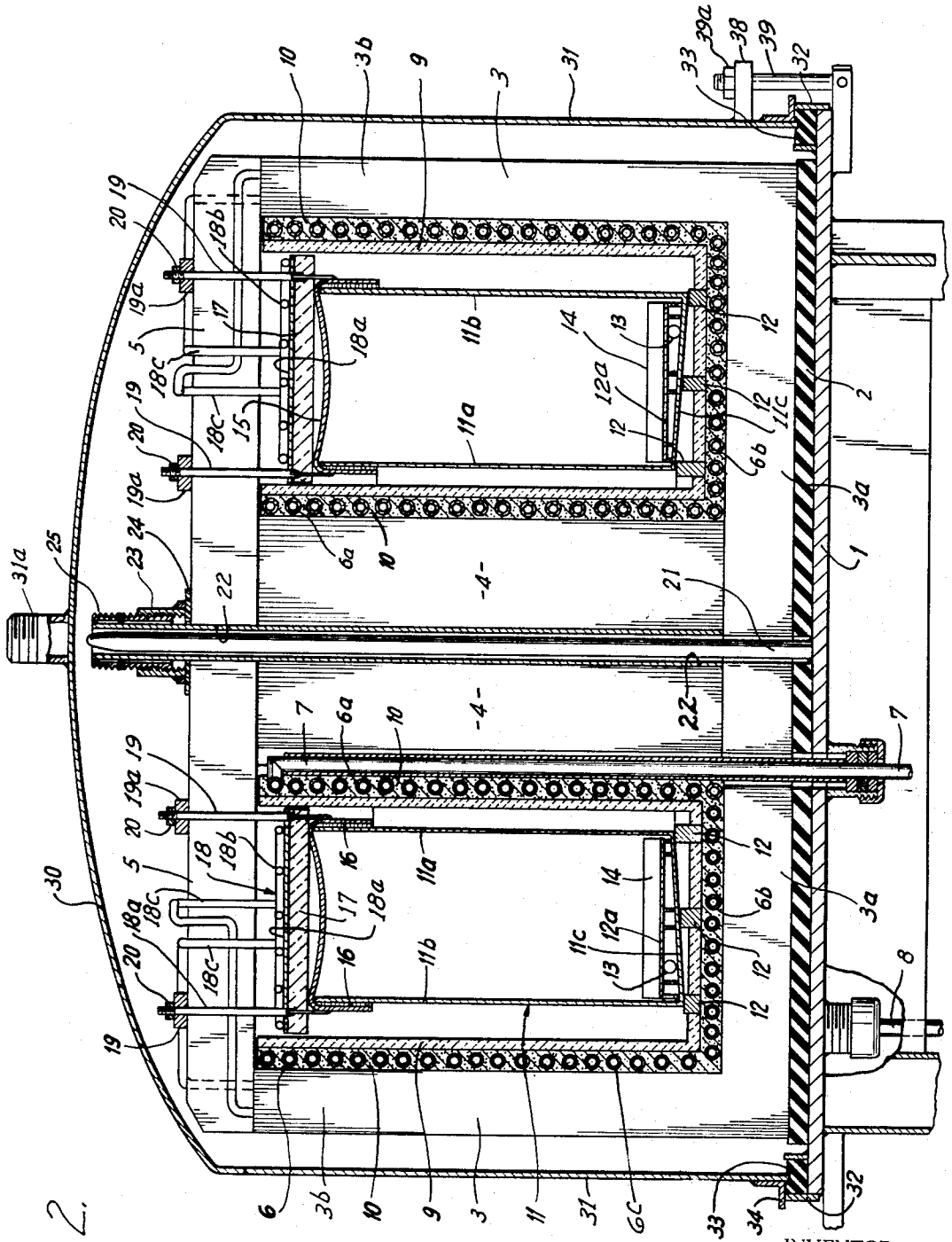


Fig. 2.

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INDUCTION FURNACE EMPLOYING HIGH PURITY ATMOSPHERE

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10 Claims. (Cl. 219—10.49)

ABSTRACT OF THE DISCLOSURE

The furnace is a low frequency induction furnace having a covered, electrically conductive annular retort forming a short circuited secondary which is heated by currents induced therein.

It has an electromagnetic core comprised of a plurality of O-shaped core pieces each arranged with one side passing through the central opening of the retort and the other sides extending along the outer walls of the retort and cover.

The retort is enclosed in an evacuable sealing chamber and means are provided for evacuating the chamber and for admitting gaseous media into the retort. A labyrinth type seal is disposed between the retort and its cover.

This invention relates to induction furnaces for brazing, sintering, and the like, and particularly to induction furnaces wherein a high purity atmosphere is to be maintained during the heating and cooling of articles therein.

For purposes of illustration the invention will be described as applied to a ring type brazing furnace, its use for purposes other than brazing being apparent from the illustrative example.

Heretofore in brazing, one practice has been to place the article within a heating chamber of a furnace. If controlled atmosphere was desired, the article was placed in a retort closed by a removal cover and disposed in the chamber. The retort was provided with suitable conduits by which the gas for the atmosphere desired could be introduced into or removed.

With such a structure, the general practice was to purge the air with an inert gas and then introduce a protective gas. Generally, a so-called sand "seal" was provided between the cover and body of the retort. Control gas was fed into the retort at pressures above that in the furnace chamber, and a continuous flow of the gas was maintained to reduce back diffusion from the chamber through the "seal" into the retort.

The infiltration and exfiltration of gasses through sand seals cannot be precisely controlled. They provide a myriad of passages for the exfiltration of gas from the interior of the retort into the furnace chamber. These passages vary much in size and are heterogeneously arranged. Consequently, the seal may be much more porous at one portion than at another. As a result, there is a pronounced tendency toward back diffusion of gasses from the chamber into the retort. In order to maintain control of the exfiltration of the gases so as to overcome the back diffusion, the flow of the control gas must be sufficiently high so that there is an assurance that gas is filtering out continuously throughout the entire periphery of the sand seal at a sufficient rate to prevent any re-entry of gas into the retort. This necessitates introduction of the atmosphere controlling gas in an amount greatly in excess of what would otherwise be required.

Further, upon the cooling of the furnace and retort, due to the high thermal capacity of the sand seal, the retort is subjected to very large temperature gradients which cause resultant warpage and rapid deterioration of the retort as well as slowing down the heating and cooling

cycles. To reduce these gradients sufficiently to reduce warpage effectively, the time required for the heating and cooling cycle has to be greatly extended.

In cases where the maintenance of a high purity atmosphere is critical, the practice is to seal the juncture of the cover and retort by welding the cover and retort together about the entire periphery of the cover. In such cases, the cover or the retort is provided with pipes for evacuating and introducing the controlled atmosphere gas. Obviously the cost and expense in time and money of welding and breaking such a seal is very great.

Induction brazing generally involves heating the work piece by means of the current induced in it from an adjacent induction coil. This coil carries an alternating current that may range widely in frequency, for example, from 1 to 500 kilocycles, according to the conditions of the particular heating situation.

For induction brazing the work is commonly heated in air with the joint area and the braze filler metal protected against oxidation by means of a suitable flux applied prior to heating. When flux is undesirable, a protective gas may be used to provide a reducing or inert gas atmosphere surrounding the work piece during its heating and cooling. If the containing enclosure or envelope for this gas is an electrical conductor it is usually made large enough to encompass the entire primary coil together with the work assembly with sufficient clearance such that the envelope will not be heated by currents induced in it from the primary coil. This arrangement is quite satisfactory where the metals being heated do not form stable oxides and, therefore, the required gas purity is not extreme.

However, when the metals of the work piece contain substantial amounts of chromium or lesser amounts of aluminum or titanium, all of which do form relatively stable oxides, then the protective atmosphere in contact with the work piece must be extremely pure and free of oxidizing contaminants. This is necessary to maintain the work piece bright and clean for successful brazing. It is not feasible to achieve this high degree of gas purity in the presence of an induction coil structure with its thermal and electrical insulation and other parts that will give off adsorbed air and other contaminating gases during the heating cycle.

This difficulty can be avoided by making the enclosure or gas containing envelope of an electrical non-conductor capable of standing high temperature and thermal shock, such as fused quartz, and placing this envelope around the work piece, while maintaining the envelope or enclosure itself within the coil so that the coil and its related sources of gas contamination are all external to the enclosure. This procedure is clearly impractical for any use where the quartz tube must be more than a few inches in diameter.

In very special cases involving small work space and temperature over 2100° F., molybdenum enclosure or envelope for the gas and located within the induction coil has been used in laboratory type work.

The present invention offers in combination a large work space which is induction heated with 60 cycle current in a high purity protective gas atmosphere capable of operation at sub-atmospheric pressures at high temperatures with rapid heating and cooling; the use of hydrogen, helium, or argon with complete safety and economy of gas; ease and rapidity of opening and closing furnace; and low maintenance cost.

In accordance with the present invention, a new and improved ring type induction furnace is provided wherein an annular metal retort is employed and a high purity atmosphere is maintained continuously within the retort without back diffusion of gases into the interior of the

retort; extremely rapid heating and cooling cycles relative to those heretofore required are obtained; the flow of atmosphere controlling gas for assuring the maintenance of high purity atmosphere within the retort free from back diffusion is effected with a low gas flow; low or sub-atmospheric pressures are maintained during heating, and pressures at substantially atmospheric pressure or above are maintained during cooling, so as to assure efficient operation with a small flow of the control gas.

Specific advantages of the present invention reside in the provision of a so-called "labyrinth seal" between the retort and its cover whereby great precision and uniformity in the passages for exfiltration of gases through the "seal" from the retort are obtained about the entire juncture of the retort and its cover; in the manner in which the parts are related so that ready access is afforded to the interior of the furnace and interior of the retort for charging the articles in the retort and for removing them therefrom; and in the use of a thin walled retort in which heat can be generated rapidly and from which the generated heat can be radiated quickly to the contents of the retort.

Another advantage is that the heating and cooling are confined mostly to the retort and charge of articles so that a large mass of conventional furnace structure does not have to be subjected to the heating and cooling cycles, whereby the time required for the heating and cooling cycles is greatly reduced.

A specific advantage is that the present structure permits the brazing of a large number of individual articles concurrently or in a batch while they are maintained out of contact with each other.

Another specific object is to provide a balance between the wall thicknesses of the retort so that under the influence of the induced currents, the heating of each unit of wall area of the retort is the same as are the others throughout the heating cycle.

Various other specific objects and advantages will become apparent from the following description wherein reference is made to the drawings, in which:

FIG. 1 is a top plan view of the furnace embodying the principles of the present invention, parts thereof being cut away for clearness in illustration;

FIG. 2 is a vertical section view of a furnace, taken on the line **2—2** in FIG. 1;

FIG. 3 is a fragmentary plan view of the furnace, showing the central core thereof;

FIG. 4 is a fragmentary vertical sectional view of a modified form of retort which may be used in connection with the present invention;

FIG. 5 is an enlarged fragmentary vertical sectional view of the retort and cover, showing spacing beads between the retort and its cover for assuring positive spacing therebetween for the labyrinth seal; and

FIG. 6 is an enlarged fragmentary sectional view on line **6—6** of FIG. 5.

Referring to the drawings, the furnace comprises a base or table **1** supported in horizontal position by a suitable frame. The upper surface of the table **1** carries at certain circumferentially spaced locations, radial strips **2** of heat resistant synthetic organic plastic material, such as Neoprene. A plurality of L-shaped core pieces **3** are disposed on the strips **2**, each with the shorter leg of the L extending radially outwardly from the upright central axis of the base and with the longer leg of the L at the outer end of the shorter leg and extending upwardly. The core pieces **3** are spaced uniformly about the central axis. At the inner ends of the short legs **3***a* of the L-shaped core pieces are central core pieces **4** arranged in such relation about the central axis that they form, in effect, a single laminated central core.

At the top of the core pieces **3** and **4** are radially extending upper core pieces **5**, arranged one core piece **5** to each core piece **3**. At their outer ends, the upper core

pieces **5** rest on the upper ends of the core pieces **3**, but are not connected thereto. The inner ends of the core pieces **5** are fixedly connected to the upper ends of the core pieces **4**, so that all of the upper core pieces **5** form with all of the core pieces **4** a single unit.

The lower end of the core piece **4** rests on the upper surface of the shorter legs **3***a* of the L-shaped core pieces **3**, but are not connected thereto. Thus, all of the core pieces **4** and **5** can be lifted as a unit by an overhead hoist to afford access to the retort.

Disposed between the upright outer leg portions **3***b* and the core piece **4** is a combined heating and cooling coil **6**, formed of copper or other electrical and heat conducting tube. The coil **6** comprises an upright inner coil portion **6***a* having a plurality of closely spaced convolutions surrounding the inner core piece **4**, a planar base coil portion **6***b* having a plurality of convolutions of gradually increasing radius extending from the inner portion **6***a* outwardly and disposed adjacent the plane of the upper faces of the legs **3***a*, and an outer coil portion **6***c* with a plurality of convolutions which extend from the outer limit of the portion **6***b* upwardly to the top of the core pieces **3** adjacent the inner surface of the leg portions **3***b*. The tube forming the coil **6** has an inlet **7** which is adapted for connection to a suitable source of cooling water and has an outlet **8** for the discharge of water.

Disposed within the coil **6** is an open top annular trough **9** of thermal insulating material. The trough **9** has an inner peripheral wall overlying the outer face of the coil portion **6***a*, a bottom wall overlying the coil portion **6***b*, and an outer peripheral wall overlying the inner face of the coil portion **6***c*. The walls are preferably of the same thickness.

The coil is mounted in suitable Ultracal plaster or other plaster **10**. The trough **9** is composed of Fiberfax or other thermal insulating material. Both the plaster **10** and the trough **9** may be molded in situ.

An annular metal retort **11** is supported on tier blocks **12** which are disposed in the bottom of the trough **9**. The retort has an inner peripheral wall **11***a*, an outer peripheral wall **11***b*, and a bottom wall **11***c*. Due to the flux patterns and resultant induced heating currents, and heat radiating patterns, the walls of the retort are made of different thicknesses so that all unit area of the walls can be heated to, and maintained at, the same temperature. In the form illustrated, the inner wall is thinner than the outer wall, the thickness being proportioned to the amount of current induced in each. The bottom wall preferably is of gradually increasing thickness outwardly, beginning with the thickness of the inner wall and ending with the thickness of the outer wall.

Within the retort **11** is a gas baffle wall **12***a* which preferably is horizontal and extends substantially from the inner wall **11***a* to the outer wall **11***b* of the retort. The bottom wall **11***c* of the retort slopes downwardly from its inner to its outer periphery so that between the baffle wall **12** and bottom wall **11***c*, a gas distributing space is provided which is of gradually decreasing cross-sectional area, in the radial plane through the axis of retort, from its outer wall to its inner wall. A gas distribution ring **13**, in the form of an annular length of perforated pipe, is disposed between the baffle wall **12** and the bottom wall **11***c* of the retort **11** near the outer periphery of the retort. The ring has flexible inlet tubes **13***a* for introduction of gas. This ring discharges into the gas distributing space between the bottom wall **11***c* and the baffle wall **12***a*. The baffle wall rests on suitable supporting lugs, as illustrated, but the gas discharged therebeneath can flow readily to the outer and inner peripheries and discharge freely upwardly along the walls **11***a* and **11***b*.

Suitable supporting rails **14** of suitable material, for example, Mulite, may be disposed on top of the baffle wall for supporting articles to be brazed in spaced relation thereto.

For closing the open upper end of the retort **11**, an an-

nular detachable cover **15** is provided. The cover **15** has a usual top wall with inner and outer depending peripheral side walls **15***a*, each with upper and lower spacing beads **15***b* and **15***c*, respectively, which engage the adjacent walls **11***a* and **11***b*, respectively. Mounted on the inner surfaces of both the inner and outer peripheral walls **11***a* and **11***b*, respectively, are annular labyrinth "seals" **16**. These seals are in very close, but positive, spaced relation to the adjacent wall surfaces of the upper margins of the walls **11***a* and **11***b*, respectively, so as to cause the outflowing gas to undergo a succession of abrupt increases and decreases in velocity, thus obtaining the full benefit of a labyrinth type seal. The beads **15***b* and **15***c* are of slightly greater radial dimension than the seals **16**, so as to assure a positive spacing of the seals **16** from the walls **11***a* and **11***b*. The beads **15***a* and **15***c* are notched at their peripheries as indicated at **15***c*, so as to assure positive clearance of the seal **16** and walls of the retort.

Labyrinth seals are well known in the art and, though not true seals, they have special advantages in the present structure. Such seals function by necessitating repeated pronounced and sudden changes in velocity of flow of gases passing over their operating surfaces, being in effect not true seals but leakage controlling barriers. If desired, the labyrinth seals may be mounted on the outer surfaces of the walls **11***a* and **11***b* instead of on the cover.

It is desirable that heat losses from the cover be balanced with the losses from the remainder of the retort. For this purpose thermal insulation, in the form of an annulus **17** of thermal insulating material, such as Fiberfax, is provided. This annulus is overlain with a plurality of cooling elements **18** through which cooling water from an extraneous source can be circulated which are separated from each other circumferentially. Each element **18** is in the form of an annular sector of copper sheet **18***a* with a copper tube **18***b* brazed to one of its faces and connectable in a water cooling circuit, by pipes **18***c*, as illustrated in FIGS. 1 and 2. The annulus **17** preferably rests directly on the cover **15** and may be fixedly secured thereto if desired.

In order to gain access to the retort, it is necessary, of course, to remove the upper core pieces **5**, and also the cover **15**. Accordingly, the cover **15** is provided with a plurality of upright supporting bolts **19** which extend through suitable brackets **19***a* on the upper core pieces **5**. The bolts are adjustable endwise by suitable nuts **20**. Preferably they are adjusted so that they suspend the cover in a position wherein, when the core pieces **5** rest upon the upper ends of the core pieces **3**, the cover is fully seated and resting with its inner surface on the upper edges of the peripheral walls **11***a* and **11***b*. If desired, the bolts can be such that they can slide through the brackets **19***a* slightly, so that axial lost motion is provided between the cover and core pieces **5** for facilitating guiding the cover into position. Since the cover **15** must be held precisely in axial alignment with the upper end of the retort **11** to effect initial engagement without damaging the labyrinth seals, it is desirable that the core pieces **5** be guided effectively as they are lifted and lowered. For this purpose, an upright guide post **21** is secured in fixed coaxial relation with the base or table **1**. An axial passage is provided at the inner ends of the short legs **3***a* of the L-shaped core pieces **3**, through the central core in coaxial relation with the base **1** and at the inner ends of the core pieces **5**. A guide tube **22** is disposed in the portion of this passage above the legs **3***a*, and is bonded to the core piece **4**, and at its lower end is unconnected to the legs **3***a*. An internally threaded coupling **23** rests on an annulus **24**, of electrical insulating material, which, in turn, rests on the upper surface of the upper core pieces **5** adjacent their inner ends. A suitable connecting nipple **25** is threaded into the coupling **23**, is welded to the tube **22**, and is arranged to receive axially the upper end of the post **21** with operating clearance. The guide pipe **22** receives the post **21** which thereby guides the core pieces **4** and **5** and the cover **15** into position. If desired, suitable complementary splines, parallel to the axis of the post, may be provided in the nipple **25** and on the post to constrain the core pieces to proper position circumferentially of the post axis to mate with the upper ends of the leg portions **3***b* of the core pieces **3**.

It is desirable that the interior of the retort **11** be purged of all objectionable gases and that a high purity atmosphere of a selected gas, such as hydrogen, be maintained therein during the heating operation. This may be done by the admission of hydrogen or selected control gas through the ring **13**, heretofore described after the cover **15** is installed. The labyrinth seals **16** permit the escape of gas from the retort while eliminating back diffusion. However, if the structure is exposed to the air, the escape of hydrogen between the cover **15** and top end of the retort **11** results in the production of a hydrogen-oxygen mixture at the lower edge of the flanges of the cover **15**. This is objectionable from the standpoint of the high temperature and thermal shock to which the retort and cover are subjected upon burning of the mixture, but also due to the heat to which the coil and core are subjected.

For rapid heating and cooling, a hood **30** is provided for enclosing the entire induction furnace. The hood **30** is preferably dome shaped with a depending peripheral side wall **31**. For its removal, a coupling element, or nipple **31***a* corresponding to the nipple **25** is secured to its top wall. The nipples **25** and **31***a* are adapted for connection, successively, to the same internally threaded coupling, which latter may be carried by an overhead hoist. Thus the hood **30**, the core pieces **4** and **5**, the cover **15**, and the insulating annulus **17** can be installed and removed readily.

In order to provide a seal between the entire lower peripheral edge of the flange **31** of the hood and the upper surface of the table or base **1**, the table is provided on its upper surface at its outer periphery with an upwardly open peripheral channel **32** in which is a rubber sealing cushion **33**. Suitable circumferentially spaced brackets **34** are provided near the lower edge of the hood and are positioned to engage the outer wall of the channel **32** and support the weight of the hood while the lower edge of the flange **31** depresses the rubber seal **33**. This assures an effective seal between the hood and the table **1**. A rubber seal is effective at this location because it is not subjected to high temperatures such as would be present were an attempt made to use such a rubber seal between the cover **15** and the retort **11**. The base or table **1** is provided with a screened filter port **35** which may be attached to any type of conventional vacuum pump so that the interior of the hood **30** can be evacuated to the degree desired. The port **35** is in the base. This is used for purging out the air before admitting hydrogen; for maintaining a discharge flow of gas at any desired partial pressure during the heating and cooling cycle; and finally to purge out the hydrogen before admitting air at the end of the cycle prior to lifting the cover.

For screening the port **35**, a filter may be arranged to rest on the base or table **1** between one pair of adjacent core pieces **3**, as illustrated in FIG. 1. The filter may comprise a strip of copper sheet **36** bent into channel shape and disposed between the adjacent core pieces **3** with the width of the sheet upright. The open side of the resultant channel is closed by a cloth or other suitable filter strip **37** so that all gases passing to the port **35** from within the hood **30** are filtered. This eliminates the necessity for a separate extraneous container for the filter.

The hood **30** may be provided at the lower margin of its side wall **31** with circumferentially spaced hold-down yokes **38** which are engaged by bolts **39** pivotally secured to the base **1** for securing the hood in place. Generally, when the hood is seated while under subatmospheric internal pressure, nuts **39***a* on the bolts may be tightened with the fingers, to assure retention of the

sealing relation of the hood with the seal **33** when the subatmospheric pressure is relieved and a superatmospheric pressure is built up in the hood due to heat or other causes.

As hereinbefore mentioned briefly, the outer wall of the retort is of greater thickness than the inner wall so that the heat input and output per square inch is equalized as between the walls. The ratio of the thickness of the outer to that of the inner wall is in proportion to the square of the respective radii. For instance, with an outer wall of two feet in diameter and the inner wall of one foot diameter, the ratio of thickness of the outer wall to the inner wall is four to one, assuming of course the same flux linkage with all walls of the retort and its cover. As to the bottom wall, radially it preferably should be tapered gradually from the outer to the inner wall beginning with the same thickness as the outer wall at the outer periphery and tapering to the thickness of the inner wall at the inner periphery. However, such a wall as this is somewhat expensive to manufacture. Consequently, as illustrated in FIG. 4, a retort **40** may be used. This retort has a thin inner wall **40***a*, a thicker outer wall **40***b*, and a bottom wall **40***c* of uniform thickness on which a plurality of annular plates **41** are secured in firm face to face juxtaposition. The plates are of different internal diameters and arranged so that, when juxtaposed against the bottom wall of the retort, they form, in effect, a bottom wall which is of progressively less thickness from its outer periphery to its inner periphery. In any event, the walls of the retort should be as thin as possible consistent with adequate current flow for heating. This is necessary not only for rapid heating and cooling, but also to eliminate thermal shocks and warpage which would otherwise occur. In like manner, the cover **15** may have its top wall provided with plates so that it is of increasing thickness from the inner to the outer periphery, the same as the bottom wall illustrated in FIG. 4.

The labyrinth seal **16** is especially desirable because it affords an accurate passage for exfiltration of control gas under light pressure of gas within the retort, yet can prevent back diffusion. This it can do in all stages of heating and cooling.

The insulation trough **9** should be relatively thin, consistent with preventing overheating of the coils and cores and consistent with radiation of heat into the coils. It preferably has an outer peripheral wall which is the same thickness as its inner peripheral wall so as to assist in maintaining a balanced heating and radiating effect.

The water cooled coils are desirable and very effective for heating the retort by the currents induced therein without themselves becoming overheated. At the same time, they operate effectively for cooling the retort and its contents rapidly. Meanwhile they prevent the transmission of a great amount of heat to the core pieces and hood so that the hood temperature does not endanger the seal between the lower edge of the hood and the sealing material **33** in the channel **32** on the base or table **1**.

Here it is to be noted that the coil portions **6***a*, **6***b* and **6***c* generally are in the form of separate coils connected in series, but they may be connected individually, each to a desired source of power and cooling water.

The difference in the thicknesses of the inner and outer walls of the retort is especially important in those instances wherein the inner radius is much less than the outer.

In operation, after the retort **11** is charged and the cover **15** thereof installed in place, along with the hood **30**, vacuum is applied to the interior of the hood **30**. Purging of the retort with hydrogen or selected gas is effected and the heating cycle is then started. The hydrogen is continuously delivered through the inlet pipes **13***a* to the ring **13**, the hydrogen being diffused throughout the interior of the retort. While vacuum is maintained in the hood, a very low flow of hydrogen under low pressure may be maintained to minimize heat loss and gas consumption. The conduction of heat by the gas is in an inverse relation to the pressure of the gas. Gas flow outward through the labyrinth seals is maintained at a space velocity greater than the back diffusion rate of the impure gas surrounding the exterior of the retort. The mass flow rate to accomplish this is in approximate relation to the absolute pressure in the furnace.

For rapid heat-up, low gas pressure is employed, combined with a low gas flow; for example, one mm. of mercury greatly reduces the heat loss.

On the other hand, in cooling, the gas pressure may be raised to atmospheric pressure, thereby greatly increasing the heat dissipation. Thus, with the vacuum or very low pressure, the loss of heat is negligible, but as the pressure of the gas increases above 1 millimeter, the heat dissipation increases rapidly, up to about atmospheric pressure. For operation at atmospheric pressure, as for rapid cooling, the gas flow must be high enough to prevent back diffusion through the seal.

The use of the cooling coils on at least three sides of the thin walled retort provides for rapid or short cycle cooling. At the same time, the cores and other parts are protected from excessive heat. Employing cooling coils above the insulation annulus **17** overlying the cover **15**, provides symmetry of cooling and core protection.

For maintaining temperatures, conventional thermocouples may be employed in the retort and elsewhere if desired.

As a result, very rapid cycles of both in heating and cooling are obtained. The heat generation is uniform throughout the retort, severe thermal shocks and strains are eliminated so that the life of the retort is greatly increased, a high purity atmosphere without back diffusion is maintained economically, and ready access is provided for cleaning the retort and removing the articles therefrom.

Having thus described my invention, I claim:

1. An induction furnace comprising an annular retort of electrically conducting material in the form of an open top metal channel having thin circumferentially continuous inner and outer side walls, respectively, a bottom wall, and a detachable annular cover;

electromagnetic means including core means and electric coil means for producing a magnetic flux field in inductive relation to the annular retort;

said core means having a flux conducting portion extending through the central opening of the retort and cover;

enclosing means providing an evacuable closed sealing chamber in which said electromagnetic means and retort are disposed;

means connected to the interior of the chamber and adapted for connection to an extraneous evacuating means for providing sub-atmospheric pressure within said chamber; and

means for admitting preselected gaseous media into the interior of the retort.

2. A structure according to claim **1** wherein an annular open top container of thermal insulating material is disposed within said chamber; the retort is contained within said insulating container; and the walls of said insulating container are between and thermally insulate the electromagnetic means and the retort.

3. A structure according to claim **2** wherein the electromagnetic means includes inner and outer coil means coaxial with the retort and disposed alongside the exterior of the inner and outer walls, respectively, of the insulating container; said coil means being in the form of tubular conductor means; inlet and outlet means connected to the coil means and extending to the outside of the chamber for admitting and discharging cooling media to and from the coil means, respectively, and adapted for connection to an extraneous source of circulatable cooling media.

4. A structure according to claim **3** wherein the elec-

tromagnetic means includes core pieces of O-shape extending generally radially of the retort and surrounding the retort exteriorly of the coil means and spaced apart from each other circumferentially of the retort.

5. A structure according to claim 1 wherein the inner wall of the retort is of less thickness than the outer wall of the retort so that, under the influence of the magnetic flux, the heating per unit surface of the inner wall and outer wall more nearly equalize.

6. A structure according to claim 1 wherein said enclosing means comprises an upwardly facing base and a hood having a dependent peripheral wall; a peripherally continuous resilient annular seal disposed between the lower edge of the wall and the upper face of the base and in sealing engagement with both the wall and the base for sealing the joint therebetween; and

stop means independent of the seal for limiting the deformation of the seal by the hood.

7. A structure according to claim 1 wherein the electromagnetic means includes a lower core portion and an upper core portion separable from the lower core portion by upward movement, said upper core portion having portions spaced above the retort and extending thereacross;

means connecting said last mentioned portions together for lifting upwardly as a unit for affording access to the retort, and means connecting the retort cover to said last mentioned portions for lifting by said last mentioned portions when the upper core portions are lifted; and

means are connected to the upper core portions and are adapted for connection to a hoist for lifting the upper core portions and thereby the cover.

8. A structure according to claim 7 wherein an insulating container is provided and has inner and outer walls disposed alongside the inner and outer walls of the retort, thermal insulator means are disposed on the top of the retort cover and extends radially of the retort substantially from the inner to the outer peripheral wall of the insulating container.

9. A structure according to claim 8 wherein the insulating container is annular and coaxial with the retort, the electromagnetic means include a coil means coaxial with the retort and extending circumferentially of the insulating container along the inner wall, bottom wall, and outer wall of the insulating container, said coil means being in the form of tubes;

means on the tubes adapted for connection to a circuit for circulating cooling media through the tubes; and

cooling tube means embedded in said thermal insulator means and adapted for connection to an extraneous cooling circuit for circulating cooling media therethrough.

10. An induction furnace according to claim 1 wherein said cover has inner and outer circumferentially extending flanges disposed alongside the upper margins of the inner and outer side walls, respectively, when the cover is in place; and

a labyrinth seal between each cover flange and the upper margin of its associated side wall operative to prevent back diffusion of gaseous media into the retort between the cover and channel.

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