Sept. 20, 1960 A. F. HOLDEN 2,953,614

ELECTRODE FURNACE

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FIG. 1

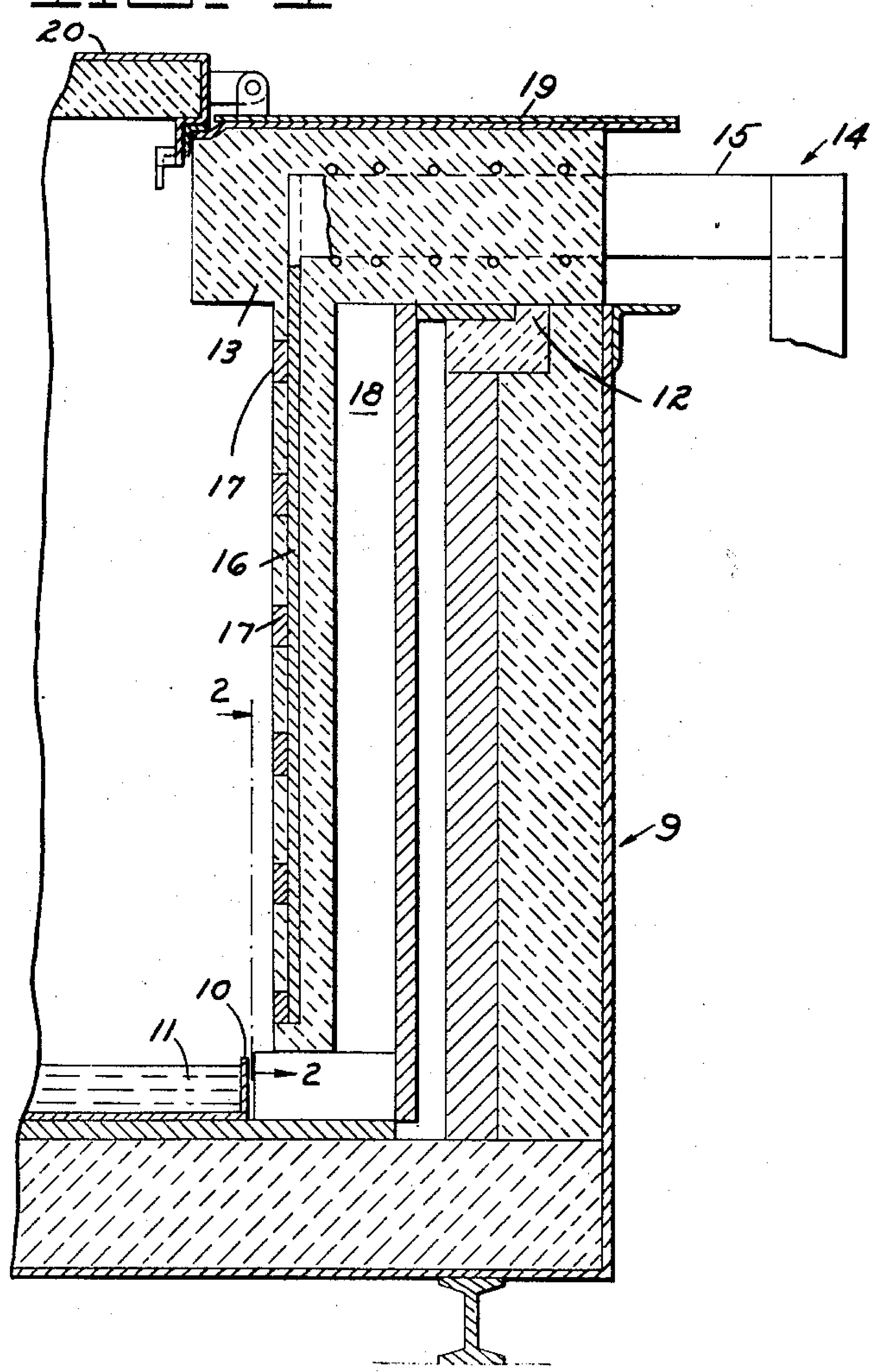
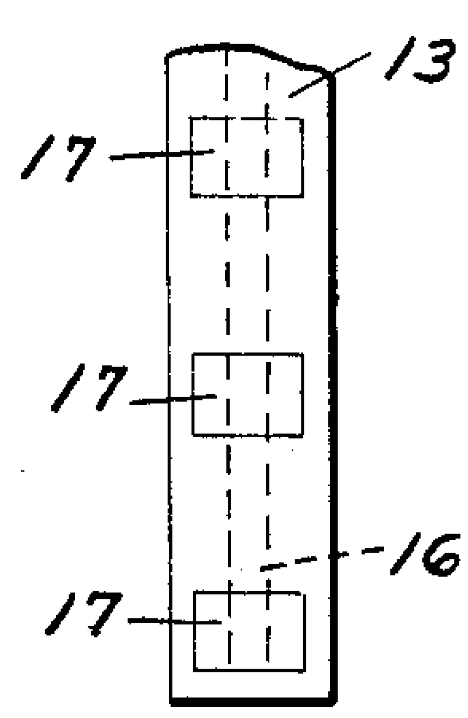


FIG. 2



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ELECTRODE FURNACE

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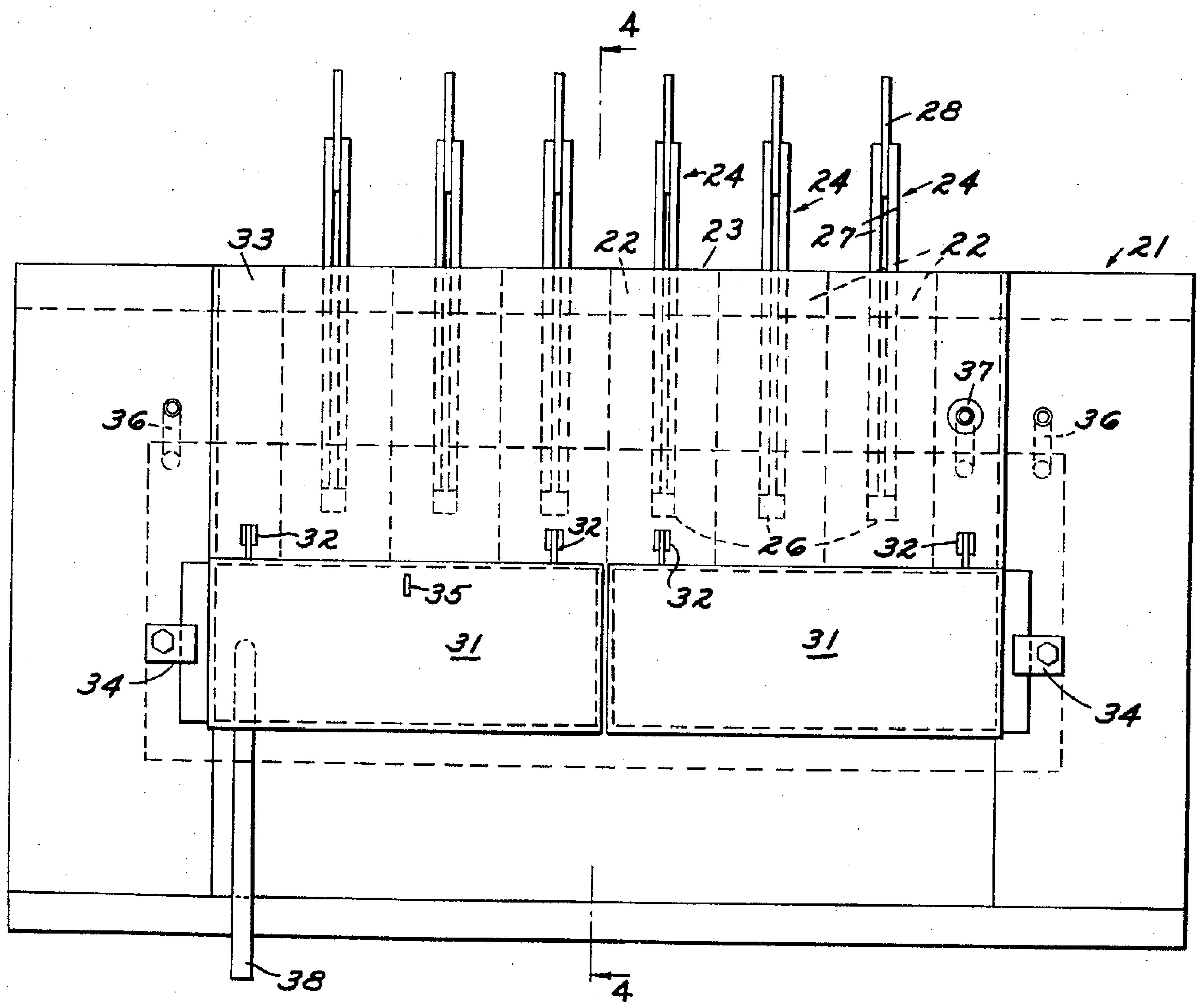

FIG. 3

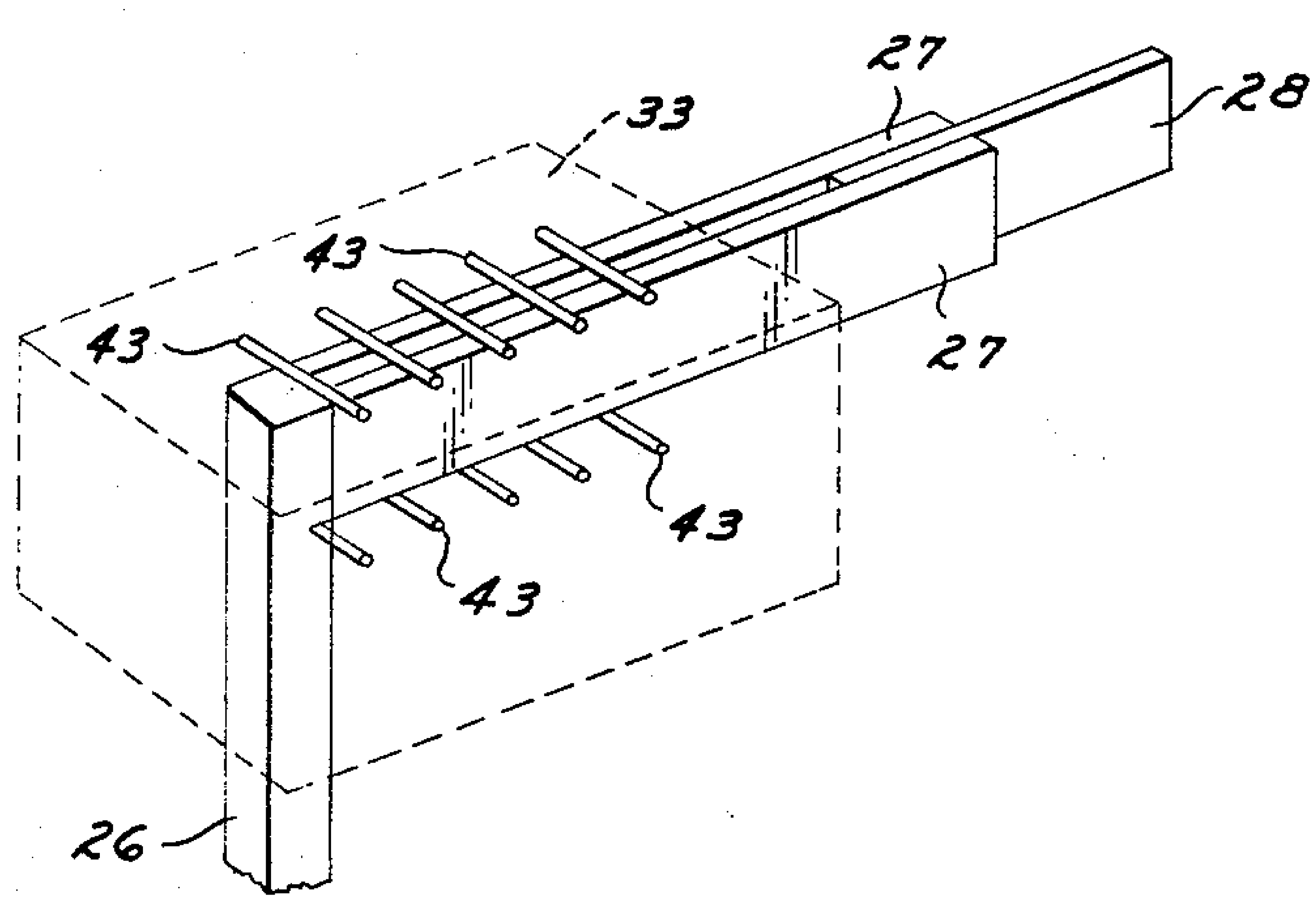

FIG. 5

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ELECTRODE FURNACE

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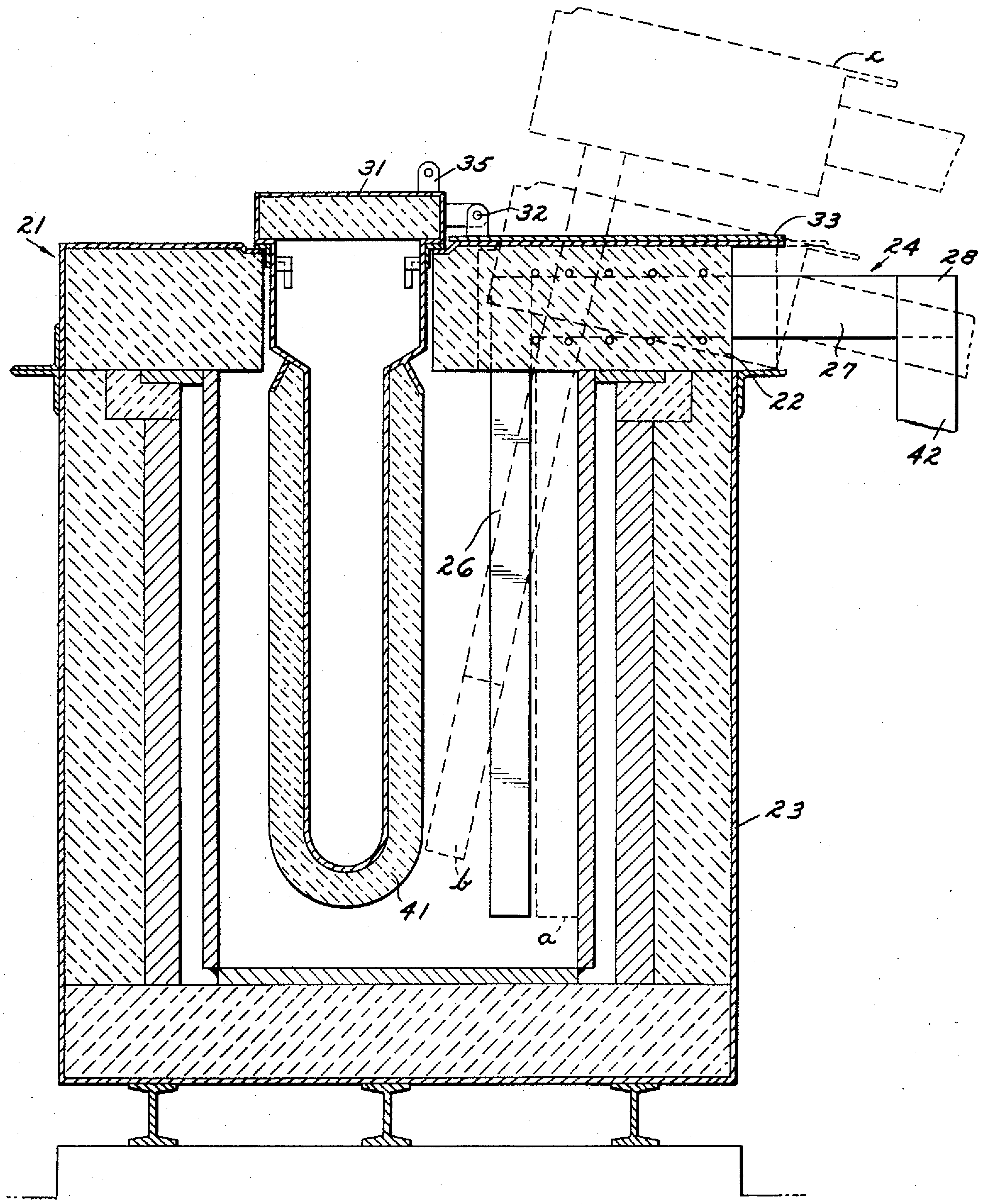

FIG. 4

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ELECTRODE FURNACE

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FIG. 7

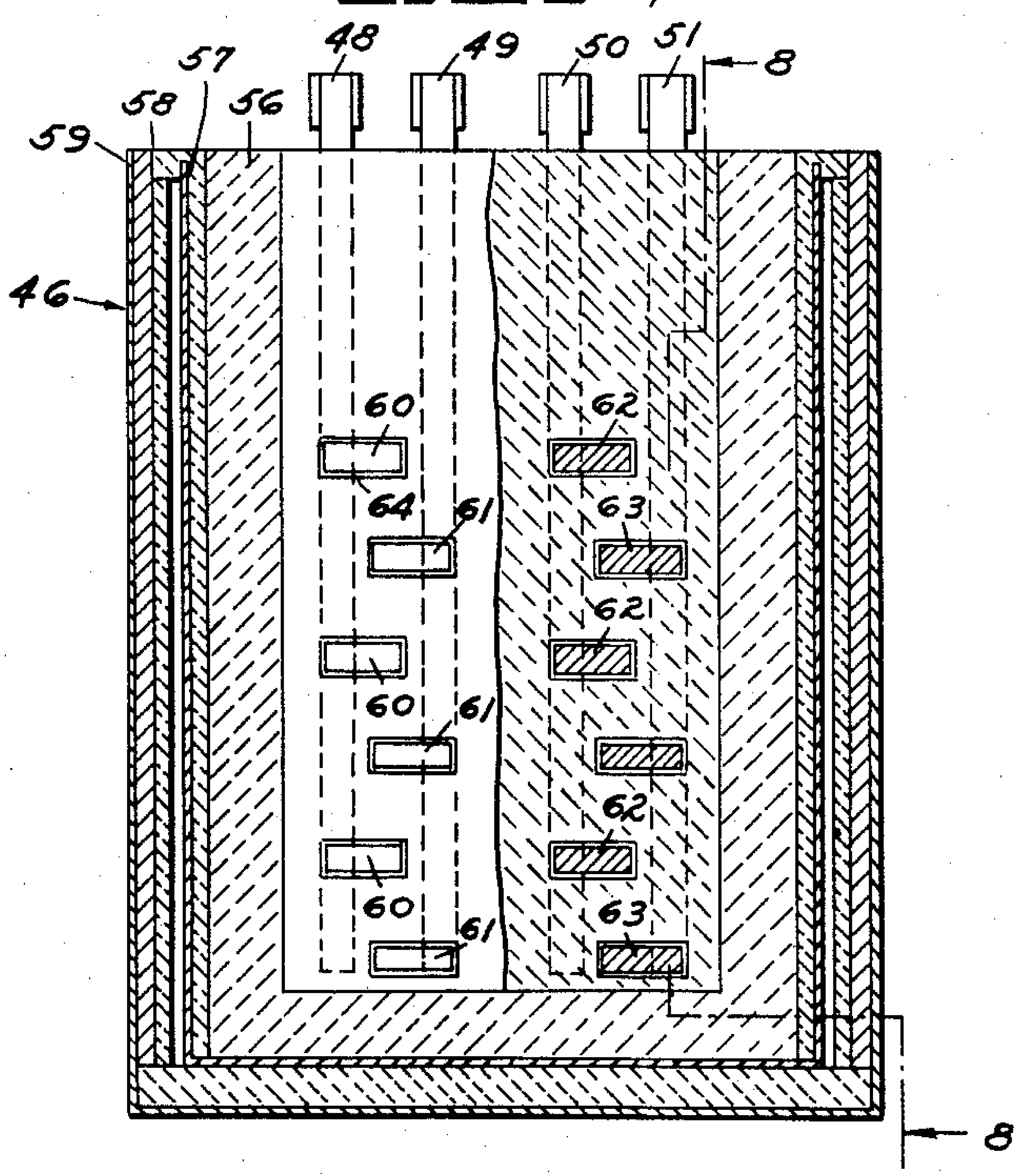


FIG. 8

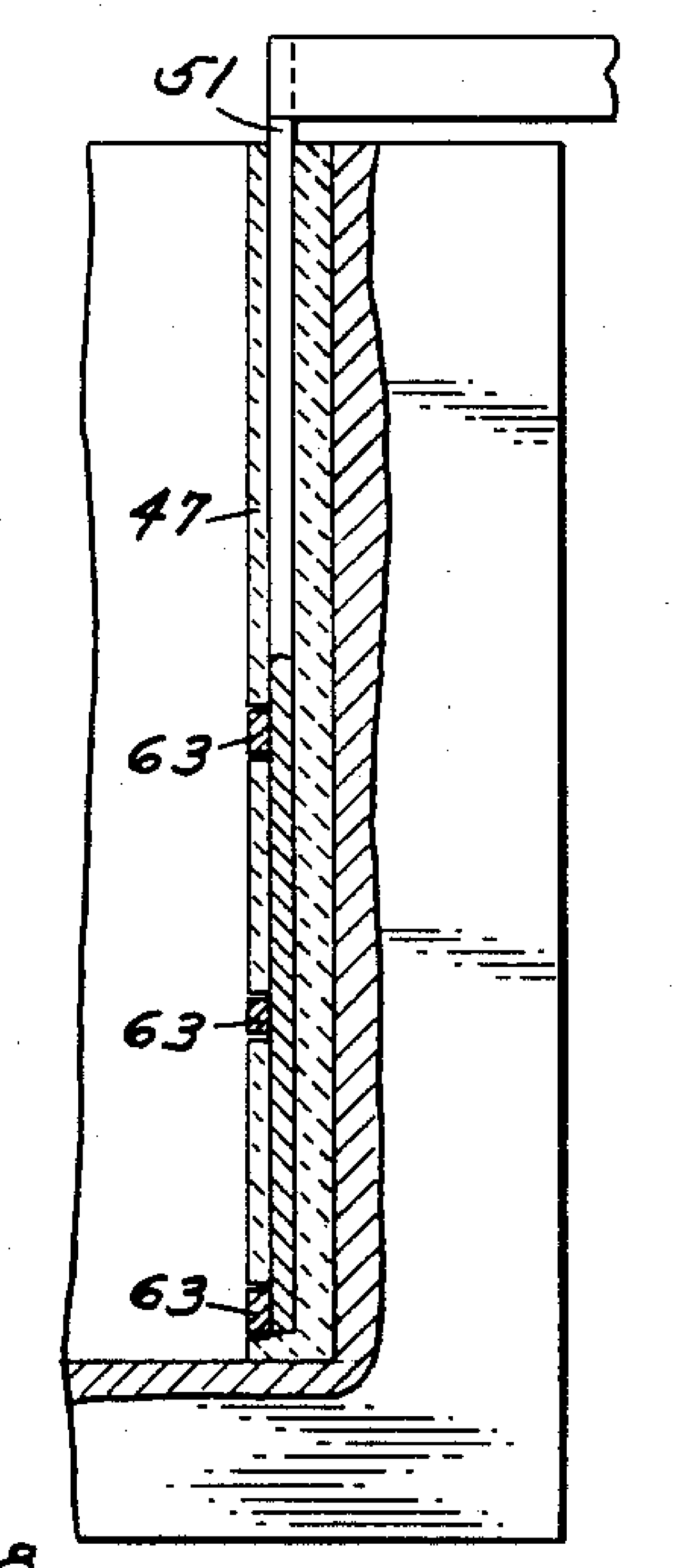
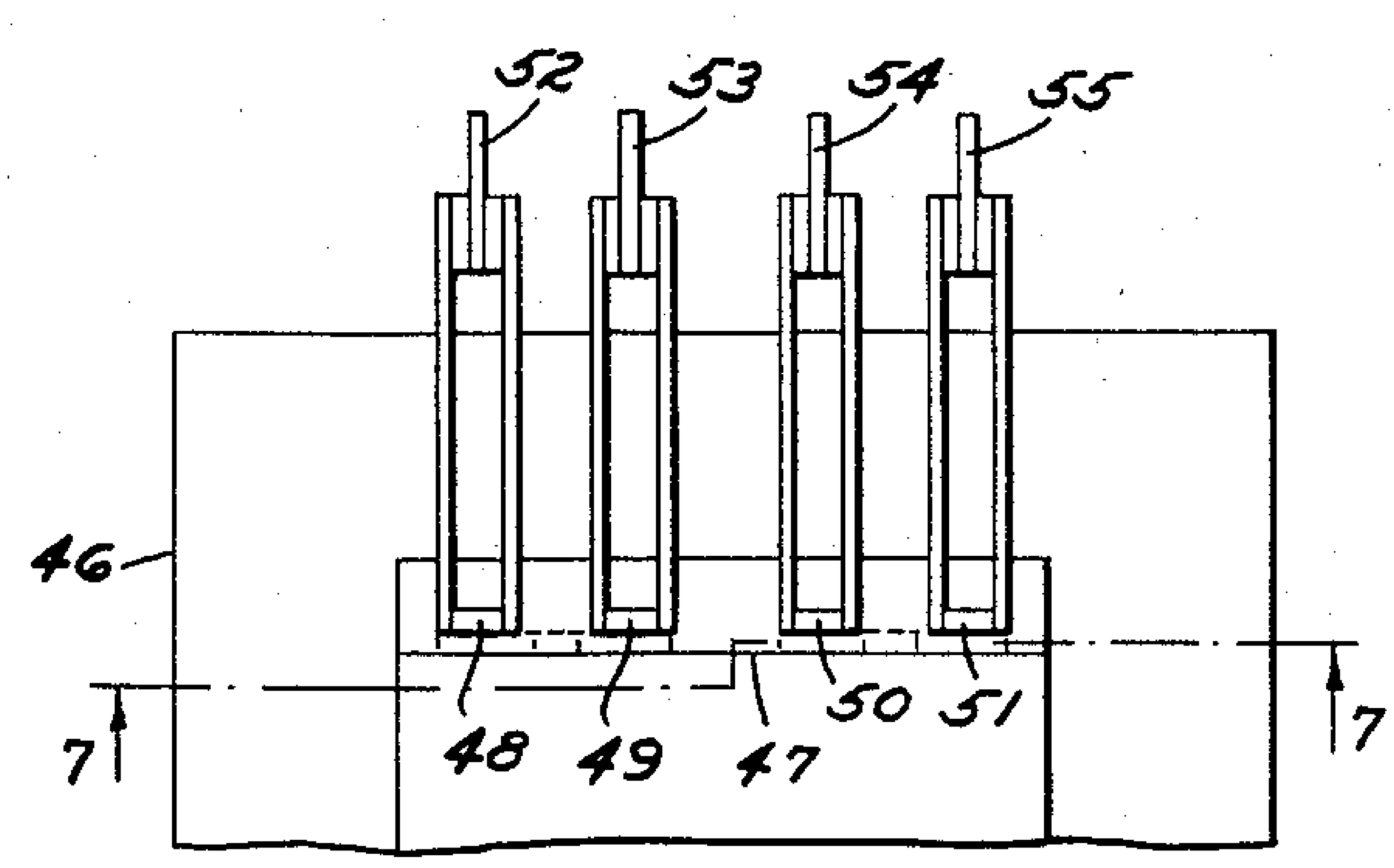


FIG. 6



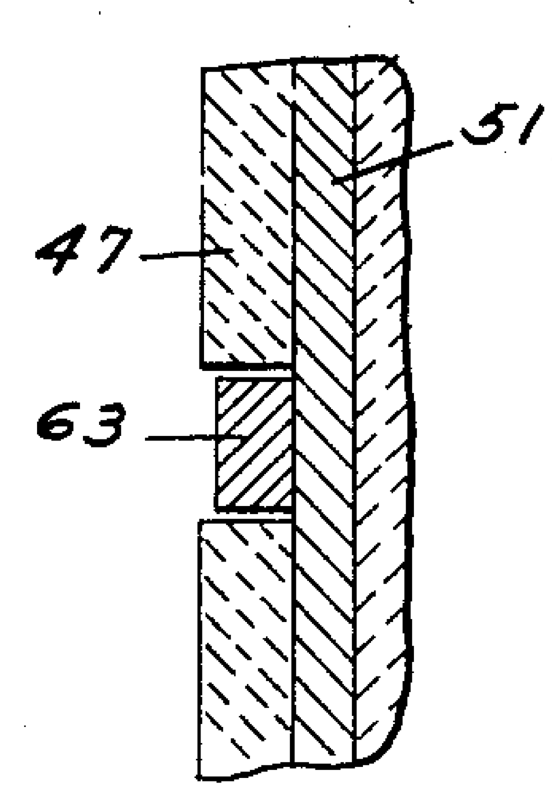


FIG. 12

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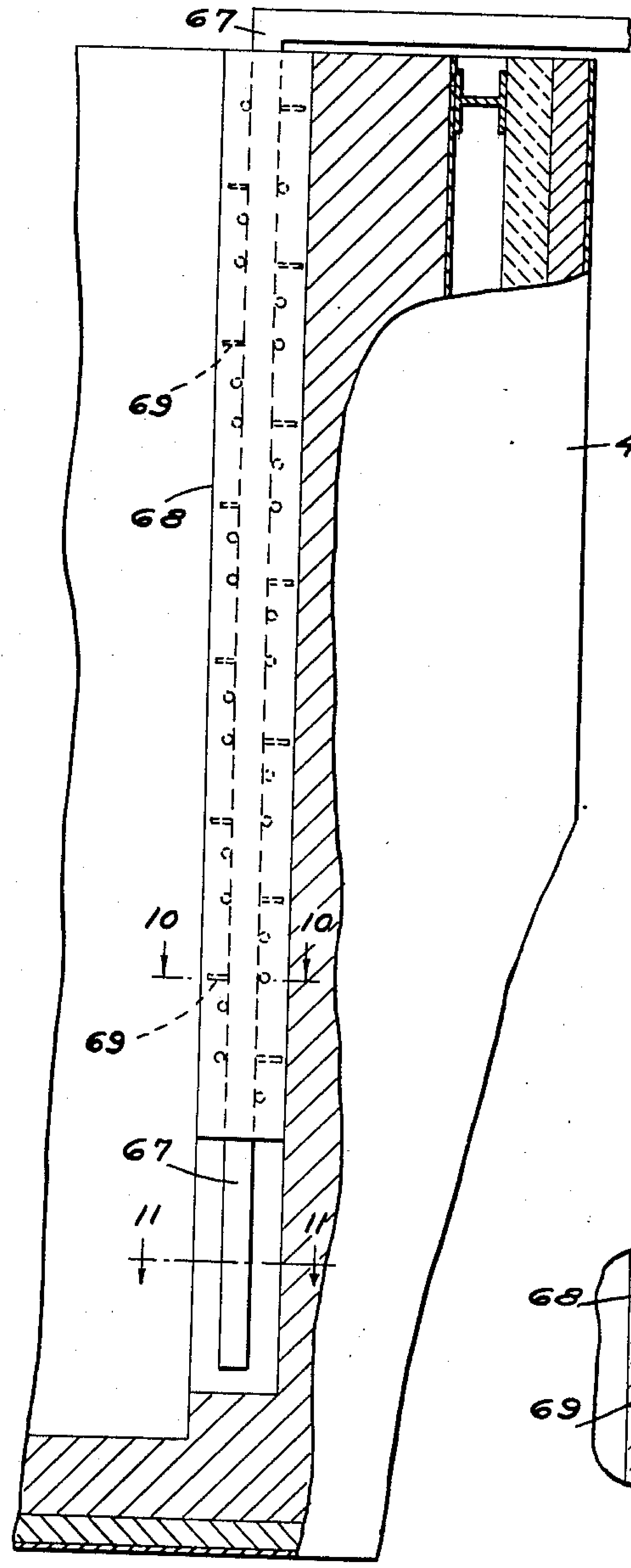
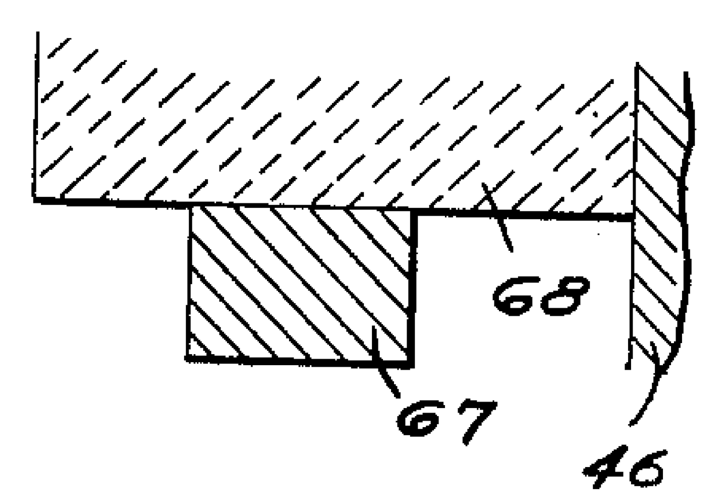


FIG. 9

FIG. 11



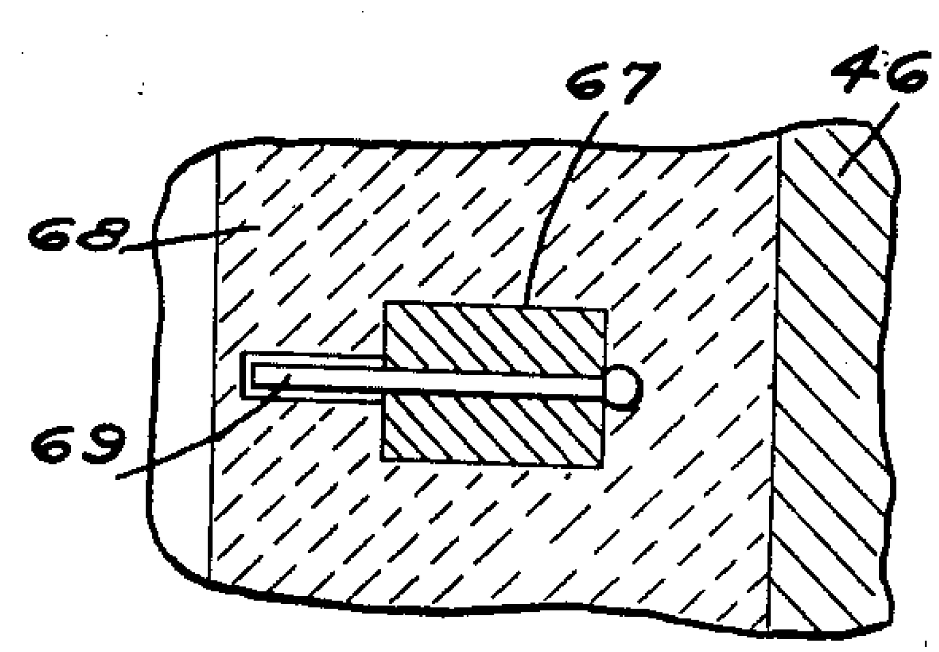


FIG. 10

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United States Patent Office

2,953,614

Patented Sept. 20, 1960

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2,953,614

ELECTRODE FURNACE

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Filed Sept. 20, 1957, Ser. No. 685,161

11 Claims. (Cl. 13—23)

This invention pertains to an electrode furnace wherein each electrode may have either or both its hot leg portion and its cold leg portion embedded in a refractory material with spaced lateral projections providing spaced supports thereto. The projections may have an exposed end surface for electrical conduction. In an electric salt bath furnace wherein the electrodes are subject to wear, it has been found advantageous to hang the electrodes over the furnace wall so that they may be easily removed and replaced. It is also desirable to cover completely the molten bath in order to minimize heat and vapor loss to the atmosphere from the top of the bath. In the past, it has been found difficult to provide a completely covered bath and, at the same time, permit a removable electrode construction because the spaces between electrodes, between electrodes and the furnace cover, and between electrodes and the furnace wall could not readily be sealed or completely covered.

This invention provides for embedding the supporting portion of each electrode assembly in a monolithic refractory material or casting and for utilizing such casting as a segment of the furnace cover which, with other similar castings, form a substantially completely covered furnace area while still permitting individual electrode removal.

In a preferred embodiment described below, the refractory material is covered with a metal top. A horizontal row of castings is placed on a furnace wall. Hinged to the metal top is an access cover which may be pivoted about the hinges to provide an opening for work insertion into the bath. The supporting or horizontal cold leg portion of the electrode assembly extends beyond the casting outside the furnace for connection to vertical power cables which extend downwardly to a power source. Any electrode may be quickly and individually removed by simply removing first the hinge pin, the metal top, then sliding the casting outwardly until the electrodes contact the furnace wall, tilting the casting about the furnace wall, and then lifting the casting in the direction of the tilt angle.

This invention also provides for replaceable electrode connected projections of relatively small size and inexpensive nature, which projections are fixed to the electrode at spaced intervals and are embedded in a refractory material which substantially isolates the electrodes from the salt bath and which cooperates with the conducting portions to support the electrode at spaced intervals along its length which at high temperatures prevents deformation of the electrode. By isolating the electrodes from the salt bath, the electrodes are protected from any corrosive action from the bath or products thereof at the air bath interface or in the bath itself.

In an electric salt bath furnace, the conduction through a salt bath between electrodes is used to bring the bath up to temperature and maintain it there. Especially in deep baths, where the electrodes are necessarily longer to provide for even bath temperature, during high bath temperatures the electrode weight tends to stretch and weaken its intermediate or upper portions. When this deformation takes place, the electrodes usually have to be replaced.

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A second cause for frequent electrode replacement is localized wearing away of a portion of the electrode. One worn spot on the electrode will require its complete replacement. With this invention, these costly replacements are largely avoided. This invention provides for projections or stubs which are fixed to each electrode at spaced intervals and further provides for the embedding of the stub-electrode combination in a refractory material. The refractory casting may expose one surface of the conductive stubs to the furnace bath. Stubs connected to electrodes of opposite polarity then co-operate to establish a current through the salt bath which provides for the temperature requirement. With this construction, the electrodes per se are not exposed directly to the salt bath and they are supported by the stubs at intervals along their length. This prevents localized wear of the electrodes and sagging and stretching at high temperatures. When the stubs become worn or defective, the refractory casting may be removed from the furnace and the stubs burned out or otherwise removed and replaced. This provides a considerable cost saving since only the worn stub need be replaced and each stub, of course, costs but a small fraction of an electrode. The portion of the bath in conventional furnaces which surrounds the electrodes is unusable since contact between the workpiece and electrode is undesirable. This means that power is required to heat a portion of the bath that is never used. With this invention, this unused portion is virtually eliminated and by recessing each stub in the refractory material, contact with the workpiece is prevented.

If desired, before casting the refractory material, the stubs may be wrapped in a combustible material which when heated will decompose leaving a small clearance between the stubs and the hardened refractory material. This clearance is provided to accommodate any difference in co-efficients of expansion of the electrode and the refractory material.

In addition to increased electrode life, this invention makes feasible electrode length not before practical. A limit had been imposed upon the length of an electrode due to the fact that its own weight would, at a high temperature, cause stretching and deformation. With this invention, any length electrode, and hence any depth of salt bath furnace, may be used since the electrode is supported at spaced intervals. In this connection, an embodiment of this invention is shown having pins attached to each electrode and embedded in the refractory. These pins are not exposed to the salt bath and are used for electrode support only. A lower portion of the electrode is exposed to the bath for heating purposes.

It is, therefore, an object of this invention to provide an electric salt bath furnace that may be completely covered and has electrodes with external projections which support the electrodes along its length and which may have exposed end portions for electric conduction. It is another object to provide a furnace that has individually removable electrodes. It is another object to provide a furnace that has a minimum heat loss due to radiation and has easily replaceable electrodes. It is an object to provide an electrode assembly having a vertical downwardly depending electrode for immersion in a salt bath and a horizontally, outwardly extending cold leg portion which extends over the furnace wall embedded in a refractory material. It is another object to have anchoring bars or pins transverse to said cold leg portion for rigid and secure holding in said refractory. It is a further object to provide a furnace construction having a series of refractory elements positioned side by side along a furnace wall to form a substantially complete cover to the atmosphere. It is another object to combine with this construction a furnace access cover.

A further object is to provide the bath or hot leg of the electrode with lateral projections and then embed this leg in a refractory casting. Another object is to provide each of the lateral projections with an open exposed end so that electrical conduction may occur between the projections of opposite electrodes. Another object is to isolate the bath or hot leg portions from the salt bath thereby preventing localized wear due to corrosion or conduction. A further object is to support each electrode at spaced intervals along its length to prevent electrode deformation. It is an object to provide a lead bath along the floor of the furnace to retain and suspend bath impurities for easy removal. A further object is to provide an additive in the lead bath which will help precipitate the sludge and foreign matter.

These and other objects and advantages will become more apparent when a preferred embodiment is described in connection with the drawings in which:

Figure 1 is a sectioned view of a furnace having the cold and hot legs of the electrode embedded in a refractory material and having a lead bath along its bottom;

Fig. 2 is a view taken at 2—2 of Figure 1;

Figure 3 is a plan view of a furnace having the cold legs embedded in refractory material;

Figure 4 is a section taken at 4—4 of Figure 3;

Figure 5 is a perspective view of an electrode assembly of this invention with cast concrete shown in phantom around the cold leg portion;

Figure 6 is a plan view of a salt bath furnace having four electrodes with each electrode having stub portions exposed to the salt bath;

Figure 7 is a section taken at 7—7 of Figure 6 showing the exposed stub surfaces and also sectioned stubs;

Figure 8 is a section taken at 8—8 of Figure 7;

Figure 9 is a partial cutaway view of a furnace having a second embodiment of this invention wherein the electrode supports are not exposed to the bath;

Figure 10 is an enlarged section taken at 10—10 of Figure 9 showing the clearance about each supporting pin which allows for expansion and contraction;

Fig. 11 is a section taken at 11—11 of Figure 9; and

Figure 12 is a view of a recessed stub.

In Figure 1 is shown an embodiment of this invention wherein furnace **9** has wall **12** which supports a refractory casting **13** which has embedded therein electrode **14** with cold leg **15** and hot leg **16**. As shown, hot leg **16** has laterally projecting stubs **17** having ends exposed to the salt bath **18** and electrical current flow takes place between exposed stub ends of electrodes of opposite polarity. In the embodiment shown in Figure 1, each electrode is cast in refractory material **13** and they are placed either side by side or between furnace wall extensions so as to provide a continuous wall along the top of the furnace. Plate **19** is then placed over this continuous wall to which cover **20** is pivoted to form a completely enclosed electrode furnace. In Figure 2 is shown a view taken at 2—2 of Figure 1 and the lower portion of refractory casting **13** in which stubs **17** can be seen. Also shown in Figure 1 is pan **10** along the bottom of furnace **9** which contains a lead bath **11** which is positioned to receive the sediment and sludge which would otherwise accumulate on the furnace floor and present a difficult removal problem. It may be desirable, especially in a neutral bath, to leave the pan dry to receive the sediment and waste. There may be a clearance of one-half inch between pan **10** and the furnace walls and pan **10** may be two inches high and one-eighth of an inch to one-quarter of an inch in thickness when comprised of a metal suitable to bath temperatures. Low carbon steel, or nickel alloys may be used for the pan metal. With bath **11**, the sludge may be skimmed off, reducing time and costs and furthering the life of furnace **9**. If desired, an alloy may be added to the bath **11** which will aid in precipitating or separating the foreign matter so that it can be easily skimmed from the top of bath **11**. A copper tin phosphorous alloy with the tin between 4% and 11% and the phosphorous between .25% and .35% or a copper (90%), tin (5%) and lead (5%) alloy may be used. Use of the copper additive is particularly advantageous when a copper or copper alloy coating on the steel is desired. Lead (67–97%) may be alloyed with either antimony, calcium or magnesium and lead may be alloyed with tin or with tin and magnesium in an amount to produce satisfactory molten conditions under bath temperatures when added to lead bath **11**.

Two embodiments are described below, one in which the cold legs are embedded in refractory material and one in which the hot legs are embedded in refractory material.

In Figure 3 is shown furnace **21** having cast concrete blocks **22** arranged side by side along wall **23** of the furnace. Each block **22** has embedded therein the cold leg of an electrode assembly **24** which is composed of a vertical electrode member **26**, which is attached to two spaced horizontal cold leg steel bars **27** which are in turn connected to copper leads **28**. Covers **31** are hinged at **32** to mountings on plate **33** which is placed over concrete blocks **22**. Also shown are thermocouple ports **36**, sighting port **37** and thermocouple **38**. Pots **41** are located side by side interiorly of furnace **21**.

In Figure 4 is seen more clearly the relationship between block **22**, electrode assembly **24** and wall **23** of furnace **21**. Also shown are three phantom outlines of the electrode assembly as it is removed from the furnace. In the first movement for removal, the assembly and block **22** are moved outwardly until the vertical electrode **26** is adjacent the inside of wall **23**, as shown by the dotted line *a*. In the next, or *b*, movement, the block and electrode are tilted about an outer point of wall **23** so that hinge **32** is cleared and then the electrode and block assembly are lifted in tilted position from the furnace to position *c*. Of course, if there are hinges and a metal cover such as top **33**, then these must first be disengaged or removed, but aside from moving these parts, individual electrode removal is possible without disturbing other furnace components.

Hold-down clamps **34** tightly secure inner pots **41** to the end walls of furnace **21** which provide support for covers **31** and inner pots **41** when and if all of the electrode assemblies **24** are removed from the furnace at one time. However, electrode assemblies **24** may be removed singly or otherwise, as desired. While each cement block **22** contains but one electrode in the embodiment shown in this invention, there might, of course, be as many electrodes in each block as desired.

Cable **42** is shown in Figure 4 attached to copper extension **28** and is connected to a power source which may be on a sub-floor level for convenience and safety. Mounting **35** is placed on each cover **31** to provide for an attachment for cover raising means (not shown). It is seen, then, by removing the hinge pins and top **31** that one or more electrode assemblies **24** may be removed for repair or replacement without disturbing the other components of this completely enclosed furnace and without any need for special sealing procedures after replacement.

In Figure 5 is shown an electrode removed from cement blocks **22**, but the outline of a block is shown in phantom as it would appear in a completed electrode assembly. Transverse rods **43** are fixed to the upper and lower portions of bars **27**, thereby providing a rigid anchor which tends to secure the electrode in block **22**. Adjustments and repeated removals of the electrode assembly from the furnace will not loosen the electrode in the block.

Looking at Figure 6 is seen furnace housing **46** having a monolithic refractory casting **47** placed therein. Located in the casting are electrodes **48** through **51** having cable attachments **52** through **55** connected to their upper ends respectively. Looking at Figure 7 is seen a cross section of housing **46** comprising a refractory ceramic pot **56**, metallic container **57**, a non-conductive refractory separator **58**, and a second metallic container **59**. Also shown are stubs **60** welded or otherwise attached to electrode **48**, stubs **61** attached to electrode **49**, and stubs **62** and **63** attached respectively to electrodes **50**, **51**. Stubs **60**, **61** are shown in elevation while stubs **62**, **63** are shown in cross section. About each electrode is seen a wrapping **64**, which will decompose with heat providing room for expansion and contraction of the electrodes in the refractory block. In Figure 8 is seen a section taken at **8—8** of Figure 7 showing stubs **63** and electrode **51**. As mentioned, the stubs may be recessed slightly in monolithic refractory **47** to prevent contact with the work (Figure 12). In this embodiment, electrodes **48** through **51** are situated in a single refractory casting and therefore may be lifted from the furnace together but they, of course, may be in separate castings or a pair in a casting or otherwise arranged. In this embodiment, electrodes **48**, **50** are of one polarity while electrodes **49** and **51** are of another. There will be current flow between stubs of different polarity along the length of the electrodes resulting in a uniform temperature bath. The stubs may be of the size, placement, or configuration to obtain desired resistances and temperature patterns.

The cable attachments **52** through **55** are secured to cables, not shown, after the casting has been placed in the furnace. Power is applied between the electrodes causing current flow between the stubs of opposite polarity. This will bring the salt bath up to temperature and maintain this temperature uniformly throughout while the power is applied. The length of the electrode and the temperature at which they may be used are increased due to the multiple supports supplied each electrode by its respective stub being formed in the refractory material. Each stub may rest on the refractory castings supporting the electrode weight above it. The stubs may be wrapped in a material which will decompose upon high temperatures so that clearance is provided for the expansion of the electrode during the high temperature. It is also seen that the electrodes are largely protected from the salt bath and that the current flow takes place between the stubs rather than the electrodes. This preserves the electrodes by preventing localized worn spots which would require their replacement.

Periodically casting **47** may be removed from the furnace and the stubs inspected. If any defective stubs are noticed they may be removed and replaced and the casting re-inserted into the furnace. The stubs may be replaced without disturbing the casting thereby saving time and resulting in further savings in time and cost. It may also be seen that in this invention, unused bath portions, such as that portion which usually surrounds the electrodes, is kept to a minimum thereby conserving the power ordinarily used to heat this unused portion. In other words, especially in the furnace in Figures 6–8, practically all of the bath is available for work.

In Figure 9 is seen an embodiment where an electrode is supported at its upper portion in a refractory casting while its lower portion is exposed to the salt bath. The pins attached to the electrode are used in this embodiment only to provide spaced supports for the electrode in the casting so that at high temperatures the weight of the electrode will not cause distortion of its upper portion. Furnace housing **46** houses and supports electrodes **67**, casting **68** and supporting pins **69**. Supporting pins **69** may be attached to electrode **67** by welding or by insertion through holes preformed in electrode **67** or by other means. Refractory material is then cast about the electrode and pins to form the structure shown in Figure 9. Before casting, each pin may be enclosed with a material which will decompose at high temperature so that a void is provided about each pin which will allow for expansion and contraction of electrodes **67** in casting **68**. Casting **68** may be secured to the wall of furnace **46** or may rest against the wall of the furnace to furnish the support to the electrode to prevent undesirable deformation. The portions of electrode **67** above castings **68** are sufficiently cool to prevent deformation and the portions below the castings are sufficiently short to prevent any stretching if the casting is fixed to the furnace wall or bending if the casting is not fixed to the furnace wall.

Shown in Figure 11 is the casting **68** which has only a side wall extending to the furnace bottom to support the electrode casting combination. A clearance between electrode **67** and the furnace bottom allows for electrode expansion. Electrical conduction between electrodes is facilitated by placing the uncovered sides of a pair of electrodes facing toward one another.

An enlarged section taken at **10—10** of Figure 9 is shown in Figure 10. Pins **69** are shown inserted through the electrode **67** which is embedded in casting **68**. The clearance or void between pins **69** and casting **68** can more easily be seen and it is this clearance which allows for expansion and contraction of electrode **67** in casting **68** as the temperature rises and falls.

While particular preferred embodiments have been disclosed and described above in detail, it will be understood that numerous modifications may be resorted to without departing from the scope of this invention as defined in the following claims.

I claim:

1. An electrode bath furnace comprising furnace electrodes, said electrodes each having a hot leg portion and a cold leg portion, supporting means projecting from said hot leg portion, refractory means, said hot and cold leg portions at least partially embedded in said refractory means to provide an enclosable furnace and with said hot leg portions at least partially supported by said means projecting therefrom, a second bath heavier than said electrode bath disposed along the bottom of said furnace for receiving and suspending furnace waste products thereby facilitating the removal thereof.

2. The furnace of claim 1 with said projecting means having end portions exposed to the furnace bath, said hot leg portions being substantially enclosed by said refractory means, and said hot and cold leg portions being embedded in removable refractory segments.

3. The furnace of claim 1 with said supporting means comprising laterally extending pins spaced lengthwise along said hot leg portions, said hot leg portion partially embedded in said refractory means so that a portion is exposed to the furnace bath for electrical connection therewith.

4. The furnace of claim 1 with said refractory means comprising individual refractory segments with a predetermined number of electrodes embedded in each segment, said segments alignable along a furnace wall to form a substantially continuous enclosure.

5. A bath furnace electrode assembly comprising a plurality of electrodes, electrode pins, refractory castings, said pins being attached to each electrode along a portion of the electrode, said portion being embedded in a casting so that at least one of said pins is supported by said casting and in turn supports said electrode with a portion of said electrodes exposed so that electrical conduction may take place in the furnace bath between said exposed portions.

6. An electrode heated salt bath furnace comprising a furnace enclosure having walls and a furnace bottom, electrodes, said electrodes having a portion embedded in refractory blocks, said blocks being aligned along the top of one of said walls, each of said blocks abutting a face of an adjacent block, said blocks forming a continuous wall portion, a cover being located between the blocks on said one wall and the opposite wall, so that the furnace bath is completely covered keeping radiation losses to a minimum.

7. An electrode heated salt bath furnace comprising a furnace enclosure having walls and a furnace bottom, electrodes, said electrodes having a portion embedded in refractory blocks, said blocks being aligned along the top of one of said walls, each of said blocks abutting a face of an adjacent block, said blocks forming a continuous wall portion, said electrodes comprising vertical depending members, horizontally outwardly extending members, the inner portion of each of said horizontal members being connected to the upper portion of one of said vertical members, said upper and inner portions being embedded in said block so that the vertical portions depend downwardly from said block and the horizontal portions extend outwardly from said block, said blocks being positioned along said wall so that said vertical portions are located interiorly of said furnace and said horizontal portions extend outwardly of said furnace for connection to a power source.

8. The furnace of claim 7 having a top plate, said plate being placed over said blocks, a furnace cover, said cover being hinged to said plate, said cover contacting said plate and said furnace walls so that when said cover is in a closed position, a completely covered furnace enclosure is provided keeping heating losses to a minimum, each of said blocks being independently removable from said furnace without disturbing said cover or said furnace walls.

9. The furnace of claim 8 where said inner horizontal portions of said electrodes have a plurality of transverse anchoring rods fixed thereto so that movement or looseness between said refractory material and said horizontal members is resisted.

10. A bath furnace electrode assembly comprising electrode means, supporting means, refractory means, said supporting means being attached to said electrode means and tangible with said refractory means so that at least a portion of said electrode means is supported by said supporting means to prevent electrode deformation, said supporting means comprising a plurality of lateral projections from said electrode means, said projections each having a portion contacting said refractory means so that projections which are in contact with and supported by said refractory means will in turn support the electrode means.

11. A bath furnace electrode assembly comprising electrode means, conduction means, refractory means, said electrode means being combined with said conduction means and this combination being embedded in said refractory means so that said conduction means has an exposed surface for electrical conduction and said electrode means is substantially isolated from said bath by said refractory means, said conduction means comprising a plurality of lateral projections from said electrode means, said projections each having an exposed surface and each projection supporting said electrode means in said refractory means, a clearance between each of said projections and said refractory means to allow for any difference in co-efficients of expansion between said electrode means and said refractory means.

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