April 28, 1959 W. H. GORGA ET AL 2,883,721

FURNACE CONSTRUCTION

Filed Dec. 27, 1956 3 Sheets-Sheet 1

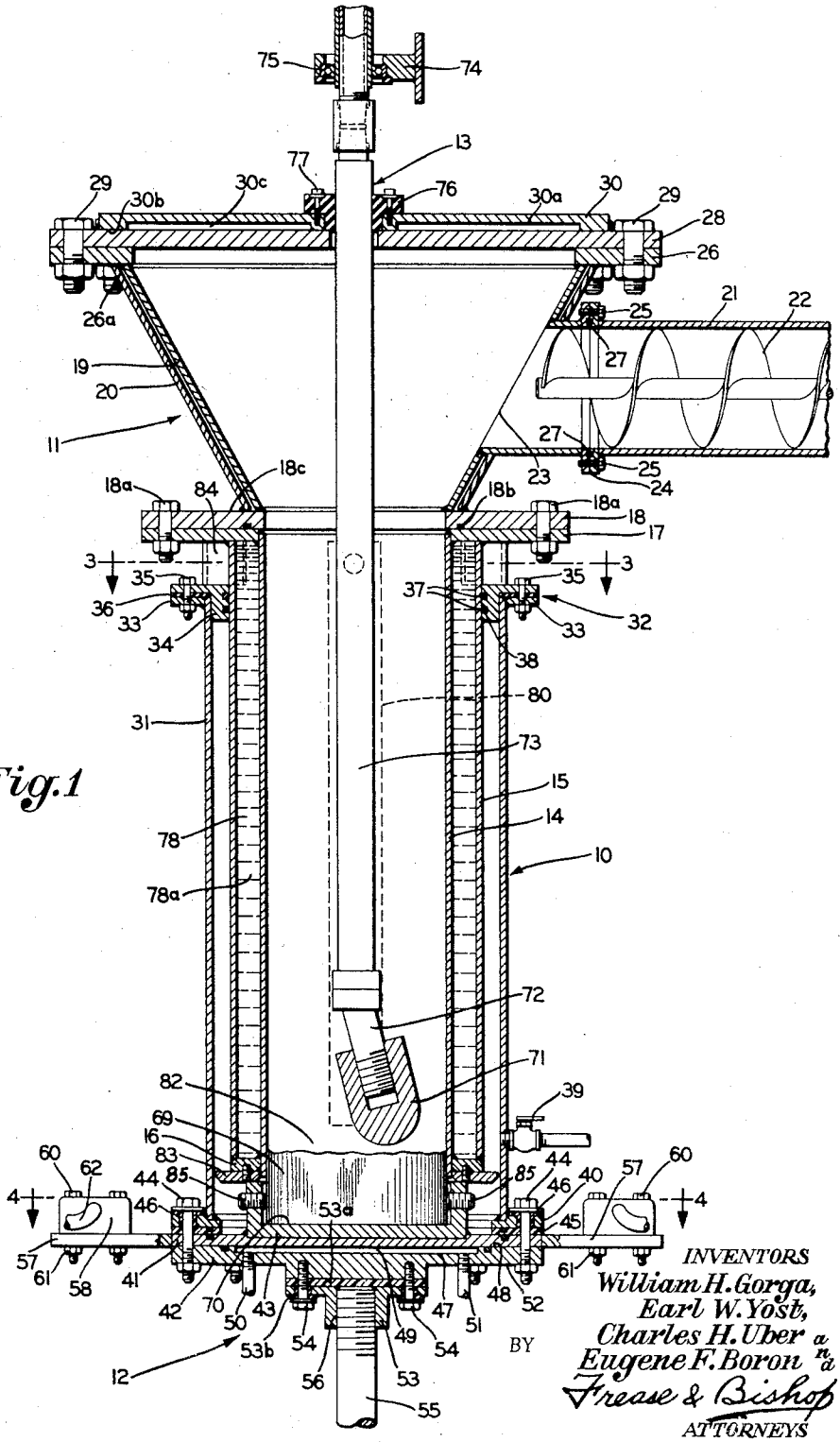


Fig. 1

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FURNACE CONSTRUCTION

Filed Dec. 27, 1956 3 Sheets-Sheet 2

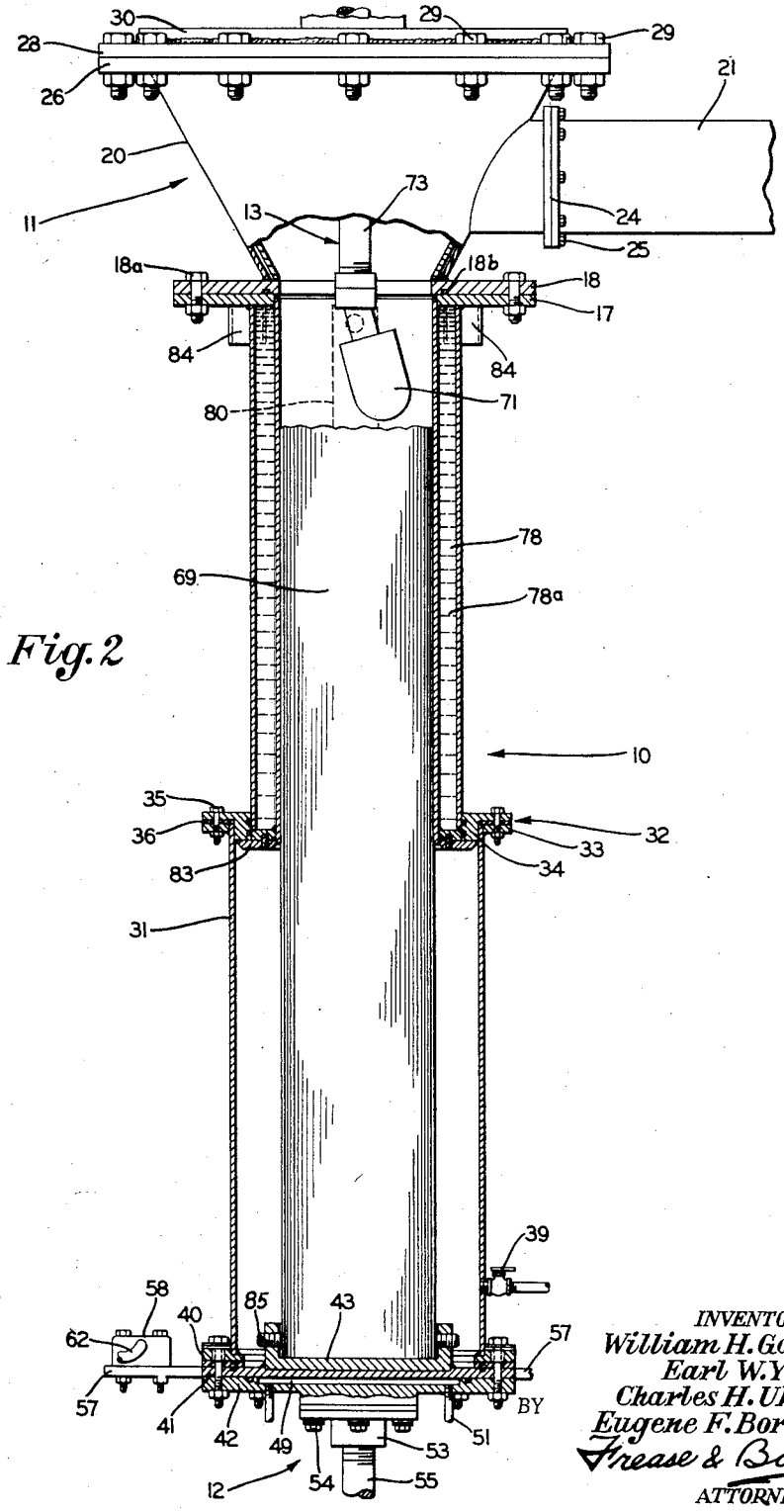


Fig. 2

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FURNACE CONSTRUCTION

Filed Dec. 27, 1956 3 Sheets-Sheet 3

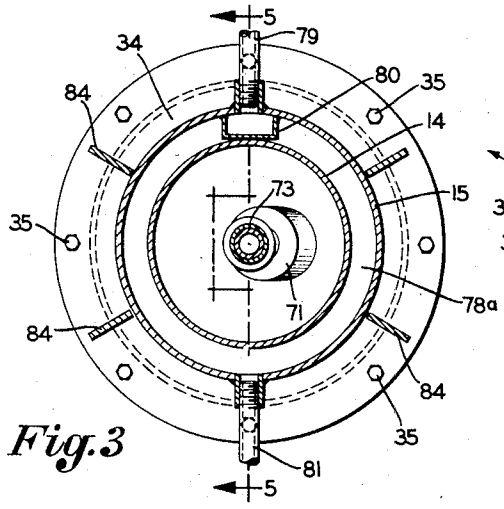


Fig. 3

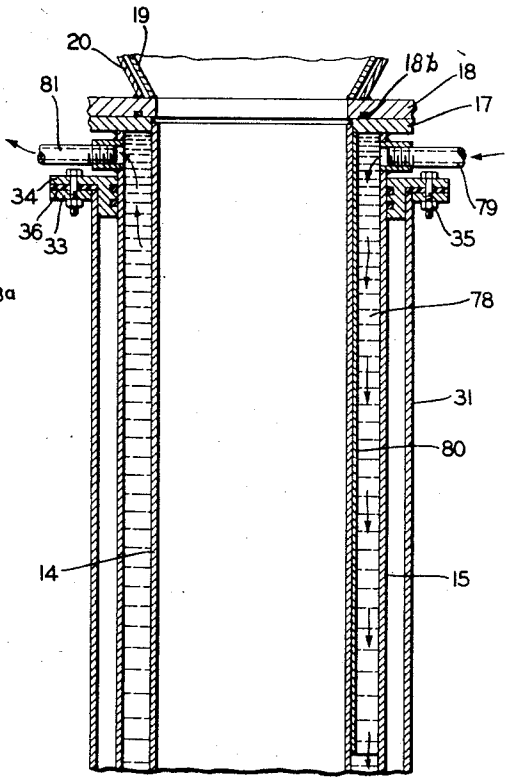


Fig. 5

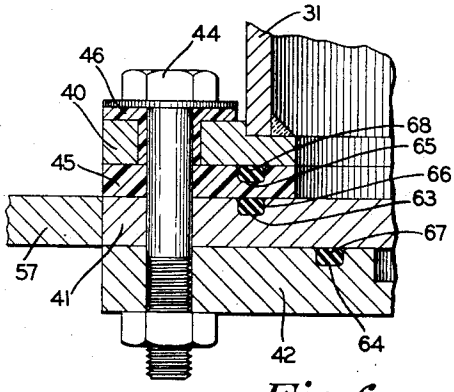


Fig. 6

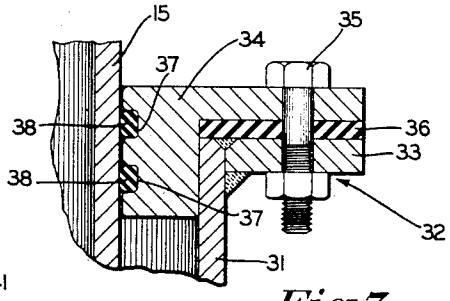


Fig. 7

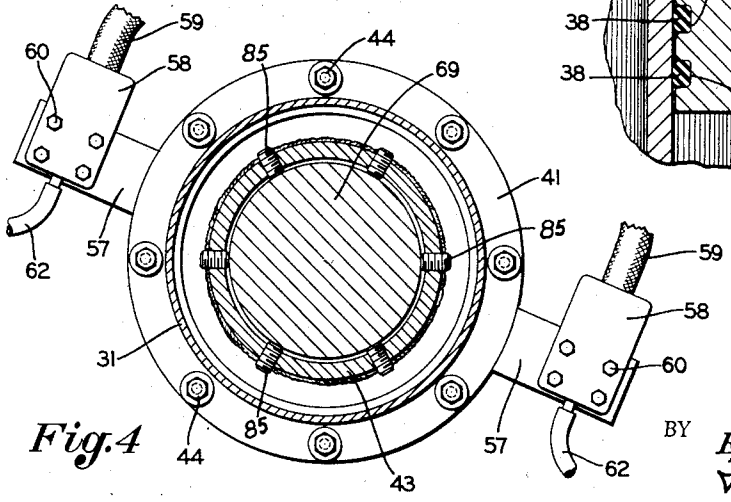


Fig. 4

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United States Patent Office

2,883,721

Patented Apr. 28, 1959

2,883,721

FURNACE CONSTRUCTION

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Application December 27, 1956, Serial No. 630,871

5 Claims. (Cl. 22—57.2)

The invention relates to furnace construction and more particularly to non-consumable and consumable electrode arc melting furnaces adapted for producing long titanium ingots.

The manufacture of products from titanium or titanium alloys requires the production of titanium or its alloys in the wrought form, and the wrought form in turn must be rolled or forged from an ingot or billet.

There are various methods of producing ingots from titanium sponge. One method of producing such ingots is to melt commercially pure titanium sponge in a non-consumable electrode arc melting furnace.

Another method of ingot production is to melt a consumable titanium electrode in an arc melting furnace.

Certain problems, however, have arisen from the use of such furnaces. The power requirements of these furnaces are usually quite large and therefore require an efficient means of supplying power to the ingot which serves as one of the electrodes. In prior furnaces, this has been accomplished by a pair of spaced power contact guide rolls positioned to engage the outer periphery of the ingot as it emerges from open ended mold shell walls.

It is only possible when using such rolls to obtain line contact between the rolls and the ingot. The surface of the ingot, however, is usually somewhat uneven, which reduces the total area of roll-to-ingot contact, itself quite small. Thus, a very high current density is present at the roll-to-ingot contact when the desired arc voltage and amperage conditions are obtained.

With such high current density, arcing may occur between areas on the ingot and areas on the contact rolls which are not in contact with one another. This arcing may cause pitting of the surface of the ingot resulting in a defective surface which may be more uneven than the original cast surface. Such surface conditions are a definite disadvantage, as additional surface preparation may be required to provide the ingot with proper surface conditions for rolling or forging.

It is desirable in arc furnaces to begin melting at full power. Furnace constructions which utilize the bottom of the mold as one electrode necessitate starting the melting operation at low power. This low power operation must be continued until a pool of molten metal is formed adequate to permit full power operations.

It is also desirable to produce ingots which are as long as possible. In prior furnaces the largest length ingot obtainable, is only slightly longer than the length of the furnace mold shell walls.

It is therefore a primary object of the present invention to provide a closed furnace construction of the non-consumable or consumable electrode type which overcomes the above stated difficulties and problems of prior constructions.

It is also an object of the present invention to provide a closed furnace construction with an efficient ingot power contact arrangement.

It is a further object of the invention to provide a closed furnace construction with an ingot power contact

which is rigidly connected to the ingot, yet which is easily detachable.

It is also an object of the present invention to provide a closed furnace construction in which the surface of the ingot produced requires minimum surface preparation, cleaning or chipping.

It is a further object of the present invention to provide a furnace construction in which it is possible to begin melting at full power.

It is still a further object of the present invention to provide a closed furnace construction in which the ingot produced is substantially longer than the length of the furnace mold shell walls.

It is also an object of the present invention to provide a closed furnace construction in which the ingot that is longer than the mold shell is molded and solidified and cooled in an inert atmosphere.

It is a further object of the present invention to provide a closed furnace construction in which the ingot may be stripped from the mold with minimum time loss.

These and other objects apparent to those skilled in the art may be obtained by the parts, constructions, arrangements combinations and subcombinations comprising the present invention, the nature of which is set forth in the following general statement, a preferred embodiment of which—illustrative of the best mode in which applicants have contemplated applying the principles—are set forth in the following description and illustrated in the accompanying drawings and which are particularly and distinctly pointed out and set forth in the appended claims forming a part hereof.

In general terms the furnace construction comprising the present invention, may be stated as including a mold surrounded by cooling means. The cooling means is surrounded by an outer shell which is telescopically movable vertically to provide an enclosure which is substantially longer than the mold.

Shell bottom means are detachably mounted on the lower end of the outer shell sealed thereto by sealing means. The shell bottom means also includes power attachment means, ingot engaging means, insulating means, and means for moving the outer shell vertically of the mold.

A hopper and hopper feed means are provided at the upper end of the mold. An electrode is rotatably mounted extending through the upper end of the hopper and along the longitudinal axis of the mold. The electrode, along with being rotatable, is vertically movable.

By way of example, a preferred embodiment of the improved furnace construction, showing the best mode in which applicants have contemplated practicing the invention is illustrated in the accompanying drawings forming part hereof, wherein similar reference characters indicate similar parts throughout the several views, and in which:

Fig. 1 is a vertical cross section of the improved furnace construction showing the outer shell in its uppermost position and the electrode in its lowermost position;

Fig. 2 is a vertical cross section showing the outer shell in its lowermost position and the electrode in its uppermost position;

Fig. 3 is a horizontal cross sectional view taken along the line 3—3, Fig. 1;

Fig. 4 is a horizontal cross sectional view taken on the line 4—4, Fig. 1;

Fig. 5 is a vertical sectional view showing the coolant flow, taken on the line 5—5, Fig. 3;

Fig. 6 is an enlarged fragmentary sectional view showing the sealing means at the bottom of the outer shell; and,

Fig. 7 is an enlarged fragmentary sectional view showing the sealing means at the top of the outer shell.

Referring more particularly to the construction illustrated in the accompanying drawings, the furnace construction comprising the present invention is indicated generally at **10** and includes a furnace charging hopper **11**, a furnace bottom **12**, and an electrode generally indicated at **13**.

The furnace **10** also includes an inner mold shell **14** surrounded by a mold water jacket or coolant shell **15**. An annular ring **16** is welded completely around its periphery on its inside edge to the bottom of the inner mold shell **14** and on its outside edge to the coolant shell **15**. The inner mold shell **14** and the mold water jacket **15** are also welded at their upper ends to an annular flange **17** thereby providing a coolant chamber.

The furnace charging hopper **11** includes a hopper bottom flange **18** bolted to flange **17** by bolts **18***a* and sealed by O-ring **18***b* to flange **17**. Flange **18** is also welded to inner tapered hopper side wall **19**, and outer tapered hopper side wall **20**. The space formed between the tapered hopper walls **19** and **20** and the bottom face **26***a* of the hopper top flange **26** and the upper face **18***c* of the hopper bottom flange **18** provides chamber means for cooling the hopper. Water or any other suitable coolant may be introduced through any convenient inlet and outlet pipes (not shown).

A hopper feed inlet tube **21** provided with screw conveyor feed means **22** is connected to a hopper feed inlet opening **23**. This connection may be formed by any suitable means, for example, as shown in the drawings, by a flanged coupling **24** secured with bolts **25**. The feed inlet opening **23** is integral with the tapered hopper side walls **19** and **20**, and is sealed at the flanged coupling for example with O-rings **27**.

The furnace charging hopper **11** further includes a hopper top flange **26** secured preferably by welding to the top ends of the tapered hopper side walls **19** and **20**.

The furnace charging hopper **11** is closed at the top by a hopper top wall **28**, which is secured to the hopper top flange **26** by bolts **29**. A top plate **30** is preferably welded to the hopper top wall **29**, and is provided with a recess **30**–*a* formed in the bottom face **30**–*b* thereof. A chamber **30**–*c* is thus formed by the recess **30**–*a* and the hopper top wall **28** thereby providing a means for cooling the upper end of the hopper **11**.

The inner mold shell **14** and the coolant shell **15** are surrounded by an outer shell wall **31** which is telescopically movable axially with respect to said inner mold shell **14** and coolant shell **15**. The outer shell wall **31** is provided with an upper sealing means **32**, as shown in Fig. 7.

The upper sealing means **32** includes a flange **33**, preferably welded to the top of the outer shell wall **31**, and an annular ring **34**. The annular ring **34** is secured to the flange **33** and thereby to the outer shell wall **31** by bolts **35**. The coupling or joint between the annular ring **34** and the flange **33** is sealed by a sealing ring **36**. The annular ring **34** is provided with grooves **37** which receive O-rings **38**, thereby permitting an air tight sliding fit between the annular ring **34** and the coolant shell **15**.

A gas inlet valve **39** is provided at the lower portion of the outer shell wall **31**. This permits the space formed between the outer shell wall **31** and the coolant shell **15** to be evacuated or filled with an inert gas.

The furnace bottom **12** includes a lower flange ring **40**, a power plate **41**, bottom support member **42** and an ingot engaging member **43**.

The lower flange ring **40** is preferably welded to the bottom end of the outer shell wall **31**. The power plate **41** and the bottom support member **42** are secured to the lower flange ring **40** by bolts **44**. The power plate **41**, bolts **44**, and bottom support member are electrically insulated from the lower flange **40** and the outer shell wall **31** by an insulation ring **45**, and insulation collars **46**.

The bottom support member **42** is provided with a

circular recess **47** in the upper face **48** thereof. The recess **47** and power plate **41** form a chamber **49**. A coolant such as water may be introduced into the chamber **49** through inlet pipe **50** and discharged through outlet pipe **51**, said pipes extending through the bottom face **52** of the bottom support member **42**, and into the chamber **49**.

An elevator shaft receiver **53** is secured to the bottom of the bottom support member **42** by bolts **54**. The shaft **55** is detachably secured to the receiver **53**, for example, by threads **56**. The elevator shaft **55** is connected to any suitable lift means (not shown) adapted to provide vertical movement, such for example as a hydraulic jack.

Bottom insulation **53**–*a* and insulation collars **53***b* insulate the receiver **53** and the lift shaft **55** from the bottom support member **42** and power plate **41**.

Preferably diametrically opposite power lugs **57** are connected to the outer periphery of the power plate **41**. Connected to the power lugs **57** are a pair of water cooled power connection members **58**, which are integral with the power lead lines **59**. This connection may be provided by any convenient means, for example, as shown in Figs. 1 and 7, by bolts **60** and nuts **61**.

In order to cool the power connection members **58**, water or any other suitable coolant flows through the power lead lines **59**, which are provided with a water passage (not shown), into the hollow interior (not shown), of the power connection members **58** and finally out coolant outlets **62**.

Power plate **41**, bottom support member **42**, and insulation ring **45** are provided with grooves **63**, **64**, and **65** respectively, which respectively receive rings **66**, **67** and **68**. The O-rings **66**, **67** and **68** are used to insure an air tight joint between the lower flange ring **40**, the insulation ring **45**, the power plate **41** and the bottom support member **42**.

The ingot engaging member **43** is preferably welded to the power plate **41**, and is cup shaped so that it may receive and clamp the end of a stub ingot **69**. The lower end of stub ingot **69** may be machined so that it affords good electrical contact with the upper face **70** of the ingot engaging member **43**. The ingot engaging member is provided with a series of circumferentially spaced set screws **85** which provides a convenient method of securing the stub ingot **69** to the ingot engaging member **43**, and which may be easily and speedily detached.

The electrode **13** is of the usual type used in non-consumable electrode arc furnaces, and includes a tip **71** which is preferably made of tungsten. The tip **71** is secured to an angled shaft **72** which is in turn secured to the main electrode shaft **73**. The electrode **13** is supported above the furnace by an electrode support **74** which is provided with bearings **75**. The electrode **13** is rotatable about its longitudinal axis, and is also vertically movable; and the electrode is insulated from the hopper top plate **30** by the insulation collar **76** which is fastened to the hopper top plate **30** by bolts **77**.

The main electrode shaft **73** may be hollow so as to provide cooling means for the electrode **13**.

The molding portion of the furnace is cooled by the introduction of a coolant **78** into the space **78***a* formed between the inner mold shell **14** and the coolant shell **15**. The coolant **78** enters through the inlet pipe **79** and is directed to the bottom of the space **78***a* by a U-shaped channel **80** forming a passage.

Coolant **78** fills the space **78***a* and is discharged therefrom through outlet pipe **81**. The direction of flow of the coolant **78** may be seen by the arrows in Fig. 5.

The furnace is operated by securing the stub of a previous ingot **69** to the engaging member **43**. The furnace bottom **12** is then assembled to the position shown in Fig. 1 of the drawings.

An arc is then struck between the ingot **69** and the

electrode tip **71**. Metal of a siutable size is fed into the furnace charging hopper **11** through the screw conveyor feed means **22** and drops therefrom into the mold interior **82**.

At the beginning of a melt, the outer shell wall **31** is in its uppermost vertical position (Fig. 1) while the electrode **13** is in its lowermost vertical position. As metal is fed into the mold **82**, it is melted by the heat of the arc, and is solidified by the coolant **78**.

As the ingot **69** builds up inside the mold **82**, the electrode **13** is moved upward while the outer shell wall **31** is moved downward. At the end of a melt the outer shell wall **31** is in its lowermost vertical position and the electrode **13** is in its uppermost vertical position. This final position is shown in Fig. 2 where the ingot **69** is illustrated as approximately twice the length of the mold **82**.

During the operation of the furnace the movement of the outer shell wall **31** is limited at its lower most position by engagement of ring **34** with stop ring **83** (Fig. 2) which is secured to annular ring **16**, and at its upper most position by engagement of ring **34** with stops **84** which are circumferentially spaced around coolant shell **15**, and welded thereto.

The gas inlet valve **39** also provides a means for purging the space between ingot **69**, and outer shell wall **31** when said outer shell wall **31** is in its lowermost position.

From one fundamental aspect, the improved furnace construction includes an open-ended stationary cylinder-like mold and an associated movable piston-like closure; and the piston-like closure has an outer shell telescopically enclosing the cylinder-like mold and has engaging means for mounting and electrically connecting the ingot being formed for telescopic movement within the cylinder-like mold.

In the improved construction, all of the walls for the hopper, its upper closure, the cylinder-like mold, and the ingot-engaging portion of the piston-like closure are provided with means for cooling such walls with any suitable coolant, such as water.

Furthermore, the various connections between the stationary and movable furnace parts are sealed in an air-tight manner so as to provide a hermetically sealed chamber in which titanium may be efficiently melted despite electrode movement within the chamber and withdrawal of the ingot from the cylinder-like mold as it is being formed.

In addition, the improved construction enables the use of a stub ingot in starting a heat which performs a number of important functions. First, the stub ingot fixed to the support and power supply closure member of the piston-like closure enables a heat to be started at full power.

Second, the stub ingot fixed to the support and power supply member provides efficient means for supplying electric power for the melting arc directly to the arc and to the pool of molten metal melted by the arc.

Finally, the stub ingot fixed to the support and power supply member enables the necessary force to be applied to the ingot as it is being formed for withdrawing it from the cylinder-like mold thereby enabling the production of a relatively long ingot within substantially shorter mold side walls, in which the elongated formed ingot has relatively smooth surfaces on its sides and lower end.

The invention provides a construction in which there is an efficient power contact arrangement between the power supply and the ingot, in which the efficient power contact is easily and speedily detachable, in which the produced ingot requires a minimum of surface preparation, in which the ingot is cooled in an inert atmosphere, in which the ingot is readily removed from the furnace, and in which an ingot substantially longer than the mold wall may be produced.

Thus, the furnace construction comprising the present invention overcomes the above-stated difficulties and problems of prior constructions and meets the necessary requirements.

In the foregoing description certain terms have been used for brevity, clearness and understanding, but no unnecessary limitations have been implied therefrom as such words are used for descriptive purposes and are intended to be broadly construed.

Moreover, the embodiment of the improved construction illustrated and described herein is by way of example and the scope of the present invention is not limited to the exact construction shown.

Having now described the invention, construction, operation and use of a preferred embodiment thereof and the advantageous new and useful results obtained thereby; the new and useful furnace construction and reasonable mechanical equivalents thereof obvious to those skilled in the art are set forth in the appended claims.

We claim:

1. Furnace construction including a fluid-cooled, tubular-walled mold, closure means for the upper end of the mold, material feed means communicating with the upper end of the mold, axially movable electrode means extending through said closure means and into said mold; bottom closure means for the lower end of the mold including a bottom unit, and a tubular shell connected to the bottom unit and telescopically surrounding and axially movable with respect to said mold with a telescopic joint therebetween, means for sealing said telescopic joint in a fluid-tight manner; means for moving the bottom closure means axially of the mold in either direction, ingot-engaging means on the bottom unit below the mold, means for supplying power to said electrode and said ingot-engaging means, and the interior of the mold and bottom unit thereby being sealed in a fluid-tight manner from the atmosphere.

2. Furnace construction including a tubular-walled mold, closure means for the upper end of the mold, material feed means communicating with the upper end of the mold, axially movable electrode means extending through said closure means and into the mold, bottom closure means for the lower end of the mold including a bottom unit and a tubular shell connected to the bottom unit and telescopically surrounding and axially movable with respect to said mold with a telescopic joint therebetween, means for sealing said telescopic joint in a fluid-tight manner; means for moving the bottom closure means axially of the mold in either direction, ingot-engaging means on the bottom unit below the mold; means for cooling the mold, upper end closure means, electrode means, ingot-engaging means, means for supplying power to said electrode and said ingot engaging means, and the interior of the mold and bottom unit thereby being sealed in a fluid-tight manner from the atmosphere.

3. Furnace construction including a fluid-cooled tubular-walled mold, closure means connected with the upper end of the mold, means for sealing the connection between the mold and upper end closure means, material feed means communicating with the upper end of the mold, axially movable electrode means extending through said closure means and into said mold; bottom closure means for the lower end of the mold including a bottom unit, a tubular shell connected to the bottom unit telescopically surrounding and axially movable with respect to said mold with a telescopic joint therebetween, means for sealing said telescopic joint in a fluid-tight manner; means for sealing the connection between the bottom unit and tubular shell; means for moving the bottom closure means axially of the mold in either direction, the bottom unit including a power supply member and a mold-engaging member mounted on the power supply member below the mold, said moving means including a support member connected to the power supply member, the support and power supply members having walls forming a cooling chamber for the power supply member, sealing means for the connection between the support and power supply

members, and the interior of the mold and bottom unit thereby being sealed in a fluid-tight manner from the atmosphere.

4. Furnace construction including a fluid-cooled tubular-walled mold, closure means for the upper end of the mold, material feed means communicating with the upper end of the mold, axially movable electrode means extending through said closure means and into said mold, bottom closure means for the lower end of the mold including a bottom unit and a tubular shell, ingot-engaging means on the bottom unit below the mold, power supply means connected to the bottom unit, the tubular shell telescopically surrounding and being movable axially with respect to the mold with a telescopic joint therebetween, means for sealing said telescopic joint in a fluid-tight manner, means for moving the bottom closure means axially of the mold in either direction to alter the telescopic arrangement of the shell with respect to the mold, the shell and mold being provided with stop means limiting relative telescopic movement of the shell and mold in either direction, and the interior of the mold and bottom unit thereby being sealed in a fluid-tight manner from the atmosphere.

5. Furnace construction including a tubular-walled mold, closure means connected with the upper end of the mold, means for sealing the connection between the mold and upper end closure means, material feed means communicating with the upper end of the mold, axially movable electrode means extending through said closure means and into the mold, bottom closure means for the lower end of the mold including a bottom unit and a tubular shell connected to the bottom unit, means for sealing the connection between the bottom unit and tubular shell; means for cooling the mold, upper end closure means, electrode means and bottom unit; the tubular shell telescopically surrounding and being movable axially with respect to the mold with a telescopic joint therebetween, means for sealing the telescopic joint in a fluid-tight manner, the bottom unit including an ingot-engaging member below the mold, means for clamping a portion of an ingot to the ingot-engaging member, an ingot-arc power supply member connected to the ingot-engaging member, a support member connected to the power supply member, elevator means connected to the support member for moving the bottom closure means axially of the mold in either direction, stop means limiting relative axial movement between the mold and shell, and the interior of the mold and bottom unit thereby being sealed in a fluid-tight manner from the atmosphere.

References Cited in the file of this patent

UNITED STATES PATENTS

803,147	Appleby	Oct. 31, 1905
1,498,582	Soderberg	June 24, 1924
2,541,764	Herres et al.	Feb. 13, 1951
2,763,903	Herres et al.	Sept. 25, 1956

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,883,721 April 28, 1959

William H. Gorga, et al

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the grant, lines 3, 4 and 13, and in the heading of the printed specification, lines 5 and 6, name of assignee, for "Mallory-Sharon Titanium Corporation", each occurrence, read -- Mallory-Sharon Metals Corporation --.

Signed and sealed this 8th day of September 1959.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

UNITED STATES PATENT OFFICE

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