

[54] **ELECTRON-BEAM FURNACE FOR REMELTING ELECTRODES**

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[30] **Foreign Application Priority Data**

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[58] Field of Search 13/31; 219/121 EB; 164/52, 164/252, 130, 258, 323

[56] **References Cited**

UNITED STATES PATENTS

3,190,949	6/1965	Gruber et al.	31/31
3,342,250	9/1967	Treppschutt et al.	164/50
3,660,584	5/1972	Holzgruber et al.	13/14

FOREIGN PATENTS OR APPLICATIONS

1,166,199	10/1969	Great Britain	164/252
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[57] **ABSTRACT**

An electron-beam furnace for remelting metals in vacuum to produce an ingot has a chamber with a melting zone, a crystallizer and a mechanism bearing ingot supports and sleeves provided with a drive for their rotation around a vertical axis and also for their vertical movement. The mechanism includes a column having a carriage carrying oppositely mounted assemblies each including a pair of elements consisting of a bar sleeve and an ingot support and having a sealing valve common for each pair of elements; the axes of the ingot supports, sleeves, crystallizer and the axes of the means for feeding the bar into the melting zone are spaced equidistantly from the axis of rotation of the mechanism said above.

2 Claims, 3 Drawing Figures

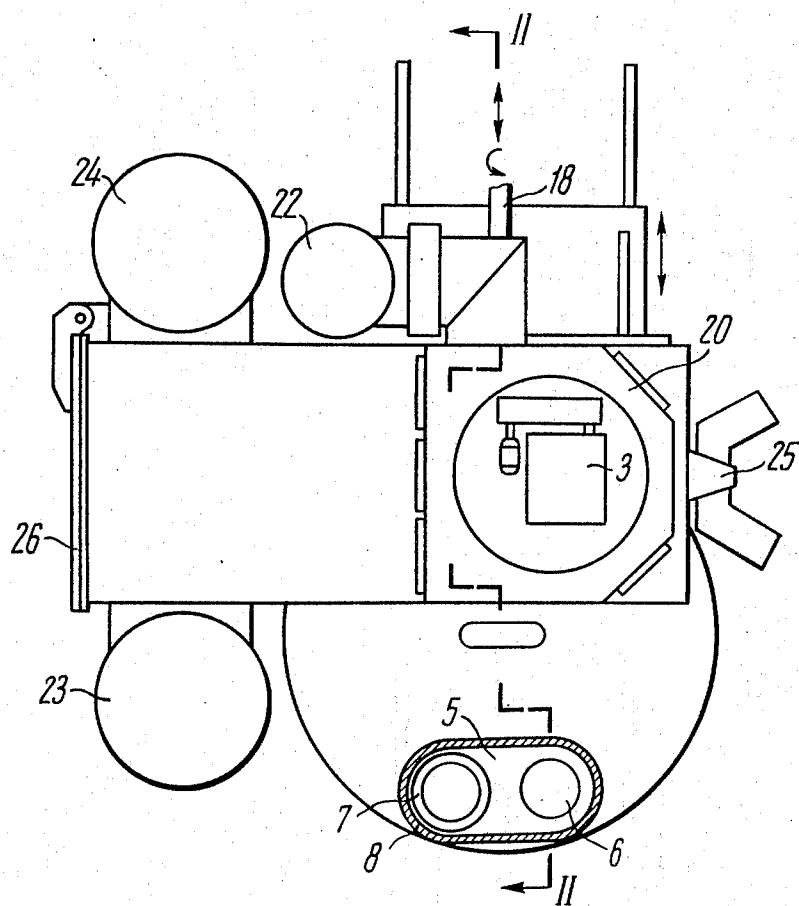


FIG. 1

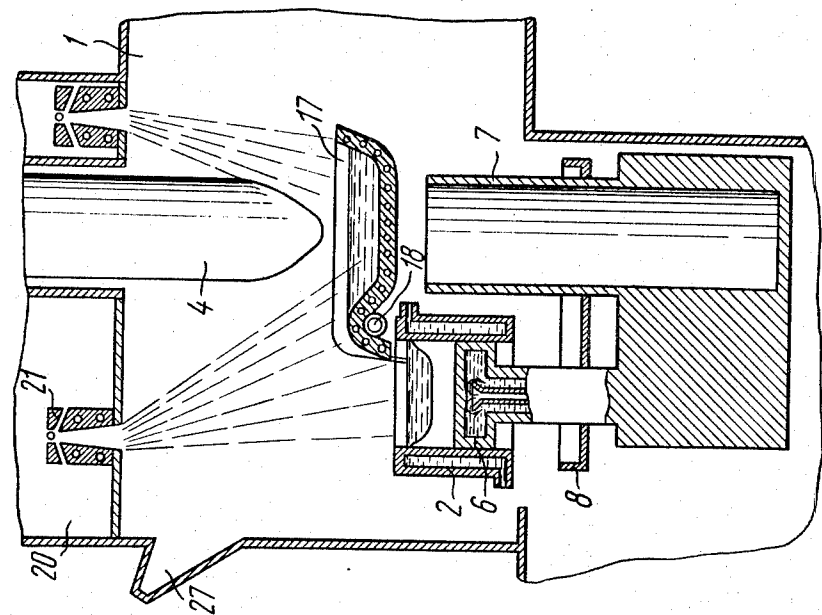


FIG. 3

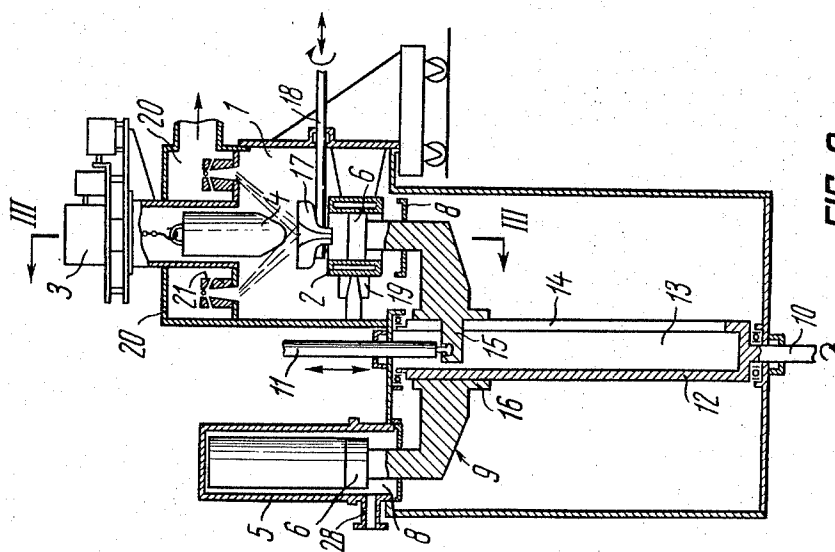


FIG. 2

ELECTRON-BEAM FURNACE FOR REMELTING ELECTRODES

This is a continuation, of application Ser. No. 187,310, filed Oct. 7, 1971, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to electron-beam furnaces for remelting metals and alloys under vacuum or a protective atmosphere.

More particularly, the invention relates to an electron-beam furnace for remelting metal bars in order to obtain high-quality metals and alloys containing a minimum amount of injurious impurities and having improved physical, chemical and mechanical properties.

2. Description of Prior Art

The most simple for the purpose are those furnaces wherein the furnaces have a melting chamber which is completely unsealed for preparing the furnace for the next heat after melting and cooling each ingot. Further, the furnaces which are currently used in industry have no sluice devices for charging metal bars and extracting ingots from the melting chamber.

These conventional furnaces are generally inefficient, since much time is required for auxiliary operations, i.e., cooling the ingot in the melting chamber, charging the bars and extraction of the ingots as well as evacuating and filling the melting chamber with a protective gaseous medium, for example, argon.

Attempts have been made to improve the operating capacity of such furnaces by charging the melting chamber with several metal bars in order to obtain several ingots simultaneously. However, such a use of the furnaces involves a number of problems due to the difficulty of handling the ingots and metal bars in the melting chamber. Besides, these furnaces do not provide the continuous process of metal melting.

Also, known are furnaces for melting under vacuum or a protective gaseous medium, such furnaces having sluicing devices in the form of prechambers designed for housing metal bars and ingots being sluiced therein. These prechambers comprise sluice valves sealing the cavities of the prechamber and melting chamber during the sluicing, said prechambers being arranged at the top and bottom or only at the bottom of the melting chamber in axial alignment with a crystallizer.

The prechambers are mounted on the melting chamber in a fixed position or are made separable from the melting chamber and displaceable towards the crystallizer axis.

Owing to the presence of prechambers any involved unsealing of the melting chamber can be avoided during the sluicing operation, but in this case the furnace height is considerably increased and the time required for auxiliary operations is appreciably lengthened, since it is necessary to operate the prechamber gates, to displace the prechambers or to interrupt the melting during the sluicing, if the prechambers are mounted in a fixed position.

There has also been proposed a known apparatus for remelting metals and alloys under vacuum or a protective gaseous medium, comprising a sluice device for charging metal bars and extracting ingots without breaking the vacuum in the melting chamber. This apparatus permits the reduction of the furnace height and

the time required for the auxiliary operations. In this apparatus the melting chamber communicates, via a sluice, with at least one prechamber designed for sluicing the ingots and bars handled by means of at least one mechanism supporting, on its turntable part, vertically movable crystallizer supports for building up an ingot.

The turnable portion of the mechanism for handling the ingots and the metal bars together with the supports is housed within the melting chamber and is equipped with several sluice valves which are pressed to the melting chamber top cover by this mechanism for sealing the chamber, said prechamber being mounted on the melting chamber.

The sluice valves are connected with the supports on which ingots are built up, or with ingot cases.

However, in this prior art apparatus or furnace, the ingot support and bar sleeve are spaced at 180° from each other, and in consequence many operations are required to be carried out with the turnable portion of the mechanism for handling bars and ingots in order to extract the finished ingot and charge the material for the next melting. The ingot support and bar sleeve are cantilever mounted at the lower end of the vertical rod adapted for their vertical movement and rotation around its axis. Thus, the carrying capacity of the sluice device depends on the rod rigidity. Besides, the remelting of the metal billet directly in the crystallizer does not provide for the best possible results in improving the quality of the finished metal ingots.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a continuous electron-beam furnace having a higher production capacity owing to the increase in the effective working time due to the reduction of the time required for the auxiliary operations including charging and extraction.

It is another object of the present invention to provide a more compact and efficient mechanism for rapid handling the ingot supports and bar sleeves and bar stub ends in the furnace vacuum chamber.

Yet another object of the present invention is to provide a simple and reliable sealing and unsealing means for the prechamber, operable during the charging and extraction the vacuum in the vacuum chamber being maintained as required for its normal operation.

These and other objects are attained in the electron-beam furnace for remelting metals and alloys under vacuum or a protective atmosphere as described hereinafter the electron beam generator comprises a cooled crystallizer, for feeding the bar or metal piece to be remelted into the melting zone and a mechanism having a drive means for the rotation around the vertical axis thereof and a rod for the vertical movement of ingot supports and bar sleeves and stub ends, said ingot supports and bar sleeves being provided with valves for hermetically sealing the prechamber adapted for sluicing the stools and sleeves, wherein, according to the invention, said mechanism has a turnable column having an axial cavity adapted for housing a rod, and a longitudinal guide slot for the carriage bearing oppositely arranged assemblies, each of the assemblies including a pair of members consisting of a sleeve and a support and having a sealing valve common for each pair, the axes of said supports, sleeves, crystallizer and means

for feeding the bar being spaced at the equal distances from the axis of rotation of said mechanism.

Owing to the aforesaid construction of the mechanism for handling supports and sleeves, the furnace of the invention, is more compact, easier in use and can be reliably sealed. In addition, due to the higher maneuverability and carrying capacity of the mechanism, loss of time in the furnace operation is, reduced and the furnace production capacity is increased.

Preferably, the electron-beam furnace is equipped with an intermediate vessel mounted on a rod associated with the drive capable of rotating the rod around the horizontal axis and moving it therealong, and adapted for feeding the liquid metal produced during the bar melting, down into the crystallizer.

The intermediate vessel for remelting metals prevents separate pieces of metal from dropping into the crystallizer during melting the bar, and therefore makes it possible to obtain a more uniform chemical composition of the liquid metal thereby to improve the quality of the obtained solid ingot.

BRIEF DESCRIPTION OF THE DRAWING

The invention may be more readily understood from reading the following description of one embodiment of the electron-beam furnace, according to the invention, with due reference to the accompanying drawings wherein:

FIG. 1 is a top view of the electron-beam furnace;

FIG. 2 is a sectional view of the same furnace taken along II—II of FIG. 1; and

FIG. 3 is a sectional view of the same furnace taken along III—III of FIG. 2.

DESCRIPTION OF PREFERRED EMBODIMENT

The electron-beam furnace for remelting metals and alloys under vacuum or a protective atmosphere includes a vacuum chamber 1 (FIGS. 1, 2 and 3) with a cooled crystallizer 2 (FIGS. 1, 2) arranged therein, and means 3 for feeding bar 4 to be remelted into the furnace melting zone. The afore-said vacuum chamber 1 communicates with prechamber 5 adapted for sluicing supports 6 and sleeves 7 (FIG. 3) having valves 8 (FIG. 2) for air-tight connection with prechamber 5. Ingot supports 6 and sleeves 7 for bars 4 and stub ends are cantilever mounted on a mechanism 9 having drive rods 10 and 11 for their rotation around the mechanism vertical axis and vertical movement within vacuum chamber 1.

Mechanism 9 has a rotatable column 12 provided with an axial cavity 13 for rod 11 and longitudinal guide slot 14 for carrier 15 connecting rod 11 with carriage 16 by means of a hinge joint, said carriage bearing diametrically opposite assemblies arranged opposite ends of the column 12 each assembly includes a pair of elements consisting of a sleeve 7 and a support 6. Each of the two pairs has a common sealing valve 8. It should be noted that the axes of supports 6, sleeves 7, crystallizer 2 and means 3 for feeding the bar into the melting zone are spaced equally from the axis of rotation of mechanism 9.

Vacuum chamber 1 houses an intermediate vessel or melting pot 17 rigidly mounted on the horizontally arranged rod 18 rotatable around its longitudinal horizontal axis and movable along this axis. The intermediate vessel 17 serves for feeding the liquid metal, pro-

duced during melting the bar 4, down into crystallizer 2.

Crystallizer 2 is rigidly fixed in vacuum chamber 1 by means of a fixture or stop 19.

Above vacuum chamber 1 a means 3 for moving the melted bar 4 in the vertical direction and turning it around the vertical axis is mounted in axial alignment with intermediate vessel 17.

At the top of vacuum chamber 1 there is a chamber 20 having electron-beam heaters 21. Vacuum pumps 22, 23 and 24 (FIG. 1) are provided for evacuation of the furnace and maintaining vacuum therein. The furnace has a control panel 25, a hatch 26 for servicing the furnace and a viewing system 27.

The prechamber 5 has a connecting pipe 28 for communicating with one of the afore-mentioned vacuum pumps.

The electron-beam furnace operates as follows:

Prior to starting, the melting carriage 16 is positioned so that one of the assemblies including support 6 and sleeve 7 is within prechamber 5 and its valve 8 isolates said prechamber from vacuum chamber 1. Then the cap forming prechamber 5 is removed and bar 4 is placed into sleeve 7, and after that the cap of the prechamber 5 is replaced. Following this, prechamber 5 and vacuum chamber 1 are evacuated and carriage 16 is moved to its lower position by rod 11 through its drive, and column 12 is turned at an angle of 180° by the rotating drive via rod 10.

In this case the support 6 is arranged in axial alignment with crystallizer 2, and sleeve 7 being in axial alignment with metal bar 4 is located under means 3 for holding the bar.

Carriage 16 is raised to its upper position by rod 11 actuated by its special drive, and bar 4 is supportingly hung on a hook of means 3 and support member 6 enters the cavity of crystallizer 2.

Simultaneously a second support member 6 and sleeve 7 of the second pair or second assembly form and constitute the bottom of prechamber 5 together with valve 8 of the second sluice seal. Being pressed by carriage 16 to the top cover of vacuum chamber 1, they hermetically cut off prechamber 5 from vacuum chamber 1.

Air is admitted to prechamber 5, its cap is removed and a second metal bar 4 is placed into sleeve 7. The cap of prechamber 5 is replaced in its initial position, and the prechamber is evacuated by the pump connected to connecting pipe 28.

The intermediate vessel 17, which has been moved aside by the drive of rod 18 to open access to bar 4 and to take it up from sleeve 7 and anchor it on means 3, is now returned to its working position under the bar so that the liquid metal can flow from it down into crystallizer 2.

To carry out the melting of bar 4, electron-beam heaters or guns 21 are energized, and as a result of the intense heating, bar 4 is melted down into intermediate vessel 17, and from this vessel the liquid metal flows down into crystallizer 2 wherein the ingot is formed on the first support 6.

At the end of the melting the unused portion of the bar or stub end is raised up by means 3 so that it clears the space required for turning over intermediate vessel 17 by means of rod 18 which is in alignment with its horizontal axis of rotation, and the liquid metal remainder in this intermediate vessel 17 is poured down into

crystallizer 2. Then intermediate vessel 17 is withdrawn or moved along its axis of rotation by means of rod 18, and carriage 16 with the bar on support 6, which has been removed from the crystallizer 2, is lowered to its lower position and the bar stub end is placed down into sleeve 7 by means 3.

The procedure will now go on as follows. The drive associated with rod 10 is actuated to rotate column 12 with carriage 16 a half-way or 180° and rod 11 is driven to move carriage 16 in the vertical direction, i.e., in this case to raise it up to its upper position.

At the upper position of carriage 16, the ingot on first support 6 and the bar stub end in first sleeve 7 will be enclosed in prechamber 5, and support 6 of the second pair will be within the cavity of crystallizer 2. The second bar 5 will be, of course, anchored to means 3.

The unsealing of prechamber 5, extraction of the ingot and bar stub end as well as the installation of the new bar is carried out with the vacuum maintained in vacuum chamber 1. Intermediate vessel 17 is periodically withdrawn and reinstalled in its initial position for melting.

The operation of the electron-beam furnace described herein will now repeat in the sequence stated above.

Bars 4 may however be remelted with no stub ends left. For this purpose the end of the replacement bar is installed at the level of intermediate vessel 17 in which the liquid bath has been formed and the stub end of the preceding bar has been melted in. After cooling the bath bar 4 is raised to its initial position, for melting, by means 3.

Since the supports 6 and bar sleeves 7 are arranged in pairs with a common sluice valve, a number of handling operations having to do with the sluicing of ingots and bars during the ingot extraction and bar charging can be eliminated the resulting in a considerable reduction in time required for auxiliary operations and an increase in the furnace production capacity.

The provision of two pairs of ingot supports and bar sleeves on a turnable portion of mechanism 9 capable of turning the pairs of elements at an angle of 180° in relation to each other permits the sluicing the finished ingot, its extraction from the ingot support, removal of the bar stub end, installation of a new bar and evacuation of the sluice chamber to be carried out while anchoring the replacement bar and starting the melting process again.

Due to the arrangement of the turnable part of the mechanism for handling ingots and bars on a turnable column and to the provision of a hinge joint for coupling it with the vertical movement rod, the load lifting capacity of the mechanism can be increased, since all bending loads are received and withstood by the rigid

turnable column held at its ends in the vacuum chamber casing, and the hinge joint, coupling the rod with the mechanism turnable part, will relieve the vertical movement drive shaft from cantilever loads. This provides for much longer service life of rod 11 and its vacuum seal.

The ingot extractor mechanism described above in combination with the mechanism for turning the carriage on which ingot supports and bar sleeves are mounted in pairs, diametrically opposite to each other with the possibility of a simultaneous sluicing of each pair, successfully solves the above-mentioned problems that would be encountered in prior art continuous vacuum electric heat-treating furnaces.

The electron-beam furnace embodying the present invention has been found to be highly productive as a continuous furnace in vacuum metallurgy art.

What is claimed is:

1. An electron-beam furnace for remelting a bar of a metal or an alloy into ingots, in vacuum or in a protective atmosphere comprising: a chamber having a melting zone for melting a metal bar; a cooled crystallizer for forming an ingot out of molten metal from said metal bar, said crystallizer being arranged in said chamber; means for feeding the bar to be remelted into the melting zone, said means extending into said chamber; a prechamber communicating with said chamber for melting the metal bar; a mechanism for transporting the metal bar from said prechamber towards said means as well as for moving the ingot from said crystallizer towards said prechamber, said mechanism having an axis and including a turnable column having an axial cavity, said column having a longitudinal guide slot; a carriage mounted on said column; a rod arranged in the cavity of said column; a carrier inserted into the slot of said column and a hinge connecting said rod with said carriage, said carriage carrying on diametrically opposite sides thereof assemblies disposed at opposite ends of said column, each of said assemblies including a pair of elements consisting of a sleeve and a support member and having a sealing valve common for each said pair for sluicing said support member and sleeve in said prechamber, the axes of said support members, sleeves, crystallizer and means for feeding the metal bar being spaced from the axis of rotation of said mechanism at equal distances.

2. A furnace in accordance with claim 1, wherein an intermediate vessel is provided for feeding the liquid metal produced during the metal bar melting into said crystallizer, said vessel being mounted on a rod associated with a drive provided to turn said vessel around a horizontal axis and moving said vessel along this axis.

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