Apparatus for continuous manufacture of a slab ingot in which a vacuum chamber raw material for an ingot is melted and continuously charged into a water-cooled mold having a stationary rectangular side frame and a movable bottom plate, while the upper surface of the charged material is heated by a plasma electron gun located above the mold. The bottom plate of the mold is gradually lowered whereby there is obtained on the bottom plate a gradually solidified rectangular pillar-shaped ingot. The plasma electron gun is oscillated by a power source, such as a hydraulic cylinder so that the beam from the electron gun is reciprocated over the upper surface of the material in the mold whereby the temperature at the upper surface of the material can be made substantially uniform.

1 Claim, 3 Drawing Figures
APPARATUS FOR SWEEPING THE BEAM FROM A PLASMA ELECTRON GUN ON THE SURFACE OF A MOLD OF A CONTINUOUS INGOT CASTING DEVICE

BACKGROUND

a. Field of the Invention

This invention relates to a plasma electron gun arrangement in apparatus for the continuous manufacture of an ingot and more particularly to such gun arrangement for complete irradiation of the upper surface of material in a mold.

b. Prior Art

An ingot manufacturing apparatus is known in which ingot raw material is melted in a vacuum chamber and charged into a rectangular mold while the upper surface of the charged material is heated by a plasma electron gun located above the upper surface of the mold. The bottom plate of the mold is gradually lowered, whereby there is obtained on the bottom plate a gradually solidified rectangular ingot. In this case, however, the beam irradiation surface of the electron gun is usually a circle whereas the upper surface of the ingot is rectangular. As a result, there is produced the unfavorable result that there remains on the upper surface of the material in the mold a surface portion which is not irradiated.

SUMMARY OF THE INVENTION

An object of the invention is to provide an apparatus which is free from the foregoing unfavorable result.

According to the invention, in an ingot manufacturing apparatus of the type in which raw material is melted in a vacuum furnace and continuously charged into a water-cooled type mold having a stationary rectangular side frame and a movable bottom plate, the upper surface of the charged material being heated by a plasma electron gun located above the mold, the bottom plate being gradually lowered to obtain on the bottom plate a gradually solidified rectangular pillar-shaped ingot, there is provided an improvement comprising means for reciprocatingly moving the plasma electron gun by a motive source such as a hydraulic cylinder or the like, so that the beam irradiation by the electron gun may be substantially equalized over the entire upper surface of the material.

BRIEF DESCRIPTION OF THE DRAWING

An embodiment of this invention will next be explained with reference to the accompanying drawing, wherein:

FIG. 1 is a diagrammatical side elevation view of the apparatus according to the invention;
FIG. 2 is an enlarged sectional view taken along line II—II in FIG. 1;
FIG. 3 is a top plan view taken along line III—III in FIG. 2; and
FIG. 4 is a top plan view, corresponding to FIG. 3, of the prior art.

DETAILED DESCRIPTION

Numeral 1 denotes a vacuum chamber which is evacuated by a vacuum pump (not illustrated). Within this vacuum chamber 1 there are disposed a hopper 2 for supplying a main raw material and a hopper 3 for supplying an additive raw material. The hoppers 2 and 3 are provided with respective measuring devices 4 and 5 at their lower outlet ends. Below the hoppers 2 and 3 are respective conveyers 6, 7, which supply the respective materials to a common conveyer 8 which feeds the material through a guide 9 to a water-cooled mold 10.

A hollow hot cathode type plasma electron gun 11 is mounted above the guide 9 to melt the material therein and a hollow hot cathode plasma electron gun 12 is mounted above the mold 10 to maintain the material in molten state therein. The mold 10 is composed of a stationary rectangular side frame 10a and a movable bottom plate 10b.

Thus, the raw materials supplied to the conveyers 6, 7 from the respective hoppers 2, 3 are supplied by the conveyer 8 into the guide 9, while being mixed together, and are heated and melted by the plasma electron gun 11 so as to be de-gasified and refined, the resultant molten material then being charged into the mold 10. The upper surface of the molten material is heated by electron gun 12 thereby insuring that the material is molten thereat. At the same time, the bottom plate 10b of the mold is lowered at the same rate that the molten material is gradually solidified so that a solid rectangular ingot is continuously formed on the bottom plate 10b. Numerals 13 and 14 denote electric sources for operating the electron guns 11, 12 respectively, numeral 15 denotes a carrier gas supply system, and numeral 19 denotes a solenoid coil.

The above described structure is substantially conventional and, in lieu of a single gun, pluralities of plasma electron guns 11, 12 may be provided. In the case when three plasma electron guns 12 for temperature maintenance are used, beam irradiation is effected over three circular areas as shown in FIG. 4, and non-irradiated surface portions remain therebetween. This is not desirable and this invention seeks to remove this disadvantage.

To this end, each electron gun 12 is pivotally supported at a middle portion 16 thereof and the upper portions of the guns are connected in common by a connecting rod 17 to a motive or power source 18 such as piston of a common hydraulic cylinder. When a swinging movement is imparted to each electron gun 12 by the operation of the motive source 18, each circular irradiation area is reciprocated between a position shown by a solid line and a position shown by a dotted line as illustrated in FIG. 3. Thereby the upper surface of the ingot is uniformly heated and is substantially free from unheated surface portions. Consequently, beam irradiation is effected over the entire surface of the ingot which is thus kept in a substantially uniform heated condition whereby a uniform quality ingot can be obtained.

Thus, according to this invention, the plasma electron gun facing the upper surface of the mold is so displaced that the effective area of the irradiation beam is reciprocated over the surface of the ingot so that it becomes possible for the upper surface of the forming ingot to be subjected to uniform irradiation over the entire surface thereof. Hence, the disadvantage caused by the existence of non-irradiated surface portions can be simply and positively eliminated.

What is claimed is:

1. In apparatus for continuous casting of an ingot wherein molten material is introduced into a top of the mold and the bottom of the mold is continuously low-
3,820,586

3

er to withdraw solidified ingot from the bottom of the mold, a plurality of plasma electron guns being mounted above the mold to supply heat to the upper surface of the molten material in the mold, an improvement comprising means supporting the plasma electron guns for relative movement with respect to the mold so that the radiation beams from the guns can travel along the upper surface of the material in the mold, and power means for moving the guns in concert to effect reciprocal movement of the beams on said upper surface of the material in the mold; said means which supports the guns including a pivotal connection for each gun at the center thereof; said power means comprising a common hydraulic cylinder for said guns, and a connecting rod attached to said guns, said connecting rod being operatively coupled to said hydraulic cylinder; each of said guns producing a circular beam at the upper surface of the molten material in said mold, the mold having a rectangular shape at the top thereof with a width substantially equal to the diameter of the circular beams, said power means effecting movement of the guns so that the beams travel over overlapping reciprocal paths.

* * * *
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,820,586
Dated June 28, 1974

Inventor(s) Hiromichi Takei

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover sheet [73] should read -- Nihon Shinku Gijutsu Kabushiki Kaisha (Ulvac Corporation in English), Kanagawa-ken, Japan --.

Signed and sealed this 26th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR. C. MARSHALL DANN
Attesting Officer Commissioner of Patents