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J. L. MANGIN

2,857,445

CONSUMABLE ELECTRODE ARC FURNACE

Filed June 17, 1957

3 Sheets-Sheet 1

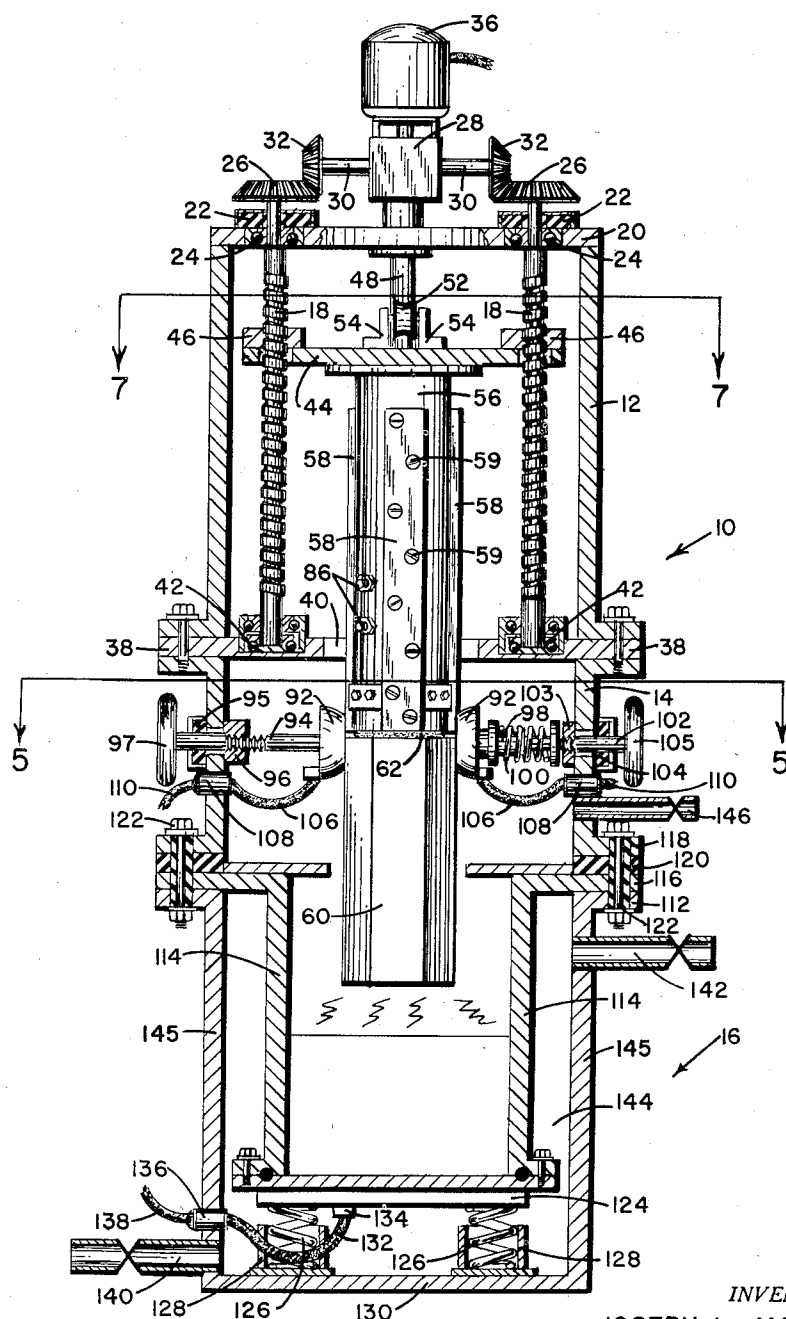


FIG. 1.

INVENTOR.
JOSEPH L. MANGIN

BY

Clarence Allen

AGENT

Oct. 21, 1958

J. L. MANGIN

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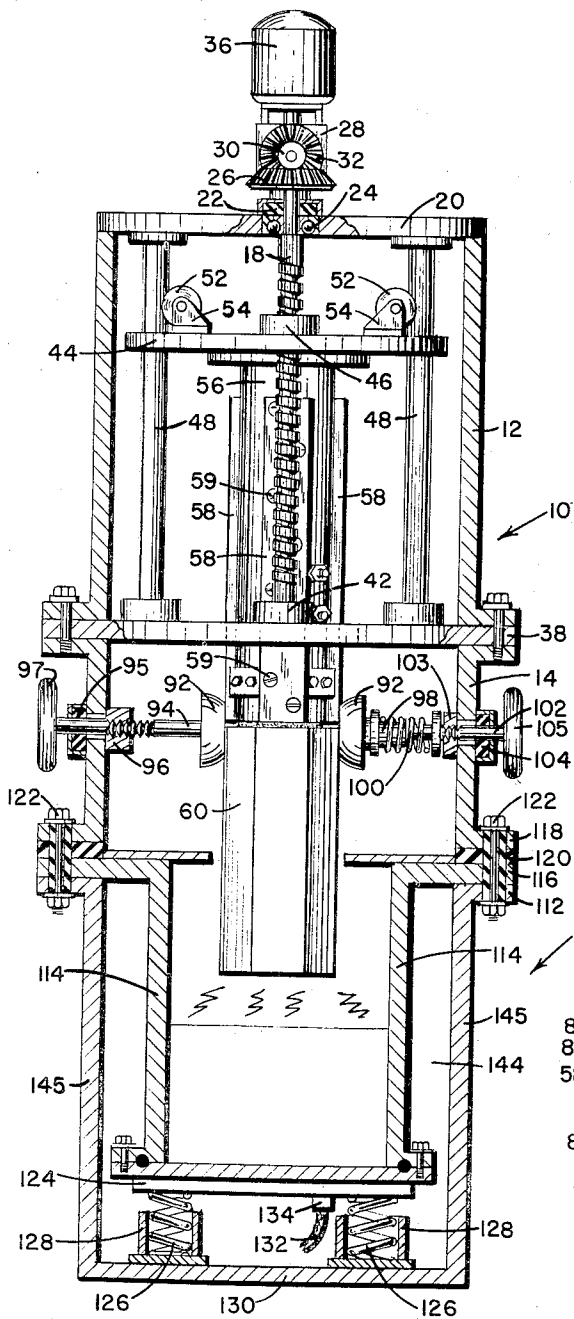


FIG. 2.

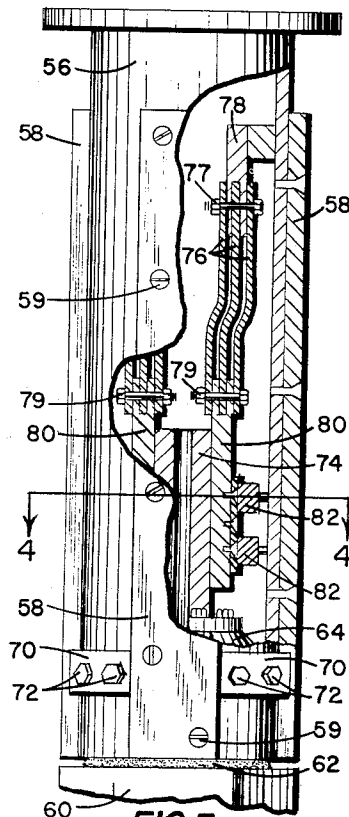


FIG. 3.

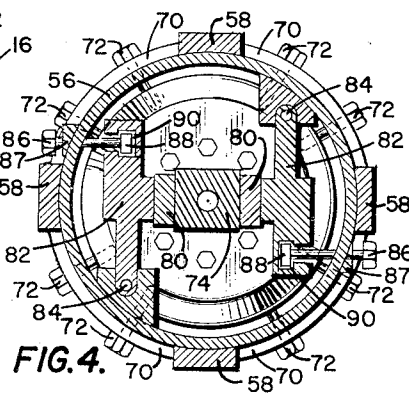


FIG. 4.

INVENTOR.
JOSEPH L. MANGIN

BY

Elementary

AGENT

Oct. 21, 1958

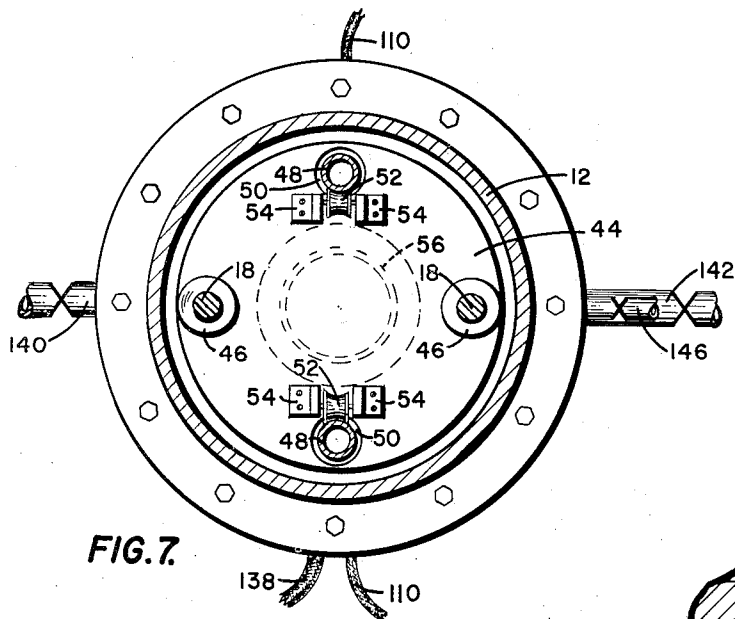
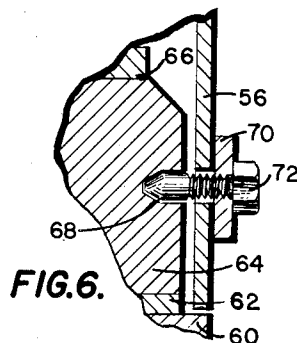
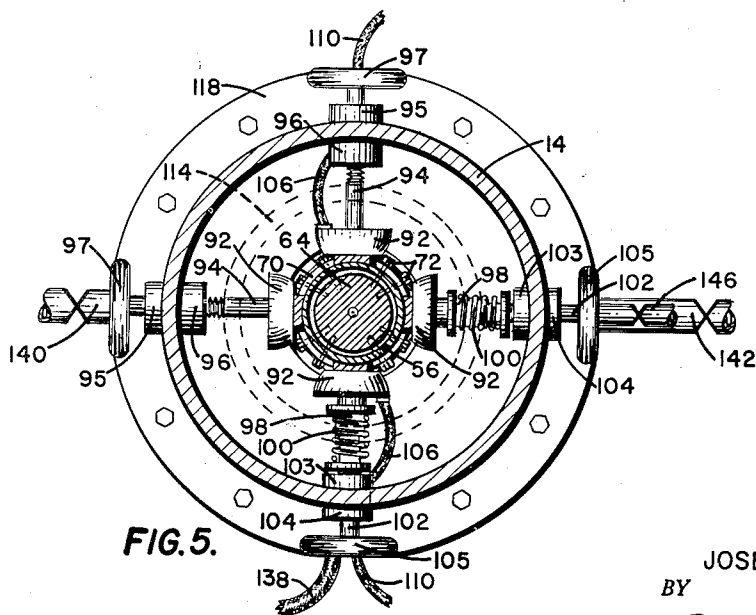
J. L. MANGIN

2,857,445

CONSUMABLE ELECTRODE ARC FURNACE

Filed June 17, 1957

3 Sheets-Sheet 3



INVENTOR.

JOSEPH L. MANGIN

BY

Clement Allen

AGENT

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2,857,445

CONSUMABLE ELECTRODE ARC FURNACE

Joseph L. Mangin, Las Vegas, Nev., assignor to Titanium Metals Corporation of America, New York, N. Y., a corporation of Delaware

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4 Claims. (Cl. 13—9)

This invention relates to arc furnaces, and more particularly to the type of furnace in which a consumable electrode is melted into a cooled crucible to form an ingot.

Consumable electrode arc furnaces are often employed for melting refractory metals such as titanium, zirconium, molybdenum and alloy steels. In general, they comprise a cooled crucible and mechanical means for gradually lowering the electrode as the melting action of the arc transfers metal into the crucible to form an ingot. The electrodes employed to produce heavy ingots are necessarily long and cumbersome, and difficulty has been encountered in previous furnace designs to obtain correct alignment and smooth and efficient control of the lowering action so that proper arcing and melting conditions may be maintained in the furnace.

It is the principal object of this invention to provide a simple and more efficient consumable electrode arc melting furnace. Another object of this invention is to provide such a furnace in which smooth control of the electrode lowering action and accurate alignment of the electrode is obtained. These and other objects of this invention will be apparent from the following more complete description thereof and from the annexed drawings in which:

Fig. 1 shows a general sectional front view of a furnace embodying features of this invention.

Fig. 2 shows a sectional side view of the furnace of Fig. 1.

Fig. 3 is an enlarged detail view showing the interior construction of the electrode carrier.

Fig. 4 shows a horizontal section of the electrode carrier of Fig. 3 taken along the lines 4—4.

Fig. 5 shows a horizontal section of the furnace of Fig. 1 taken along the lines 5—5.

Fig. 6 is an enlarged detail view showing more clearly the attachment of the electrode stub to the electrode carrier.

Fig. 7 shows a horizontal section of the furnace of Fig. 1 taken along the lines 7—7.

Referring now particularly to Fig. 1 and Fig. 2, a furnace embodying features of this invention comprises an electrode housing indicated generally at 10 composed of an upper housing 12 and a central throat section 14. A crucible housing indicated at 16 is removably attached to the bottom of throat section 14. Mounted within the upper housing 12 are diametrically opposed, spaced-apart, rotatable vertical screw shafts 18. The tops of these shafts 18 are provided with non-threaded portions which pass through upper plate 20 of upper housing 12. Seals 22 protect the passage of the upper portions of shafts 18 through plate 20, the shafts themselves being maintained in position and alignment by bearings 24. The upwardly extending portions of each of the shafts 18 are fixedly attached to horizontal bevel gears 26. Fixedly mounted on plate 20 and generally centrally with respect to shafts 18 is reduction gear box 28 from which extend horizontal drive shafts 30 having attached bevel

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pinions 32 which mesh with horizontal gears 26. Input power is supplied to gear box 28 by superimposed electric drive motor 36 to thus provide synchronous rotation of screw shafts 18.

The bottom of upper housing 12 is defined by horizontal lower plate 38 which is centrally provided with aperture 40. The lower ends of screw shafts 18 are maintained and aligned by foot bearings 42 which are suitably attached to plate 38.

Spanning the vertical screw shafts 18 is horizontal cross plate 44 which is provided with internally threaded nut members 46 which operatively engage the threads of screw shafts 18. Diametrically opposed and in 90° relationship to the screw shafts 18 are vertical guide shafts 48 which are, as more clearly shown in Fig. 2, fixedly attached to upper plate 20 and lower plate 38. These shafts pass through suitable apertures 50 in plate 44 as shown in Fig. 7 and engage guided elements such as rollers 52 which are themselves rotatably mounted on the upper surface of plate 44 as by bearing support assemblies 54. Fixedly attached to and depending from the under side of cross plate 44 is electrode carrier 56. This may conveniently be of tubular construction and is provided with flat bearing and contact plates 58 at 90° intervals around its periphery fixedly attached as by flush bolts 59. As shown more clearly in Fig. 3 and Fig. 6, an electrode 60 to be melted is demountably attached to electrode carrier 56 by first attaching as by welding at 62 to a permanent stub assembly 64. The permanent stub assembly is provided with a reduced diameter section near its top as at 66 in which vicinity are a series of bolt holes 68. The lower end of electrode carrier 56 is provided with ring 70 through which are threaded bolts 72 whose inner ends firmly engage the bolt holes 68 and thereby maintain the electrode stub 64 and its subtended electrode in fixed and immovable temporary attachment to the bottom of electrode carrier 56. The stub 64 is additionally provided with an upwardly extending central projection 74. Side plates 58 attached to the outside of electrode carrier 56 are arranged to be electrically connected to central projection 74 of stub 64 by provision of bus bar connectors 76 which are firmly attached by clamps 77 to an internally projecting extension 78 of plate 58. Bus bars 76 at their lower ends are attached by clamps 79 to contact plates 80 which are supported adjacent the projection 74 by provision of attached arms 82 which are hingedly mounted on the interior walls of electrode carrier 56 as at 84, as shown in Fig. 4. Adjusting bolts 86 project through the wall of electrode carrier 56 engaging fixed nuts 87, and their interior ends are provided with an expanded portion as at 88 which engages an interior cavity 90 in the end of arm 82. Adjustment of bolts 86 may be made to produce firm contact between the side surfaces of projection 74 and contact plates 80 through bearing pressure exerted on the ends of arms 82.

In the central throat portion 14 of the furnace 10 are provided diametrically opposed contact shoes 92. In the embodiment illustrated there are two pairs of shoes 92 arranged at 90° angles to each other around the electrode and electrode carrier. One of opposite pair of shoes is adjustable but fixed after adjustment, while the other of the pair is adjustable and also spring biased. This is accomplished as shown in Fig. 5 by supporting the adjustable shoes on arms 94 which project inwardly and which pass through seals 95 in the wall of throat section 14 and which arms are also threaded through fixed nuts 96. Appropriate and desirable adjustment of the corresponding shoes 92 may be made by rotation of external handwheels 97. In the case of the adjustable and spring biased shoes these are mounted on inwardly projecting tubular arms 98 which are urged inwardly by

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springs 100 which surround shafts 102 whose free inner ends telescope into the free outer ends of arms 98. Shafts 102 are threaded through fixed nuts 103 which are attached to the wall of throat section 14 and seals 104 are provided to protect their passage therethrough. External handwheels 105 are provided for adjustment of shafts 102 to provide corresponding adjustment of the spring biased shoes 92. One of shoes 92 and preferably as shown, an opposite pair is also employed to transmit electric current to the electrode 60 or its carrier through contact plates 58. This is accomplished by provision of flexible power leads 106 which are electrically connected to shoes 92 and to connector bushings 108 in the wall of throat section 14, which are in turn connected to external power leads 110.

Crucible housing 16 is provided with outwardly extending top flange 112. The crucible housing 16 contains a crucible 114 which is also provided with an outwardly extending top flange 116 adapted to overlay flange 112. Between flange 116 and lower outwardly extending flange 118 at the bottom of the sidewall of throat section 14, is interposed insulating gasket 120. The mating flanges and interposed gasket are firmly maintained in demountable relationship by provision of insulated bolts 122.

Electric contact is made to the bottom of crucible 114 by provision of spring biased contact plate 124. This plate 124 is upwardly urged by springs 126 which are maintained by socket members 128 attached to the inner surface of the bottom 130 of crucible housing 16. A suitable flexible cable 132 is attached in good electrical contact with plate 124 as at 134 and is also attached to connector bushing 136 which in turn is attached to external power lead 138 which connects to a power source not shown.

Cooling means are supplied to maintain the crucible 114 at desirable temperature. These, in the embodiment illustrated, comprise lower inlet pipe 140 and upper outlet pipe 142 which can provide a circulation of cooling fluid, such as water, in the jacket 144 formed between the sidewalls 145 and the bottom 130 of the crucible housing, and the outer surface of crucible 114.

A pipe connection 146 is provided through the sidewall of throat section 14 to enable the furnace interior to be evacuated and the atmosphere therein replaced with inert gas, if desired.

The drive motor 36 is preferably controlled by an electric circuit which responds to changes in the arc current or voltage so that proper motion of the electrode carrier 56 will result in substantially uniform melting of the electrode 60. Such electrical circuits and associated controls are well known in the electric art, are commercially available, and in themselves form no part of this invention.

In operation of the furnace, the electrode 60, which may have been previously formed by compacting crude metal or a mixture of metal and alloying elements or may be a previously melted ingot which is to be re-melted to obtain improved homogeneity, is attached as by welding at 62 to the permanent stub assembly 64. The stub assembly 64 with attached electrode is then temporarily firmly connected to the bottom of electrode carrier 56 by inserting the inner ends of the bolts 72 in the mating holes 68 in the permanent stub 64 and firmly tightening the bolts 72. Bolts 86 are then tightened to accomplish a good electrical connection between the side plates 58 and the electrode carrier through bus bar connectors 76 and contact plates 80 which will be in firm contact relationship with the central projection 74 of the permanent stub 64. The crucible 114 is disposed in place in crucible housing 16, and the crucible housing insulated gasket and lower flange 118 of the electrode housing throat section are placed together and maintained in proper temporary fixed relationship by firmly tightening bolts 122. With the furnace now assembled, and the electrode to be melted and the crucible in place, the atmosphere inside

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the furnace is evacuated through pipe connection 146 by connection of suitable pumping means thereto to insure the desired pressure and atmosphere inside the furnace. Cooling water is circulated through the crucible housing jacket 144. A suitable electric power supply is employed for arc melting, one pole being connected to the power lead 138 which provides a connection to plate 124 in contact with the bottom of crucible 114, and the other pole being connected to power leads 110 which maintain contact with the electrode carrier 56 and the electrode 60 through the contacting shoes 92. Preferably the crucible terminal is connected to the positive side of the direct current power supply and the electrode terminals to the negative side to initiate and maintain the arc. The driving motor control circuit may be adjusted so that constant arc voltage is maintained and the electrode carrier will move vertically up and down in response to variations in this condition.

Under these conditions, since the length of the arc is related to the voltage, a more or less constant distance may be maintained between the bottom of the electrode and the pool of molten metal in the crucible and, as the electrode becomes gradually consumed and transferred into the crucible, the electrode will move automatically to maintain desired melting conditions. When the electrode has been consumed to the point where proximity of the arc to the permanent stub and the electrode carrier and associated apparatus makes further melting undesirable the current is shut off and the ingot is preferably retained in the furnace under non-contaminating atmosphere conditions until reasonably cool. Then the crucible housing is disconnected from the electrode housing and the crucible with contained ingot is separated therefrom, and the ingot conveniently removed. The unmelted end of the electrode, still attached to the permanent stub, may be disconnected and separated from the stub by breaking the weld. A new electrode may be attached and connected as before. The crucible, after removal of the previously melted ingot, may then be replaced in the crucible housing and the furnace reassembled and thus made ready for another melting cycle.

The furnace of this invention is simple, compact and efficient. The operation of the pair of screw shafts provides balanced support and smooth control movement of the electrode carrier. The organization is compact and efficient. Superior alignment and electrical contact with the electrode and electrode carrier is provided by the particular aligning and contact shoe arrangement. When the electrode carrier is in position at the beginning of the melting operation, the contact shoes generally will ride directly on the electrode to provide excellent contact therewith. During the later stages of the melting operation the contact shoes will ride on the electrode carrier side plates 58, which as described and illustrated, also provide excellent electrical connection with the electrode 60. Thus the furnace provides advantages of compactness and efficiency, as well as desirable electrical power contact through the full range of vertical movement of the electrode carrier and the suspended electrode.

I claim:

1. In a furnace for use in melting a consumable electrode into a crucible, the combination which comprises an electrode housing, a crucible housing removably attached to the bottom of said electrode housing, a pair of diametrically opposed and spaced-apart screw shafts vertically and rotatably mounted in said electrode housing, a horizontal cross plate spanning said screw shafts and operatively engaging the threads thereof, an electrode carrier fixedly attached to and depending from said horizontal cross plate, means for synchronous rotation of said screw shafts thereby to impart vertical up and down movement to said cross plate and to the electrode carrier depending therefrom, means for attaching an electrode to be consumed to a lower portion of said electrode carrier, and means projecting inwardly from a lower

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section of said electrode housing adapted to contact said electrode carrier and an electrode held thereby to maintain said carrier and electrode aligned and to transmit electric current thereto during melting of the electrode into a crucible disposed in said crucible housing.

2. In a furnace for use in melting a consumable electrode into a crucible, the combination which comprises an electrode housing, a crucible housing removably attached to the bottom of said electrode housing, a pair of diametrically opposed and spaced-apart screw shafts vertically and rotatably mounted in said electrode housing, a horizontal cross plate spanning said screw shafts and operatively engaging the threads thereof, an electrode carrier fixedly attached to and depending from said horizontal cross plate, means for synchronous rotation of said screw shafts thereby to impart vertical up and down movement to said cross plate and to the electrode carrier depending therefrom, means for attaching an electrode to be consumed to a lower portion of said electrode carrier, and shoes mounted on arms adjustably projecting inwardly from a lower section of said electrode housing, said shoes adapted to contact said electrode carrier and an electrode held thereby to maintain said carrier and electrode aligned and to transmit electric current thereto during melting of the electrode into a crucible disposed in said crucible housing.

3. In a furnace for use in melting a consumable electrode into a crucible, the combination which comprises an electrode housing, a crucible housing removably attached to the bottom of said electrode housing, a pair of diametrically opposed and spaced-apart screw shafts vertically and rotatably mounted in said electrode housing, a horizontal cross plate spanning said screw shafts and operatively engaging the threads thereof, an electrode carrier fixedly attached to and depending from said horizontal cross plate, means for synchronous rotation of said screw shafts thereby to impart vertical up and down movement to said cross plate and to the electrode carrier depending therefrom, means for attaching an electrode to be consumed to a lower portion of said electrode carrier, a shoe mounted on an arm adjustably projecting

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inwardly from a lower section of said electrode housing and an opposite shoe spring biased and adjustably projecting inwardly through a lower section of said electrode housing, said shoes adapted to contact said electrode carrier and an electrode held thereby to maintain said carrier and electrode aligned and to transmit electric current thereto during melting of the electrode into a crucible disposed in said crucible housing.

4. In a furnace for use in melting a consumable electrode into a crucible, the combination which comprises an electrode housing, a crucible housing removably attached to the bottom of said electrode housing, a pair of diametrically opposed and spaced-apart screw shafts vertically and rotatably mounted in said electrode housing, a horizontal cross plate spanning said screw shafts and operatively engaging the threads thereof, a pair of fixed vertically mounted guide shafts in 90° relationship to said screw shafts passing through apertures in said cross plate, guided elements rotatably mounted on said cross plate and engaging said guide shafts, an electrode carrier fixedly attached to and depending from said horizontal cross plate, means for synchronous rotation of said screw shafts thereby to impart vertical up and down movement to said cross plate and to the electrode carrier depending therefrom, means for attaching an electrode to be consumed to a lower portion of said electrode carrier, and means projecting inwardly from a lower section of said electrode housing adapted to contact said electrode carrier and an electrode held thereby to maintain said carrier and electrode aligned and to transmit electric current thereto during melting of the electrode into a crucible disposed in said crucible housing.

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