Feb. 27, 1968 P. J. WYNNE 3,371,140

OPTICAL SYSTEM FOR ELECTRIC ARC FURNACES

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Fig. 5

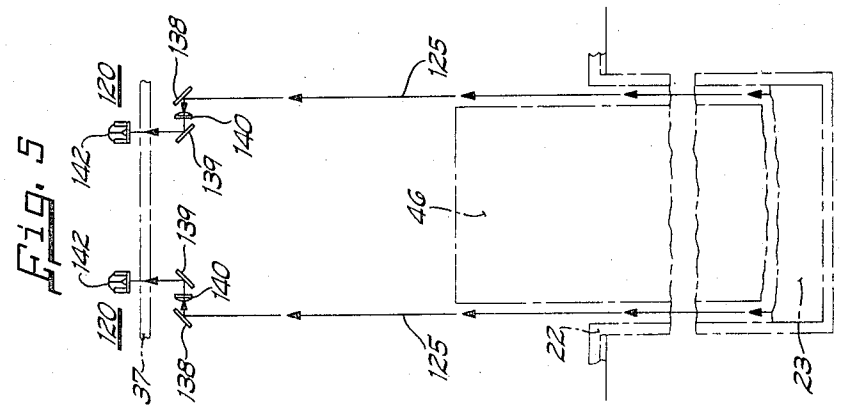
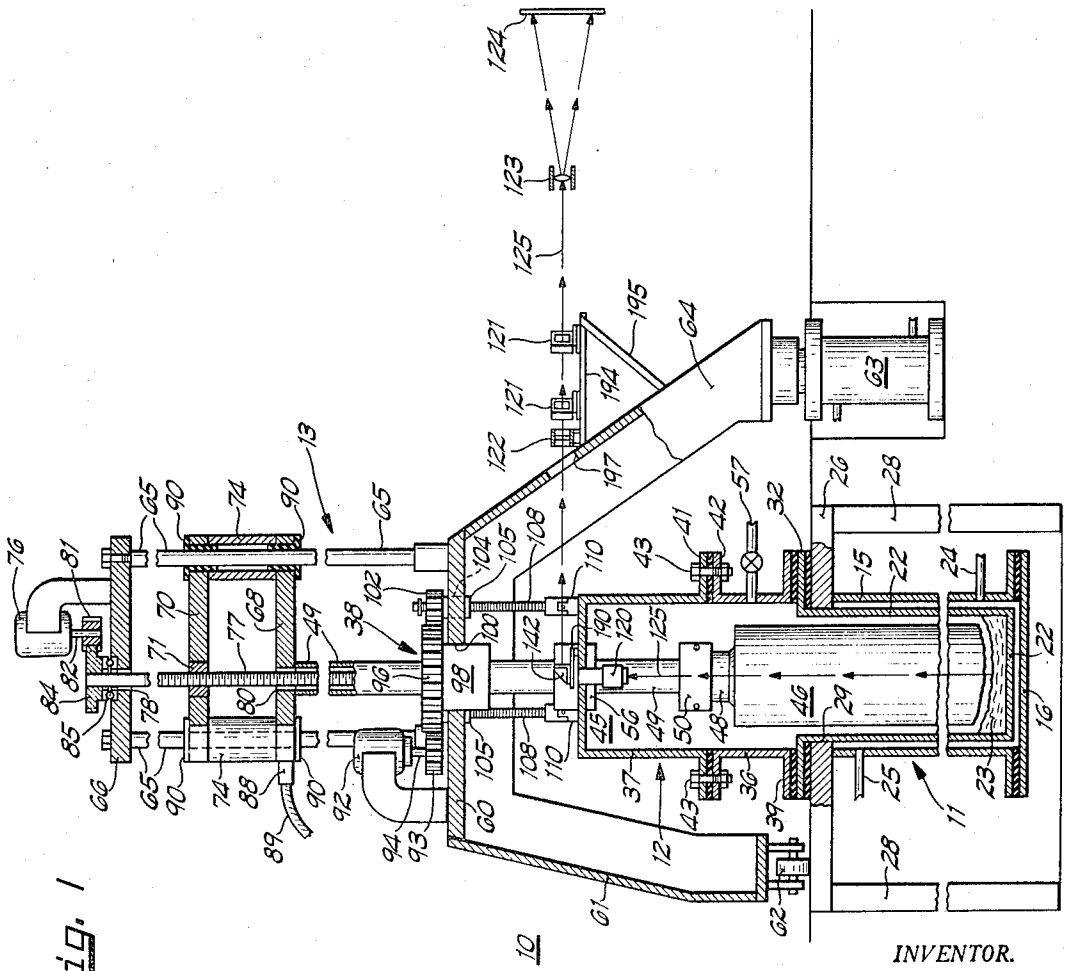


Fig. 1



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OPTICAL SYSTEM FOR ELECTRIC ARC FURNACES

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Fig. 2

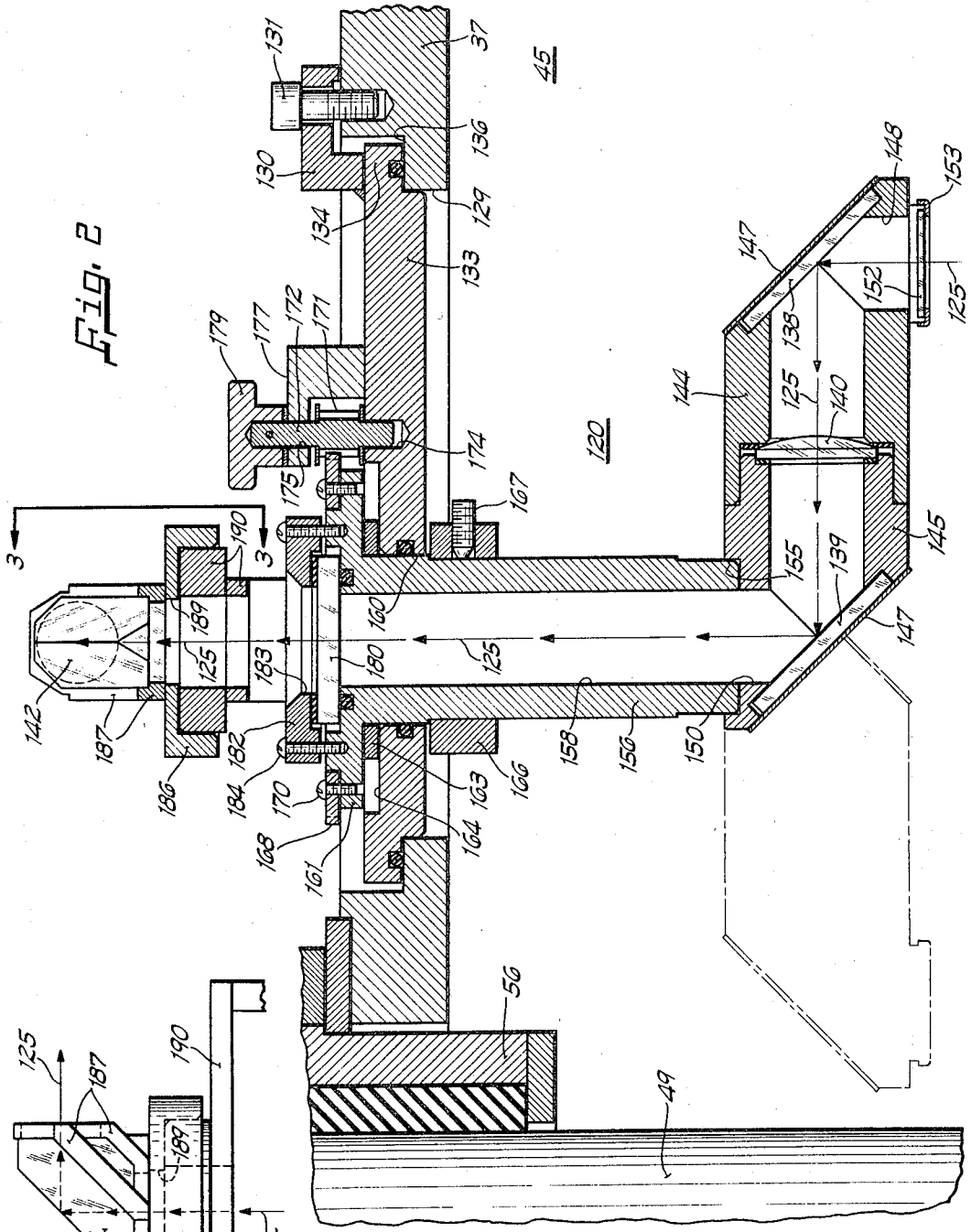


Fig. 3

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OPTICAL SYSTEM FOR ELECTRIC ARC FURNACES

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Fig. 4

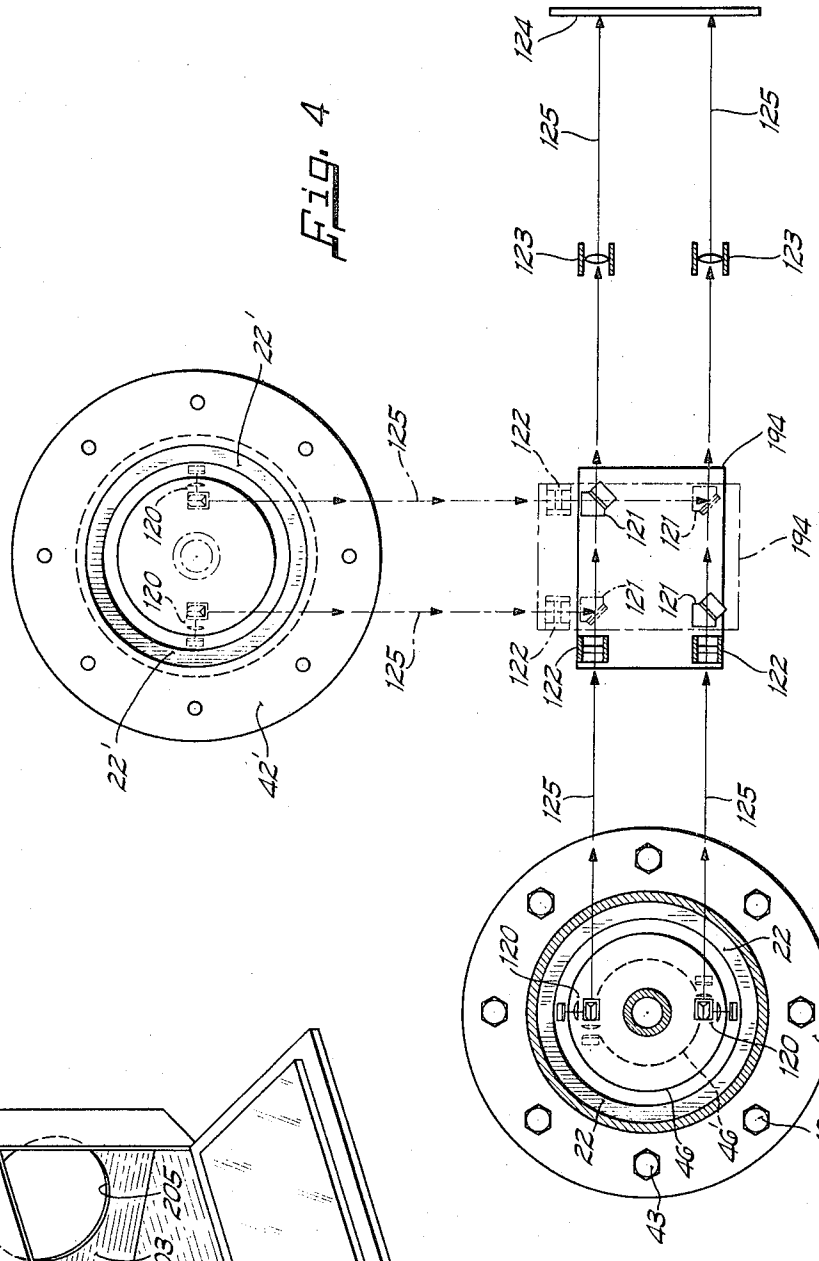
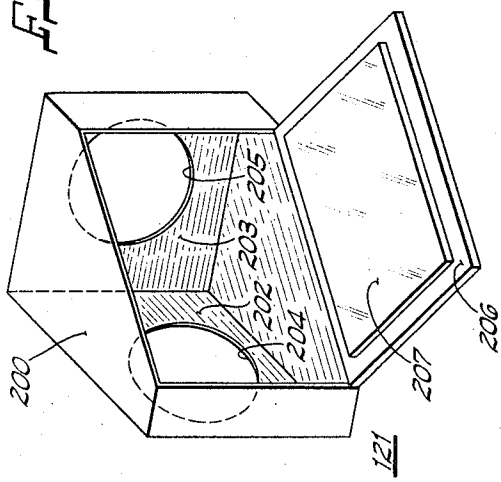


Fig. 6



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United States Patent Office 3,371,140 Patented Feb. 27, 1968

3,371,140

OPTICAL SYSTEM FOR ELECTRIC ARC FURNACES

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Filed Nov. 9, 1964, Ser. No. 409,661
15 Claims. (Cl. 13—9)

This invention relates to optical systems for electric arc furnaces and, more particularly, to an optical system for a controlled atmosphere consumable electrode type electric arc furnace.

Consumable electrode electric arc furnaces have been widely used for such applications as the melting of refractory metals, of which titanium is an example. Such furnaces, in general, include a sealed chamber wherein a consumable electrode is progressively melted under a controlled atmosphere and the resulting molten metal collected in a crucible to form an ingot. Melting is accomplished by means of an arc which is drawn between the consumable electrode and the ingot, and which is sustained by relatively large direct currents. As the ingot forms, the electrode length gradually decreases so that it must be lowered in order to maintain the proper arc length for the desired melting conditions. For this purpose, a motor-driven electrode ram is provided for feeding the electrode toward the ingot, in accordance with the electrical conditions in the arc. After the electrode has been completely consumed, the ingot must first be allowed to cool and then be removed from the crucible prior to the initiation of another melting operation. Because a relatively long time is required for such ingots to cool, it is desirable that a single electrode drive and ram assembly be mounted for successive operation over several crucibles.

In most melting applications, it is necessary to observe the arc at various times during a melting operation. For this reason, most prior art controlled atmosphere, consumable electrode arc furnaces were provided with fixed sight tubes for viewing along the electrode and in the gap between the electrode and the crucible. Prior art sight tubes were not wholly satisfactory, however, because the gap between the electrode and the crucible varies considerably even where the electrodes are nominally of the same size. This is additionally complicated by the fact that consumable electrodes employed in this type of furnace are generally in the order of twelve feet in length and may have surface irregularities. Prior art sight tubes were additionally unsatisfactory where various size electrodes were employed, because they could not penetrate sufficiently close to the electrode ram to view along the surface of smaller-sized electrodes.

In controlled atmosphere, consumable electrode vacuum arc furnace installations, the arc image is generally projected on an operator viewing screen. Prior art optical systems could not be employed, however, in installations having a single electrode drive assembly and a plurality of crucibles.

It is an object of the invention to provide a new and improved optical assembly for controlled atmosphere, consumable electrode, electric arc furnaces.

A further object of the invention is to provide an optical assembly capable of viewing along the gap between the electrode and the crucible of controlled atmosphere, consumable electrode, arc furnaces regardless of electrode size and surface irregularities.

Another object of the invention is to provide an optical system for use with consumable electrode arc furnaces having a single electrode drive assembly and a plurality of spaced apart crucibles.

A still further object of the invention is to provide an arc melting furnace having a plurality of vessels, electrode means for being selectively positioned over the vessels and an optical system having a first light modifying means mounted on the electrode means for receiving the arc image ray and for projecting the same to viewing means when the electrode means is over one vessel and second light modifying means for receiving the projected ray and for transmitting the same to the viewing means when the electrode means is over a second vessel.

Yet another object of the invention is to provide in an electric arc furnace an optical assembly rotatably mounted about an axis generally parallel with the electrode and including tube means disposed at a predetermined angle relative to the axis of rotation and having first light modifying means for redirecting arc image rays along the axis of the tube means and fixedly mounted second light modifying means for receiving the projected rays and for redirecting them at a preselected angle.

These and other objects and advantages of the instant invention will become more apparent from the detailed description thereof taken with the accompanying drawings in which:

FIG. 1 is a side elevational view, partly in section, of a controlled atmosphere, consumable electrode, electric arc furnace which incorporates the optical assembly according to the instant invention;

FIG. 2 is a side elevational view, partly in section, of a portion of the optical assembly illustrated in FIG. 1;

FIG. 3 is a view taken along lines 3—3 of FIG. 2;

FIGS. 4 and 5 are respectively a top plan view and a side elevational view schematically illustrating the operation of optical system according to the instant invention; and

FIG. 6 is a perspective view of another portion of the optical system illustrated in FIG. 1.

Referring now to the drawings in greater detail, FIG. 1 shows a consumable electrode, controlled atmosphere, electric arc furnace designated by the reference numeral **10** and having a crucible section **11**, a middle section **12** and an electrode drive assembly **13**.

The crucible section **11** includes an outer, substantially cylindrical shell **15** having a bottom closure member **16** which is suitably affixed thereto in a sealed relation to provide a cooling jacket for a crucible **22** disposed therein and which receives an ingot **23** formed from the metal being melted. Cooling fluid is supplied to the shell **15** through inlet and outlet pipes **24** and **25**, respectively. A horizontal base plate **26** is supported adjacent the upper end of shell **15** by vertical columns **28** and has a central aperture **29** for receiving the upper end of the crucible **22**. A gasketed flange **32** extends outwardly from the upper end of the crucible **22** and is suitably affixed to the upper surface of the mounting plate **26**.

The middle section **12** of the furnace **10** includes a lower middle section **36**, an upper middle section **37** and an upper middle section drive assembly **38**. The lower middle section **36** has a generally cylindrical configuration which is cordial with the crucible **22**. An outwardly extending flange **39** at the lower end of lower middle section **36** is suitably affixed to the flange **32** on crucible **22**.

The upper middle section **37** which is an inverted, cup-shaped member forms a closure for the hollow assembly **45** consisting of the crucible **22**, the lower middle section **36** and the upper middle section **37**. A suitably gasketed flange **41** extends outwardly from the lower end of the upper middle section **37** and is releasably securable to a corresponding flange **42** on the upper end of the lower middle section **36** by means of bolts **43**.

An electrode **46** is disposed within the hollow assembly **45** and has a stub **48** integrally formed at its upper end for releasable attachment to the bottom of a hollow electrode ram **49** by a clamp **50**. The ram **49** slidably passes

through a sealing bushing **56** which provides a fluid-tight seal for the enclosure **45** and, in addition, electrically insulates ram **49** from the upper middle section **37**.

A pipe **57** is connected to and communicates with the interior of the enclosure **45** for placing the latter in communication with an evacuator or source of inert gas if a partial vacuum or inert gas atmosphere is required during the melting operation.

A generally rectangular base plate **60** is disposed above the upper middle section **37** and is mounted on the upper ends of first and second frame members **61** and **64**, respectively. The lower end of member **61** is supported in a pair of wheels **62**, which engage the upper surface of the plate **26** and the lower end of the second frame member **64** engages a rotary hydraulic cylinder **63** whose purpose will be explained in greater detail hereinbelow. The plate **60** supports the upper middle section drive assembly **38** and the electrode drive assembly **13**.

The electrode drive assembly **13** is supported above the base plate **60** by vertically extending rods **65** whose lower ends are affixed to the plate **60** and whose upper ends support a top plate **66**. The drive assembly **13** also includes a first plate **68** which is affixed to the upper end of the electrode ram **49** and a second plate **70** disposed vertically above the plate **66** and having a nut **71** affixed in an aperture formed therein and concentric with the ram **49**. A tubular member **74** is slidably disposed on each of the support rods **65** and each is affixed at its lower end to the first plate **68** and at its upper end to the second plate **70** so that the plates **68** and **70** are coupled for sliding vertical movement on the support rod **65**.

The electrode drive assembly **13** also includes a motor **76** suitably mounted on the upper plate **66** and a drive screw **77** which threadably engages the fixed nut **71** in the second plate **70** and extends vertically downward through apertures **78** and **80** in the plates **66** and **68**, respectively, and into the hollow interior of the electrode ram **49**. A pinion **81** is carried on the output shaft **82** of the motor **76** and engages a gear **84** affixed to the upper end of the screw shaft **77** and rotatably mounted about the aperture **78** in the plate **66** by a suitable bearing assembly **85**.

Electrical energy is supplied to the electrode **46** through a terminal **88** mounted on plate **68** and which is constructed and arranged to receive a flexible conductor **89**. Current flows from the plate **68** through the electrode ram **49**, the clamp **50**, the stub **48** and to the electrode **46**. Bushings **90**, of any suitable insulating material, insulate the guide rods **65** from the plates **68** and **70** and the tubes **74**.

The upper middle section drive assembly includes a motor **92** suitably mounted on the base plate **60** and a pinion **93** affixed to the motor output shaft **94**. Pinion **93** engages a ring gear **96** which is rotatably mounted by means of a bearing (not shown) on a bushing **98** disposed in an aperture **100** formed in the support plate **60**. The bushing **98** slidably receives the electrode ram **49** and electrically insulates it from the base plate **60**. Three small gears **102** engage the ring gear **96** at approximately 120° intervals and each is rotatably mounted in bearings **105** disposed in corresponding apertures **104** formed in the plate **60**. Each of the small gears **102** has a suitable internal threaded aperture for engaging the upper end of a screw shaft **108**, the lower end of which is coupled to the upper surface of the upper middle section **37** by a universal coupling **110**.

The electrode drive assembly motor **76** may be of the reversible, variable speed, DC type, which is controlled in accordance with electrode voltage and current conditions. The motor control, which is not shown but is well known in the art, causes the motor **76** to rotate in a direction which maintains the arc between the electrode **46** and the ingot **23** at a relatively uniform length. Thus, when the arc length is too short, the motor will rotate the screw shaft **77** in a first direction through the pinion **81** and the gear **84**. This moves the nut **71** and the plate **70** to which it is affixed upwardly relative to the shaft **77**. The electrode ram **49** which is rigidly coupled to the plate **70** by the plate **68** and the tubes **74** also moves upwardly to raise the electrode **46**. Conversely, when the arc length is too long the motor **76** will rotate the shaft **77** in an opposite direction to lower the electrode **46**. However, since the electrode **46** has a smaller diameter than the crucible **22**, the general direction of movement of the electrode will be downward during a melting operation.

After the electrode **46** has been melted so that substantially only the stub **48** remains, the electrode drive assembly **13** is positioned above the alternate crucible **22'** while the ingot **23** is allowed to cool. For this purpose, the motor **76** is driven in a direction which raises the clamp **50** to its uppermost position in the chamber **45**. The bolts **43** are then removed to release the upper middle section **37** from the lower middle section **36**. Motor **92** is then operated to rotate the gears **102** through the agency of the pinion **93** and the ring gear **96** in a direction which raises each of the screw shafts **108**. As a result, the upper middle section **37** is raised to a position free of the lower middle section **36**. The motor **76** is then reactuated in a direction which raises electrode clamp **50** and the stub **48** to a position above the upper flange **41** of the lower middle section **36**. The rotary hydraulic cylinder is then actuated to pivot the base plate **60** and the frame member **61** and **64** to a position above an alternate crucible as the wheels **62** roll on the base plate **26**. After the electrode drive assembly **13** has been positioned above the alternate crucible **22'**, the electrode ram assembly **49** is lowered until the clamp **50** is in a position to be secured to the stub on the electrode which was previously disposed within said alternate crucible. The motor **92** is then operated in a direction which lowers the upper middle section **37** until it is in a position to be secured to the flange on the lower middle section of the alternate crucible **22'**, whereby melting may begin in said alternate crucible while the ingot **23** in the first crucible **22** cools.

The optical system, according to the instant invention, is shown in FIGS. 1, 4 and 5 to include a pair of optical assemblies **120**, one of which is mounted on each of the opposite sides of the upper surface of the upper middle section **37** and adjacent the opposite sides of the bushing **56**. The optical system also includes a mirror assembly **121**, a first lens **122** and a second lens **123** associated with each of the optical assemblies **120**. Each of the optical assemblies **120** along with its associated mirror assembly **121**, first lens **122** and second lens **123** transmits an image of the arc at its side of the electrode to an operator viewing screen **124**.

The optical assembly **120** is shown in FIG. 2 to be mounted in an aperture **129** formed in the upper end of the upper middle section **37** and adjacent the bushing **98** by means of a plurality of clamping blocks **130** and screws **131**, only one set of which is seen in FIG. 2. The clamping blocks **130** engage the upper surface of an optical assembly base plate **133** to force an outer peripheral flange **134** on said plate against a shoulder **136** formed in the periphery of the aperture **129**.

The optical assembly **120** is shown to include a first mirror **138**, a second mirror **139**, a lens **140** and a reflecting prism **142**. The lens **140** is disposed at the junction of a pair of hollow, open-ended coaxially disposed and coradial mirror support tubes **144** and **145**. One end of each of the tubes **144** and **145** is cut at a substantially 45° angle and is recessed for receiving one of the mirrors **138** and **139**, respectively. The mirrors **138** and **139** are held in position by means of mirror support plates **147**, which are suitably affixed to the remote ends of each of the tubes **144** and **145**.

A bottom aperture **148** is formed in the end of the tube **144** and opposite the mirror **138** to permit the passage of the arc image rays **125** from the crucible **22** disposed

therebelow. The first mirror **138** redirects the rays **125** in a direction parallel to the axis of the tubes **144** and **145** through the lens **140** and onto the mirror **139** which, in turn, redirects them upwardly. Similarly, a top aperture **150** is formed in the end of the tube **145** and opposite the mirror **139** to permit the arc image ray **125** directed upwardly from the mirror **139** to pass to the prism **142**. A cover glass **152** is mounted over the opening **148** by means of a glass holder **153** which is suitably affixed to the tube **144**.

The aperture **150** adjacent the mirror **139** is recessed at **155** for receiving the lower end of a vertical tube **156** to which the mirror support tube **145** is suitably affixed in a sealing relation. The bore **158** of the tube **156** is coaxial with the opening **150** to permit the passage of the arc image rays **125** from the mirror **139** to the prism **142**. The vertical tube **156** extends through an aperture **160** in the base plate **133** and terminates at its upper end in an outwardly extending flange **161**. The lower surface of the flange **161** is supported by an annular bearing ring **163** which surrounds the tube **156** and is disposed in a circular recess **164** formed in the upper surface of the base plate **133**. A collar **166** surrounds the tube **156** below the base plate **133** and is held in position by a set screw **167** to prevent upward movement of the tube **156** relative to the base plate **133**.

A ring gear **168** is affixed by screws **170** in an annular groove formed at the outer periphery of the upper surface of the flange **161** and is concentric with the axis of the tube **156**. The gear **168** engages a pinion **171** which is affixed to a vertical shaft **172** whose lower end is disposed for rotation in an aperture **174** formed in the upper surface of the base plate **133** and which extends upwardly through an aligned aperture **175** formed in an inverted L-shaped pinion holder **177** suitably affixed to the base plate **133**. A hand knob **179** is affixed to the upper end of the shaft **172** so that the pinion **171** may be rotated in either direction.

A cover glass **180** is secured over the upper end of the tube **156** by a glass cap **182** which is affixed to the flange **161** by screws **184** and which has an aperture **183** coaxial with the axis of the tube **156**.

The prism **142** which is of the 45° total reflecting type is secured to a prism mount **186** by a prism frame **187**. The prism mount **186** has a central aperture **189**, which is fixedly positioned above the bore of the tube **156** by a prism support bracket **190** rigidly affixed to the base plate **133**.

It will be appreciated that rotation of the pinion **171** by means of the hand knob **179** will cause the tube **156** to rotate about its axis. This, in turn, will move the mirror **138** and the opening **148** in the tube **144** in a circular path about the axis of tube **156**, as indicated by phantom lines in FIG. 2. This allows the mirror **138** to be moved relative to the inner surface of the crucible as, for example, between the position shown by full lines in FIG. 4 to the position shown by dotted lines. In this manner, the mirror may be placed in a position as close as possible to the electrode's outer surface to view the arc, taking into consideration discontinuities in the electrode's outer surface. In addition, when a smaller diameter electrode **46'** is employed as shown by phantom lines in FIG. 4 the mirror **138** may be rotated into a correspondingly close position relative to such an electrode. Regardless of the position of the mirror **138**, however, it will always face the mirror **139** so that the electrode image ray **125** will be projected upwardly to the prism **142**.

As seen in FIG. 4, the prism **142** reflects the arc image rays **125** through 90°, so that it will be directed toward the screen **124**. Because the prism is fixed the arc image ray **125** will be reflected in the same direction relative to the furnace **10** regardless of the rotation of the tube **156**.

Referring again to FIG. 1, it can be seen that the lens **121** and the mirror assembly **122** associated with each of the optical assemblies **120**, is mounted on a horizontal plate **194**, which is supported on the member **64** by a bracket **195**. Support member **64** is suitably apertured at **197** to permit the arc image ray **125** to pass from the prisms **142** to their associated lens **122** and mirrors assembly **121**.

As seen in FIGS. 4 and 5, the arc image rays from each side of the electrode pass upwardly to the first mirror **138** where they are reflected backwardly onto the second mirror **139**, for redirection upwardly to the prism **142**, which in turn reflects them 90° through their associated lens **122** and mirror assembly **121** and then through the lens **123** to the operator viewing screen **124**.

Each mirror assembly **121** is shown more particularly in FIG. 6 to include a three sided housing **200** having side walls **202** and **203** and a back wall **206** which is pivotally mounted between an open position shown in FIG. 6 and a closed position. The sidewalls **202** and **203** of housing **200** are preferably of substantially equal areas and each has an enlarged aperture **205** formed therein. Sidewalls **202** and **203** are joined at an angle substantially equal to the angle through which the electrode drive assembly **13** pivots, which is 90° in the illustrated embodiment. The backwall is equiangularly disposed relative to each of the sidewalls **202** and **203** and this angle is 45° in the illustrated embodiment.

A mirror **207** is affixed to the inner surface of the closure cover **206**. It will be appreciated that when the backwall **206** is open, light rays entering either of the apertures **205** will pass out of the open back of the housing **200**. However, when the back wall **206** is in a closed position, light rays entering one of the apertures **205** will be reflected by the mirror **207** outwardly through the other of said apertures.

It can be seen in FIG. 4 that each of the shade housings **200** is mounted on the plate **194** in such a manner that their openings **204** face their respective prisms **142**. In addition, when the electrode drive assembly is in its position over the first crucible **22**, as shown by full lines in FIG. 4, each of the openings **204** and prisms **142** are also in alignment with its respective lens **123**. However, when the electrode drive assembly **13** is pivoted to its position over the alternate crucible **22'**, as shown by phantom lines in FIG. 4, the optical center line of each prism and opening **204** is displaced from that of their associated lens **123** by an angle equal to the angle through which the drive assembly **13** pivots. For this reason, the arc image rays **125** must be redirected through an angle equal to the complement of the pivoted angle. This result is achieved by the angular arrangement of the walls **202**, **203** and **206** of the housing **200**.

When the electrode drive assembly **13**, which carries the optical assemblies **120**, is in a position over the first crucible **22**, each of the backwalls **206** of the housings **200** is open so that the arc image rays **125** pass through the openings **204** and out of the open backs of the housings **200** to the lens **123** and the operator viewing screen **124**. However, when the electrode drive assembly is pivoted to a position above the alternate crucible **22'**, as shown by phantom lines in FIG. 4, the backwalls **206** of the housings **200** are closed, so that the mirror **121** is opposite the apertures **204** and **205**. When in this position, aperture **204** is in alignment with the prism **142** while aperture **205** is in alignment with the lens **123**. As a result, the arc image rays from the prisms **142** will enter the opening **205** in each of the housings **200** and be reflected by the mirrors **121** through the complement of the pivotal angle and outwardly through the openings **205** to the lens **123** for projection on the operator viewing screen **124**.

In order that each of the mirror assemblies remain in alignment with their respective lens **124** after the electrode drive mechanism **13** has pivoted over the alternate crucible **22'**, the plate **194** is positioned over the pivotal axis of the drive mechanism **13**. In addition, the mirror assemblies are positioned equidistantly from and on dia-

metrically opposite sides of the pivotal axis and lie along a line angularly displaced relative to the arc image rays 125 by an angle which is one-half of the complement of the pivotal angle. In the illustrated embodiment the assembly illustrated pivots 90° so that the minor assemblies lie along a line displaced 45° from the arc image rays 125.

It will be seen that the optical system according to the instant invention permits the arc to be viewed on a single operator viewing screen even when the electrode drive assembly is pivoted from a position over a first crucible 22 to a position over a second, or alternate, crucible 22'.

It will also be appreciated that if the pivotal angle of the electrode drive assembly is other than 90°, the angles between the walls 202 and 203 and the closure 206 of the housing 200 will have to be adjusted accordingly.

While only a single embodiment of the instant invention has been shown and described, it is not intended to be limited thereby but only by the scope of the appended claims.

I claim:

1. In an arc melting furnace, the combination of a plurality of vessels, support means, electrode drive means mounted on said support means for supporting an electrode in said vessels, said support means being movable from a first position above one of said vessels to a second position above another of said vessels, an optical system including light modifying means mounted on said electrode drive means and constructed and arranged to receive an electric arc image ray and to project said ray at a predetermined angle, viewing means disposed for receiving said projected ray when said electrode drive mechanism is in its first position, reflecting means positioned to receive said projected rays when said electrode drive mechanism is in its second position, said reflector being disposed in such an angular position relative to said light modifying means and said viewing means that the projected rays will reflected to said viewing means.

2. In an arc melting furnace, the combination of a plurality of vessels each adapted to receive an ingot formed by the melting of a consumable electrode therein, closure means selectively engageable with the upper ends of said vessels, an electrode drive mechanism extending through said closure means for supporting an electrode in said vessels, and means for moving said electrode drive mechanism from a first position above one of said vessels to a second position above another of said vessels, an optical system including light modifying means mounted on said electrode drive means and constructed and arranged to receive an electric arc image ray and to project said ray at a predetermined angle, viewing means disposed for receiving said projected ray when said electrode drive mechanism is in its first position, reflecting means mounted on said electrode drive mechanism and positioned to receive said projected rays when said electrode drive mechanism is in its second position, said reflector being disposed in such an angular position relative to said light modifying means and said viewing means that the projected rays will be reflected onto said viewing means.

3. In an arc melting furnace, the combination of a plurality of vessels, support means, an electrode drive mounted on said means for supporting an electrode in said vessels, said support means being movable from a first position above one of said vessels to a second position above another of said vessel, an optical system including light modifying means mounted on said electrode drive means and constructed and arranged to receive an electric arc image ray to project said ray at a predetermined angle, viewing means disposed for receiving said projected ray when said electrode drive mechanism is in its first position, reflecting means mounted on said electrode drive mechanism and being movable therewith, said reflecting means being positioned to receive said projected rays when said electrode drive mechanism is in each of its first and second positions, said reflecting means also being movable relative to said drive mechanism between an operative position which is effective to reflect said rays and an inoperative position in which it s ineffective to reflect said rays, said reflector being disposed in such an angular position relative to said light modifying means and said viewing means that the projected rays will be reflected at an angle which is a complement of the angle through which said electrode drive mechanism pivots from its first to its second positions.

4. In an arc melting furnace, the combination of a plurality of vessels, support means, an electrode drive mechanism mounted on said support means for supporting an electrode in said vessels, said support means being movable from a first position above one of said vessels to a second position above another of said vessels, an optical system including light modifying means mounted on said electrode drive means and constructed and arranged to receive an electric arc image ray and to project said ray at a predetermined angle, viewing means disposed for receiving said projected ray when said electrode drive mechanism is in its first position, reflecting means pivotally mounted on said support means and being movable therewith, said reflecting means being positioned to receive said projected rays when said support means is in each of its first and second positions, said reflecting means also being movable relative to said support means between an operative position which is effective to reflect said rays and an inoperative position in which it is ineffective to reflect said rays, said reflecting means being disposed in such an angular position relative to said light modifying means and said viewing means when said electrode drive mechanism is in its second position that the projected rays will be reflected to said viewing means.

5. In an arc melting furnace, the combination of a plurality of vessels each adapted to receive an ingot formed by the melting of a consumable electrode therein, frame means constructed and arranged to be moved horizontally from a first position above one vessel to a second position above another vessel, closure means carried by said frame means and selectively engageable with the upper ends of said vessels, an electrode drive assembly mounted on said frame means and extending through said closure means for supporting an electrode in said vessels, an optical system including light modifying means mounted on said frame means and constructed and arranged to receive an upwardly directed electric arc image ray and to project said ray at a predetermined generally horizontal direction, viewing means disposed for receiving said projected ray when said frame means is in its first position, reflecting means pivotally mounted on said frame means and being movable therewith, said reflecting means being positioned between said light modifying means and said viewing means when said electrode drive mechanism is in its first position, said reflecting means being pivotable relative to said frame means between an operative position in which it is effective to reflect said rays and an inoperative position in which it is ineffective to reflect said rays, said reflector being disposed in such an angular position relative to said light modifying means and said viewing screen that said projected rays will be reflected at an angle which is a complement of the angle through which said frame means pivots from its first to its second positions.

6. In an arc melting furnace, the combination of a plurality of vessels each adapted to receive an ingot formed by the melting of a consumable electrode therein, frame means constructed and arranged to be moved horizontally from a first position above one vessel to a second position above another vessel, closure means carried by said frame means and selectively engageable with the upper ends of said vessels, an electrode drive assembly mounted on said frame means and extending through said closure means for supporting an electrode in said vessels, an optical system including a pair of light modi-

fying means mounted on said frame means in spaced relation on the opposite sides of said electrode drive assembly and each being constructed and arranged to receive an upwardly directed electric arc image ray and to project said rays at the same predetermined generally horizontal direction, a viewing screen disposed for receiving said projected rays when said frame means is in its first position, first and second reflecting means mounted on said frame means and being movable therewith, each of said reflecting means being positioned between one of said light modifying means and said viewing screen when said electrode drive mechanism is in its first position, each of said reflecting means being pivotable relative to said frame means between an operative position in which each is effective to reflect the projected rays from a different one of said light modifying means and an inoperative position in which each is ineffective to reflect said rays, each of sad reflectors being disposed on such an angular position relative to said light modifying means and said viewing screen that said projected rays will be reflected at an angle which is a complement of the angle through which said frame means pivots from its first to its second positions.

7. In an electric arc furnace, the combination of a vessel adapted to receive molten metal, support means engageable with said vessel, electrode means carried by said support means for supporting an electrode in said vessel, optical assembly means mounted on said support means for rotation about an axis generally parallel with said electrode means, said optical assembly including tube means disposed at a predetermined angle relative to said rotational axis and having light modifying means constructed and arranged for receiving light rays from said arc and for projecting said rays along the axis of tube means, second light modifying means fixedly mounted on said support means and disposed for receiving said light rays and for redirecting said light rays through a preselected angle.

8. In an electric arc furnace, the combination of a vessel adapted to receive molten metal, closure means selectively engageable with the upper end of said vessel, an electrode drive mechanism extending through said closure means for supporting an electrode in said vessel, optical assembly means mounted on said closure means for rotation about a vertical axis and disposed adjacent said electrode drive mechanism, said optical assembly including tube means disposed at a predetermined angle relative to said rotational axis and having light modifying means at its outer end and constructed and arranged for receiving upwardly directed light rays from said arc and for projecting said rays along the axis of tube means, second light modifying means fixedly mounted on said closure means and disposed for receiving said light rays and for redirecting said light rays through a preselected angle.

9. In an electric arc furnace, the combination of a vessel adapted to receive molten metal, support means, an electrode drive mechanism extending mounted on said support means for supporting an electrode in said vessel, an optical assembly mounted on said support means and adjacent said electrode drive mechanism, said optical assembly including first tube means extending generally parallel with said electrode, second elongate tube means affixed to said first tube means and extending generally transversely thereto, first light modifying means mounted in said second tube means and disposed for receiving light rays directed parallel to said electrode and for redirecting said light rays along the axis of second tube means, second light modifying means disposed at the juncture of said first and second tube means and oriented for receiving light rays directed along the axis of said second tube means and for redirecting said rays along the axis of said first tube means, means for rotating said first tube means about its axis so that said first reflecting means is moved and relative to said electrode, and third light modifying means fixedly mounted on said support means and disposed for receiving light rays which are directed along the axis of said first tube means and being operable to redirect said rays through a preselected angle.

10. In a consumable electrode arc melting furnace, the combination of a vessel adapted to receive an ingot formed by the melting of a consumable electrode therein, support means above said vessel, an electrode drive mechanism mounted on said support means and extending vertically for supporting an electrode in said vessel, an optical assembly mounted on said support means adjacent said electrode drive mechanism, said optical assembly including first tube means extending vertically, second tube means affixed to said first tube means and extending generally transversely thereto, first reflecting means mounted in said second tube means and disposed for receiving upwardly directed light rays and for reflecting said rays along the axis of second tube means, second reflecting means disposed at the juncture of said first and second tube means and oriented for receiving light rays directed along the axis of said second tube means and for reflecting said rays upwardly along the axis of said first tube means, means for rotating said first tube means about a vertical axis so that said first reflecting means is moved relative to said electrode drive means, and light modifying means fixedly mounted on said closure means and disposed above the upper end of said first tube means for receiving light rays directed along the axis of said first tube means and for redirecting said rays through a preselected angle.

11. In a consumable electrode arc melting furnace, the combination of a vessel adapted to receive an ingot formed by the melting of a consumable electrode therein, closure means selectively engageable with the upper end of said vessel, an electrode drive mechanism extending through said closure means for supporting an electrode in said vessel, an optical assembly mounted on said closure means and adjacent said electrode drive mechanism, said optical assembly including first elongate tube means extending vertically through said closure means, second elongate tube means affixed to the lower end of said first tube means and extending normally relative thereto, first reflecting means disposed at the outer end of said second tube means and disposed for receiving upwardly directed light rays and for reflecting said rays along the axis of second tube means, second reflecting means disposed at the juncture of said first and second tube means and oriented for receiving light rays directed along the axis of said second tube means and for reflecting said rays upwardly along the axis of said first tube means, manually operable means for rotating said first tube means about its axis so that said first reflecting means is moved in a circular path and relative to said electrode drive means, and light modifying means fixedly mounted on said closure means and disposed above the upper end of said first tube means for receiving light rays directed along the axis of said first tube means and for redirecting said rays through a preselected angle.

12. In a consumable electrode arc melting furnace, the combination of a vessel adapted to receive an ingot formed by the melting of a consumable electrode therein, closure means selectively engageable with the upper end of said vessel, an electrode drive mechanism extending vertically through said closure means for supporting an electrode in said vessel, an optical assembly mounted on said closure means and adjacent said electrode drive mechanism, said optical assembly including first elongate tube means extending vertically through said closure means in substantial parallelism with said electrode drive means, second elongate tube means having one end affixed to the lower end of said first tube means and extending normally relative thereto, an opening adjacent the other end of said second tube means and facing downwardly toward said vessel, first reflecting means disposed adjacent the other end of said second tube opposite the

opening therein for receiving upwardly directed light rays and for reflecting said rays along the axis of second tube means, second reflecting means disposed at the juncture of said first and second tube means and oriented for receiving light rays directed along the axis of said second tube means and for reflecting said rays upwardly along the axis of said first tube means, manually operable means for rotating said first tube means about a vertical axis so that said first reflecting means is moved in a circular path and relative to said electrode drive means, and reflecting prism means fixedly mounted on said closure means and disposed above the upper end of said first tube means for receiving light rays directed along the axis of said first tube means and for reflecting said rays through a preselected angle.

13. In an electric arc furnace, the combination of a plurality of vessels, support means constructed and arranged to be moved horizontally from a first position above one vessel to a second position above another vessel, optical assembly means mounted on said support means for rotation about a vertical axis and disposed adjacent said electrode drive mechanism, said optical assembly including tube means disposed at a predetermined angle relative to said rotational axis, first light modifying means at the outer end of said tube means and constructed and arranged for receiving upwardly directed light rays from said arc and for redirecting said rays along the axis of tube means, second light modifying means fixedly mounted on said frame means and disposed for receiving said light rays and for projecting said light rays through a preselected angle, viewing means disposed for receiving said projected rays when said electrode drive mechanism is in its first position, reflecting means mounted on said frame means and being movable therewith, said reflecting means being positioned to reflect said projected rays and being movable relative to said frame means between an operative position in which it is effective to reflect said projected rays and an inoperative position in which it is ineffective to reflect said rays, said reflecting means being disposed in such an angular position relative to said second light modifying means and said viewing means when said frame means is in its second position that said projected rays will be reflected to said viewing means.

14. In an electric arc furnace, the combination of a plurality of vessels, frame means constructed and arranged to be moved horizontally from a first position above one vessel to a second position above another vessel, closure means carried by said frame means and selectively engageable with the upper ends of said vessels, an electrode drive mechanism mounted on said frame means and extending through said closure means for supporting an electrode in said vessels, an optical assembly mounted on said closure means and adjacent said electrode drive mechanism, said optical assembly including first tube means extending vertically through said closure means in substantial parallelism with said electrode drive means, second tube means having one end affixed to the lower end of said first tube means and extending normally relative thereto, first reflecting means disposed adjacent the other end of said second tube means for receiving upwardly directed light rays and for reflecting said rays along the axis of second tube means, second reflecting means disposed at the juncture of said first and second tube means and oriented for receiving light rays directed along the axis of said second tube means and for reflecting said rays upwardly along the axis of said first tube means, manually operable means for rotating said first tube means about a vertical axis so that said first reflecting said projected rays when said electrode drive means and light modifying means fixedly mounted on said frame means and disposed above the upper end of said first tube means for receiving light rays directed along the axis of said first tube means and for projecting said rays through a preselected angle, viewing means disposed for receiving said projected rays when said electrode drive mechanism is in its first position, reflecting means mounted on said frame means and being movable therewith, said reflecting means being positioned to reflect said projected rays and being movable relative to said frame means and between an operative position in which it is effective to reflect said projected rays and an inoperative position in which it is ineffective to reflect said rays, said reflector being disposed in such an angular position relative to said light modifying means and said viewing means when said frame means is in its second position that said projected rays will be reflected to said viewing means.

15. In an arc melting furnace, the combination of a plurality of vessels each adapted to receive an ingot formed by the melting of a consumable electrode therein, frame means constructed and arranged to be moved horizontally from a first position above one vessel to a second position above another vessel, closure means carried by said frame means and selectively engageable with the upper ends of said vessels, an electrode drive mechanism mounted on said frame means and extending through said closure means for supporting an electrode in said vessels, an optical assembly mounted on said closure means and adjacent said electrode drive mechanism, said optical assembly including first elongate tube means extending vertically through said closure means in substantial parallelism with said electrode drive means, second elongate tube means having one end affixed to the lower end of said first tube means and extending normally relative thereto, an opening adjacent the other end of said second tube means and facing downwardly toward said vessel, first reflecting means disposed adjacent the other end of said second tube opposite the opening therein for receiving upwardy directed light rays and for reflecting said rays along the axis of second tube means, second reflecting means disposed at the juncture of said first and second tube means and oriented for receiving light rays directed along the axis of said second tube means and for reflecting said rays upwardly along the axis of said first tube means, manually operable means for rotating said first tube means about a vertical axis so that said first reflecting means is moved in a circular path and relative to said electrode drive means, and reflecting prism means fixedly mounted on said frame means and disposed above the upper end of said first tube means for receiving light rays directed along the axis of said first tube means and for reflecting said rays through a preselected angle, a viewing screen disposed for receiving said projected rays when said electrode drive mechanism is in its first position, reflecting means mounted on said frame means and being movable therewith, said reflecting means being positioned between said light modifying means and said viewing screen when said frame means is in its first position, said reflecting means being pivotable relative to said frame means between an operative position in which it is effective to reflect said projected rays and an inoperative position in which it is ineffective to reflect said rays, said reflector being disposed in such an angular position relative to said light modifying means and said viewing screen that said projected rays will be reflected at an angle which is a complement of the angle through which said frame means pivots from its first to its second positions.

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