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INDUCTION HEATING DEVICE FOR HEATING A SUCCESSION OF ELONGATED WORKPIECES

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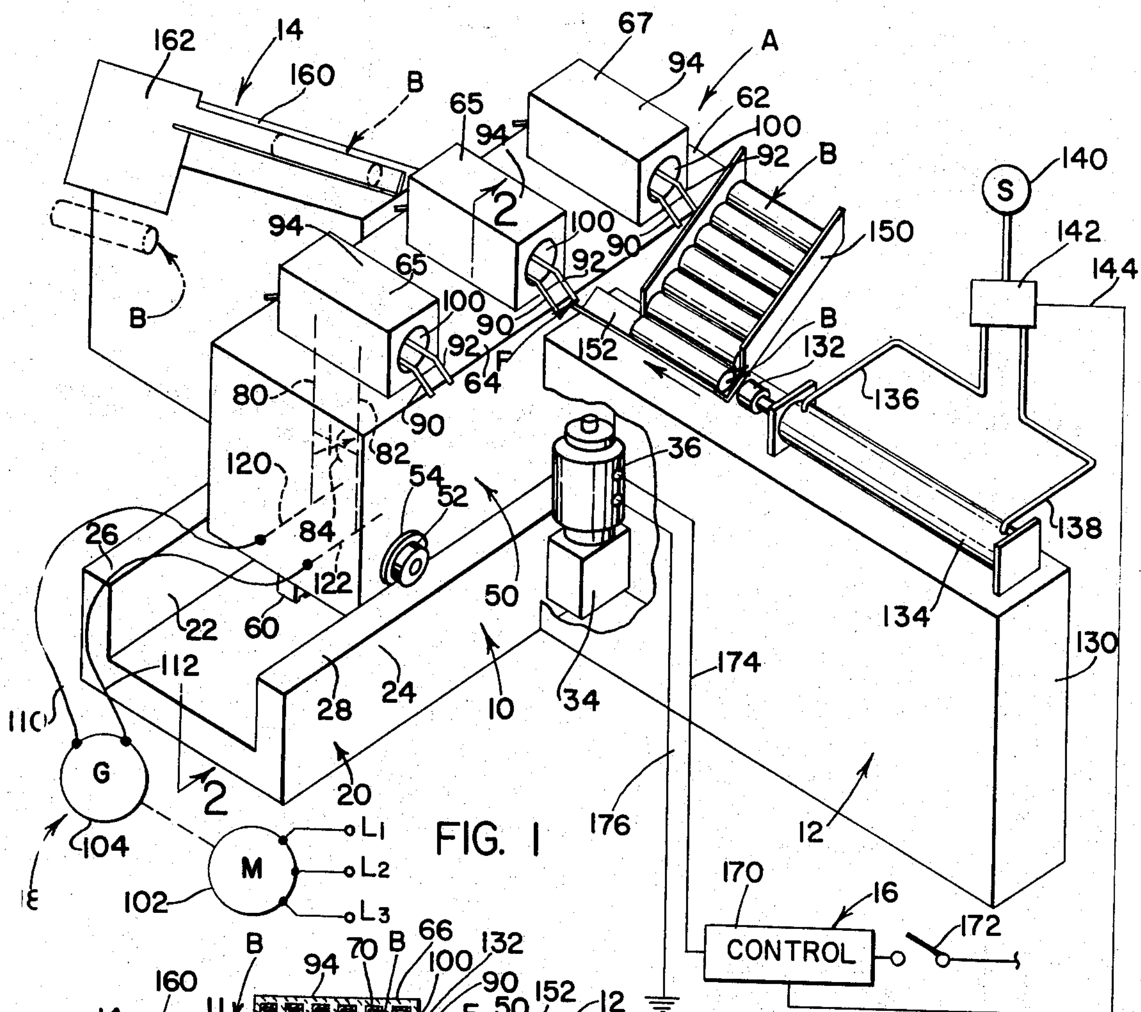

FIG. 1

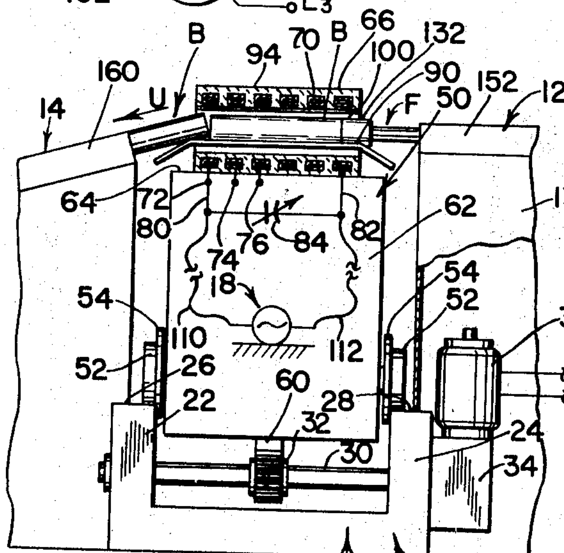

FIG. 2

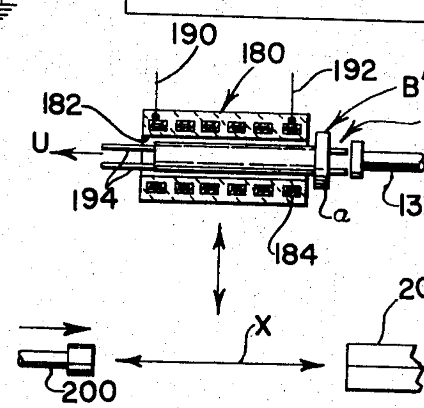

FIG. 3

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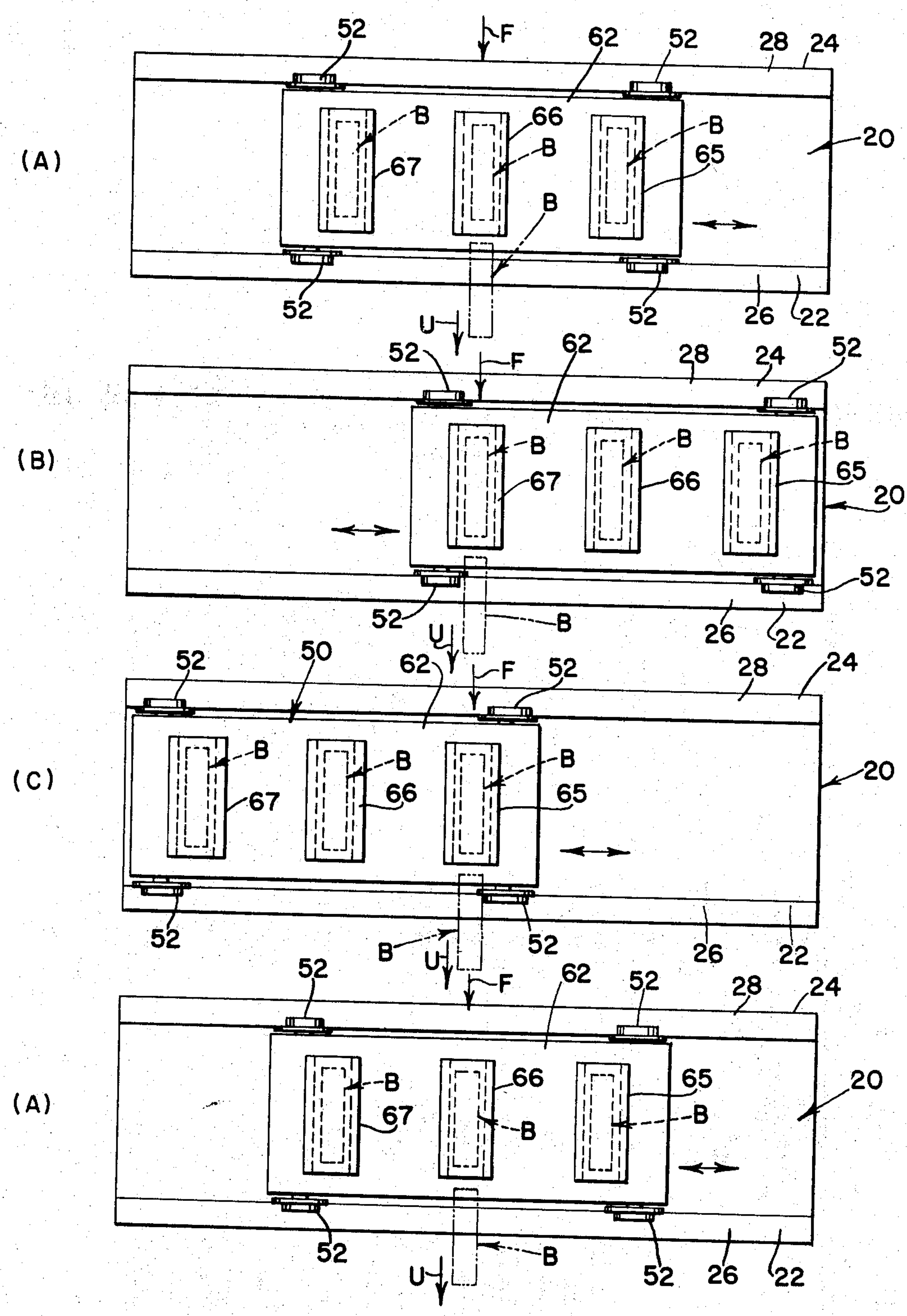

FIG. 4

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INDUCTION HEATING DEVICE FOR HEATING A SUCCESSION OF ELONGATED WORKPIECES

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U.S. Cl. 219—10.69 1 Claim

ABSTRACT OF THE DISCLOSURE

An induction heating device for heating a succession of elongated workpieces including a support frame, a shuttle frame, means for guiding the shuttle frame on said support frame and means for moving the shuttle frame between first and second positions along a path determined by the guide means. Two coil assemblies are secured onto the shuttle frame and include a multi-turn coil, a workpiece receiving passageway in the coil, a pair of leads and a power factor correcting capacitor connected between these leads. A stationary feeding means is located at a feed point along the path of movement of the shuttle so that this feed means is located opposite the workpiece receiving passageway of the respective coils when the support frame is in its respective two positions. A power source is secured with respect to the support frame and flexible leads join the leads of the respective coils so that the shuttle may move without movement of the power source. The feed means is operated at both positions of the shuttle to alternatively load and unload the two coils.

The present invention relates to the art of induction heating and more particularly to an induction heating device for heating a succession of elongated workpieces.

The invention is particularly applicable for heating a number of metal billets preparatory to forging, and it will be described with particular reference thereto; however, it should be appreciated that the invention has much broader applications and may be used for inductively heating a variety of different shaped workpieces.

In forging metal billets into final shape the billets are first heated to the forging temperature. At one time the heating was accomplished by gas fired furnaces; however, because of the expense, maintenance difficulties and uniform heating difficulties, the billets are now generally inductively heated by placing them in a multi-turn induction heating coil. This process is widely used; however, in many instances, the heating time for each billet is quite long. Consequently, the billet must remain in the heating coil a substantial length of time. During this time, no other billet can be heated by this particular coil. To overcome this disadvantage, it has been somewhat common practice to provide a succession of induction heating coils forming an elongated tubular structure through which a succession of billets is pushed. A billet is pushed into one end of the tubular structure. This forces a heated billet out of the other end. The heating time for each billet is fixed, but, the speed of operation can be controlled by changing the number of coils in the assembly and changing the billet feeding rate. This particular type of mechanism does increase the number of billets heated in a given period by the induction heating installation. However, certain difficulties are encountered.

If one coil in the line of induction heating coils becomes defective, the whole mechanism must be shut down. In many instances the heating installation must be excessively long to accommodate a rapid heating of a workpiece requiring a substantially long heating cycle. Because a large number of billets are forced, one-after-

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another, through the heating coils, there is always the problem of buckling the column of billets and increasing the wear or damaging the coil lining and guide rails. If the length of the billets is changed substantially, then the coils must be adjusted to change their effective lengths. This requires that the coils be moved closer together to prevent dark, or cold, portions along the length of the tubular opening through the aligned group of coils. All of these disadvantages have been overcome by the present invention which is directed toward an induction heating device for heating a succession of elongated workpieces, such as billets, without requiring these workpieces to be moved through a tunnel having a length determined by the desired heating cycle time.

In accordance with the present invention, there is provided an induction heating device for heating a succession of elongated workpieces which device comprises a support frame, a shuttle frame, means for guiding the shuttle frame on the support frame, means for moving the shuttle frame between first and second positions along a path determined by the guiding means, at least two coil assemblies secured onto the shuttle frame and each including a multi-turn coil, a workpiece receiving passageway in the coil, a pair of leads and a power factor correcting capacitor connected between the leads, and a feeding means located at a feed point on the path for pushing a succession of workpieces toward the path in a direction generally perpendicular to the path. The device is constructed so that the passageway of one of the coils is opposite to the feed point when the shuttle is in its first position and the passageway of the other coil is opposite the feed point when the shuttle is in its second position. In addition, there is a power source fixed with respect to the support frame for creating single phase high frequency current through the leads within the shuttle frame. Flexible leads connect the leads within the shuttle frame to the power source. In this manner, movement of the shuttle frame back and forth with respect to the support frame, and thus the power source, can be effected without sliding contacts or any other movable connections through which high frequency current must be passed.

By using the present invention, a relatively inexpensive device is obtained for heating a succession of billets without the maintenance difficulties usually encountered when sliding connections are required for introducing the high frequency current to the leads of the respective heating coils.

The primary object of the present invention is the provision of an induction heating device for heating a succession of elongated workpieces, which device is efficient in operation, relatively low in maintenance, and provides uniform heating of various size workpieces.

Another object of the present invention is the provision of an induction heating device for heating a succession of elongated workpieces, which device has separate, movable induction heating coils without requiring sliding connections for the high frequency current used to energize these coils.

These and other objects and advantages will become apparent from the following description used to illustrate the preferred embodiment, as taken in connection with the following drawings, in which:

FIG. 1 is a pictorial view illustrating, somewhat schematically, the preferred embodiment of the present invention;

FIG. 2 is a cross sectional view taken generally along line 2—2 of FIG. 1;

FIG. 3 is a schematic view illustrating a slight modification of the embodiment of the invention shown in FIGS. 1 and 2; and,

FIG. 4 is a schematic view illustrating various positions of the shuttle frame which forms a part of the present invention.

Referring now to the drawings wherein the showings are for the purpose of illustrating preferred embodiments of the invention only and not for the purpose of limiting same, FIGS. 1 and 2 show an induction heating device A used for raising the temperature of a succession of billets B to a forging or forming temperature. The heating device includes, as primary elements, heating mechanism **10**, feeding mechanism **12**, unloading mechanism **14**, control device **16** and a high frequency alternating current power supply, illustrated in FIG. 1 as a motor-generator set. The billets B may have various shapes; however, for the purposes of illustrating the invention, they comprise elongated, cylindrical ferro-magnetic structures.

Referring now to the heating mechanism **10**, it includes a support frame **20** having upstanding side flanges **22, 24** termintating in upper bearing surfaces **26, 28**, respectively. Extending between the side flanges is a drive shaft **30** carrying a pinion **32** and driven by a gear reducer **34**. The gear reducer is, in turn, driven in selected directions by a reversible motor **36** whereby the direction of rotation of the motor determines the direction in which the pinion is turned. The purpose of the reversible motor will be hereinafter described in detail. Above frame **20** there is a reciprocal shuttle **50** riding on support wheels **52** having inardly positioned flanges **54**. The flanges **54** coact with the flanges **22, 24** to guide the shuttle **50** along the support frame **20** in a generally rectilinear, reciprocated manner. To drive the shuttle there is provided a rack **60** coupled to the lower portion of shuttle **50** and coacting with pinion **32** so that rotation of the pinion causes a corresponding rectilinear movement of the shuttle. It is appreciated that the rack and pinion drive illustrated in the preferred embodiment of the invention may be replaced by other reciprocal drive arrangements for causing movement of the shuttle with respect to the support frame **20**. Such other mechanisms include, for example, a fluid cylinder, a lever system, a leaf screw, or a direct motor coupling. Shuttle **50** also comprises an enclosed housing **62** having a Transite top plate **64**.

As best shown in FIG. 1, a plurality of coil assemblies are secured onto the top plate **64**. Any number of coil assemblies, exceeding one, may be used in practicing the invention; however, in accordance with the preferred embodiment of the invention, there are three coil assemblies **65, 66**, and **67**. Each of these coil assemblies is substantially identical; therefore, only one will be described in detail, and this description will apply equally to the others. Each coil assembly includes a multi-turn induction heating coil **70** having length adjusting tabs **72, 74**, and **76**. Leads **80, 82** are used to introduce alternating current through the coils. To adjust the energized length of the coils, lead **80** may be coupled with any one of three taps, **72, 74** and **76**. Between the leads **80, 82** there is provided a conventional adjustable power factor collecting capacitor **84**. Each coil assembly includes a pair of support or guide rails **90, 92** extending within an encapsulating casing **94** to a central workpiece receiving passageway **100**. By this construction, billets B may be forced into the passageways **100** and heated therein by one of the coils **70**.

To better appreciate the heating operation, the high frequency power source **18** is illustrated as a motor **102** having a three-phase input, schematically represented as line L1, L2, and L3, and a generator **104** coupled onto the motor. Output leads **110, 112** of the generator are in the form of flexible leads having a sufficient length to allow movement of the shuttle **50** along the frame **20** between the extreme reciprocated positions. Within the housing **62** there are provided a pair of common bus bars **120, 122** coupled onto the respective leads **80, 82** of the individual coils **70**.

Referring now to the feeding mechanism **12**, this mechanism includes a support stand **130** for carrying a pusher rod **132** operated by a fluid actuated cylinder **134** through fluid supply conduits **136, 138**. A source of fluid, schematically represented as source **140**, is communicated with the respective conduits **136, 138** through an appropriate control valve **142**. The position of the control valve is determined by signals received through line **144** which, in turn, changes the reciprocated position of the plunger **132**. Billets B are supplied by a magazine trough **150** into a feed trough **152** aligned with both the rod **132** and a passageway **100** of a particular coil **70** which is ready to receive an unheated billet. The feed point, or axis, F is in direct alignment with the passageway **100** during the feeding operation so that the plunger **132** may force a billet into an awaiting passageway **100**.

The unloading mechanism **14** may take a variety of structural shapes; however, in accordance with the illustrated embodiment of the present invention, this mechanism includes an outlet trough **160** generally aligned with a passageway **100** of one of the coils when the shuttle **50** is in a loading and unloading position at axis F. The arrow U indicates the general direction in which the billets B move during unloading. A drop-off plate **132** receives the heated billets B from the trough **160** and moves them into an appropriate position for subsequent forging or forming.

The control device **16** is schematically represented as an appropriate programmer **170** having a starting switch **172** and motor control lines **174, 176**. At the proper time, the valve control line **144** receives signals from the programmer **170** to shift rod **132** alternately between inward and outward positions. The programmer sequentially shifts the shuttle **50** into three separate positions so that at each position a different one of the coil assemblies **65, 66** or **67** is aligned with the feed axis F and the unload axis U. At the proper time, a signal from line **144** energizes valve **142** and piston **132** moves toward the coil assembly. This forces a billet B into the awaiting passageway **100**, as shown in FIG. 2. At the same time, a heated billet within the passageway is forced onto the inclined trough **160** where it is moved to the appropriate forging operation.

In operation, there is a need for only two coil assemblies. Assuming that coil assemblies **65** and **66** are used for the heating operation, a billet is forced into coil assembly **66**. Thereafter the programmer **170** causes motor **36** to rotate bringing coil assembly **65** into alignment with the feed point, or axis F. Then, a signal from line **144** causes rod **132** to force another billet into assembly **65**. While this is being done, the billet previously forced into assembly **66** is being heated to the forging temperature at a remote position. At the appropriate time, a shuttle **50** is then reversed by motor **36** under the control of programmer **170**. This again brings the passageway **100** of assembly **66** into alignment with the rod **132**. Another billet is then forced by the rod into the assembly **66**. This forces the previously heated billet into the inclined trough **160**. Of course, between the feeding operation rod **132** is moved backwardly, or inwardly, upon receipt of a signal from line **144**, and another billet drops into trough **152** for subsequent feeding. This operation is continued, in sequence, to alternately load the two coil assemblies. In this manner, the billets remain in a single coil assembly for the necessary length of time to effect proper heating. If one of the coils becomes defective, it may be removed and repaired and programmer **170** may be adjusted so that the coil assembly **67** is used in place of the removed coil assembly.

In accordance with the preferred embodiment of the present invention, three separate coil assemblies are used for the heating operation. This allows a lengthening of the heating time to correspond with two separate feeding cycles or increases the number of billets heated in a given period. This operation is illustrated in FIG. 4 wherein shuttle **50** is shown in three separate positions labeled (A), (B), and (C). Position (A) is shown twice. Referring to position (A), an unheated billet is forced into coil assembly **66**. This removes a previously heated billet therein. Shuttle **50** is then moved to position (B) wherein a billet is forced into coil assembly **67** which removes a heated billet therefrom. At the same time, the billet in assembly **66** is being heated. Then, the shuttle is moved to position (C). In this position, a billet is forced into coil assembly **65** which removes a heated billet therefrom. At the same time, the billet within assembly **66** is finally heated and the billet within assembly **67** is initially heated. Thereafter, the shuttle **50** is shifted back into position (A) so that the first mentioned billet forced into assembly **66** is removed by an unheated billet. This process is repeated time and again to heat a succession of billets B. It is seen that each billet is heated in two separate positions and removed when the shuttle is reciprocated into the third position. Consequently, the heating operation is prolonged while billets are fed into the other two coil assemblies. Other arrangements and sequences could be used. If the length of the workpiece is changed, lead **80** may be adjusted to connect one of the other taps **74, 76,** as shown in FIG. 2. This provides a convenient manner to change the length of the heating coils to correspond with the approximate length of the billet.

As so far explained, the billets are forced into one side of the coil assemblies and removed from the other side. Some workpieces cannot be forced through a coil assembly; therefore, in accordance with another embodiment of the present invention a different unloading arrangement is contemplated. This is illustrated in FIG. 3, wherein the workpiece B′ includes a flange *a*. The coil assembly **180** has an internal passageway **182** which can receive part of the workpiece but not the flange *a*. The coil assembly also includes a multi-turn coil **184** having input leads **190, 192** and appropriate guide rails **194** for supporting a portion of the workpiece B′ in the passageway **182.** To accomplish the heating operation, the previously explained rod **132** forces the workpiece into the passageway **182.** Then the shuttle assembly, not shown, is moved away from the plunger **132** and the workpiece is heated. At a spaced position indicated by axis X, an extracting plunger **200** is positioned to move into the passageway **182** from a position on the opposite side of the coil assembly from rod **132.** This forces the heated workpiece from the coil assembly and onto extracting trough **202.** Except for the change in the unloading position, the operation of the embodiment schematically illustrated in FIG. 3 does not differ substantially from the operation previously explained in connection with the preferred embodiment illustrated in FIGS. 1 and 2.

Having thus described my invention, I claim:

1. An induction heating device for heating a succession of elongated workpieces, said device comprising a support frame having a first guide element, a shuttle frame movable on said support frame and having a second guide element, said guide elements being mutually coacting to guide said shuttle along a generally straight, horizontal path as said shuttle frame is moved with respect to said support frame, reversible drive means for reciprocating said shuttle frame in a first and second direction along said generally straight path between first and second positions, at least two induction heating coil assemblies mounted on said shuttle frame and each comprising a multi-turn coil with a central workpiece receiving passageway extending in a direction generally perpendicular to said path and guide members in said passageway to allow movement of a workpiece into and out of said coil in a direction generally perpendicular to said path, a pair of conductors located on said shuttle frame and connected to said coils, a power factor correcting capacitor connected in parallel with each of said coils and located on said shuttle frame, a high frequency power source for creating single phase high frequency current fixed with respect to said support frame, flexible lead means for connecting said power source to said conductors whereby said connection remains as said shuttle frame moves with respect to said support frame, said flexible lead means having a first end fixedly connected with respect to said support frame and a second end fixedly connected with respect to said conductors, and stationary means for alternately feeding elongated workpieces into said workpiece receiving passageways after movement of said shuttle frame into one of said first and second positions.

References Cited

UNITED STATES PATENTS

2,942,089	6/1960	Baker et al.	219—10.69
3,185,810	5/1965	Peschel et al.	219—10.69

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