

United States Patent

[11] 3,614,366

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[21] Appl. No. **7,075**
[22] Filed **Jan. 30, 1970**
[45] Patented **Oct. 19, 1971**
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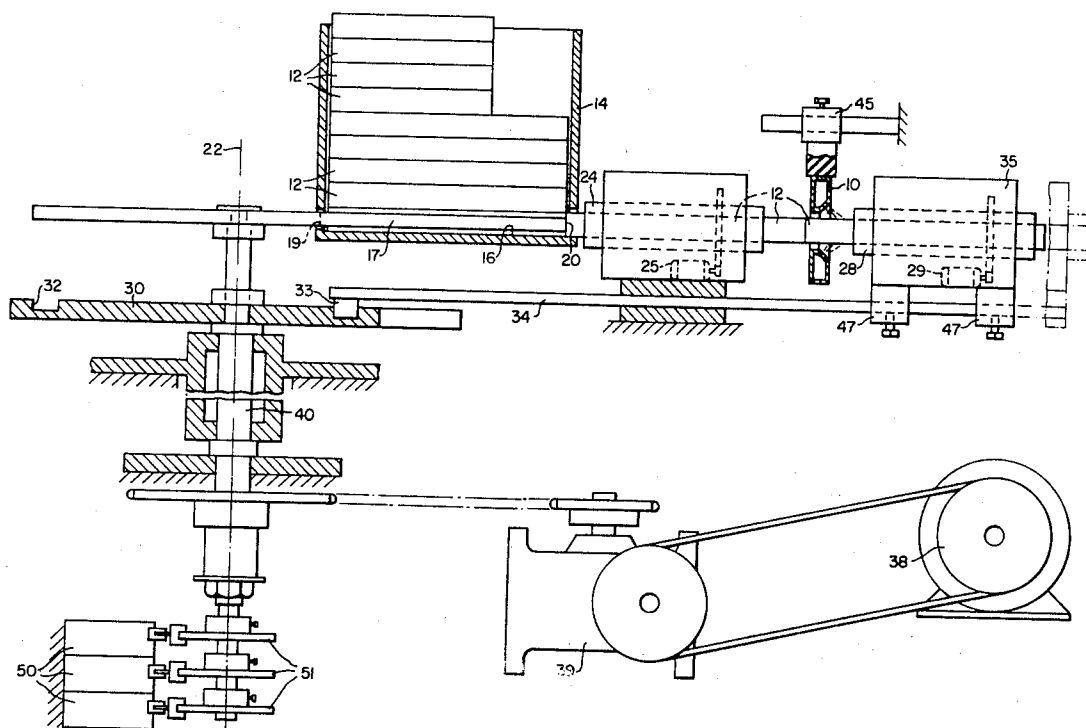
[54] **CAM FEED SCANNER-TYPE INDUCTION HEATING APPARATUS**
4 Claims, 5 Drawing Figs.

[52] U.S. Cl. **219/10.69,**
219/77
[51] Int. Cl. **H05b 5/00,**
H05b 1/02
[50] Field of Search. 263/6;
266/4 E; 219/10.69, 10.77

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ABSTRACT: Improvements in an induction heating apparatus which employs a constant rise feed cam that shoves a line of end-to-end workpieces toward an integral quench induction heating coil for scansion of the leading workpiece, and a cam operated collet for completing scansion of such leading workpiece. Means are provided for preventing overheating of certain length workpieces that tend to come to rest in the heating coil during workpiece-introducing and slack-gathering portions of the feed cam cycle, and for increasing speed of operation of the feed cam during such slack-gathering period.



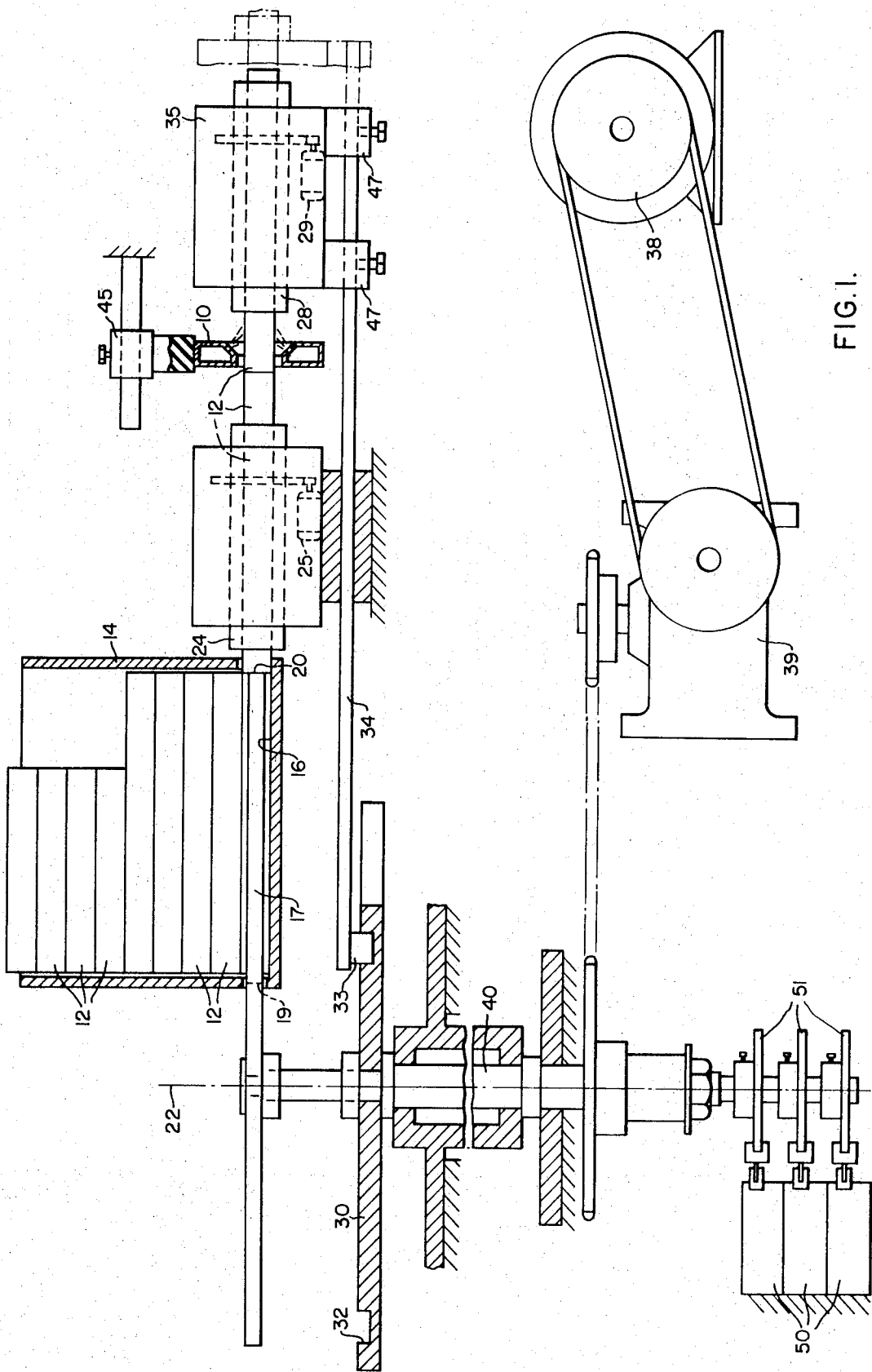


FIG. 1.

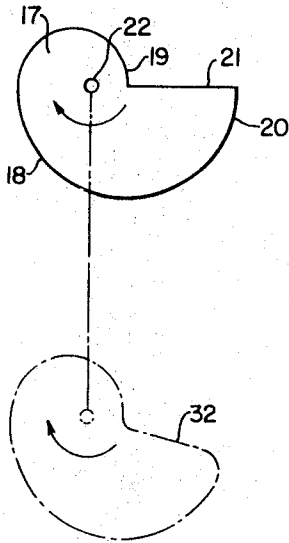


FIG. 2.

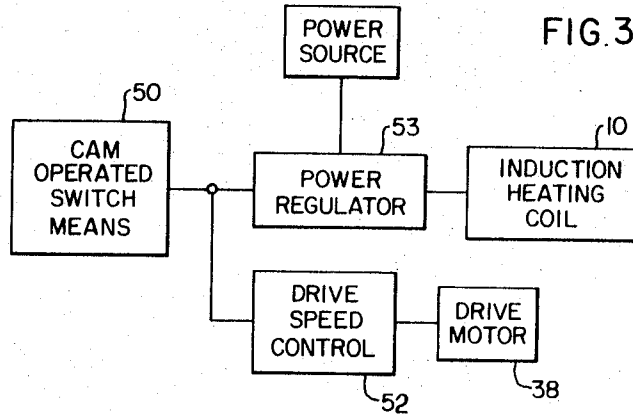


FIG. 3.

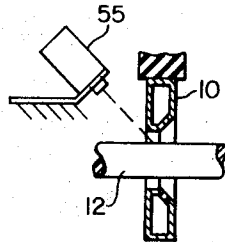


FIG. 4.

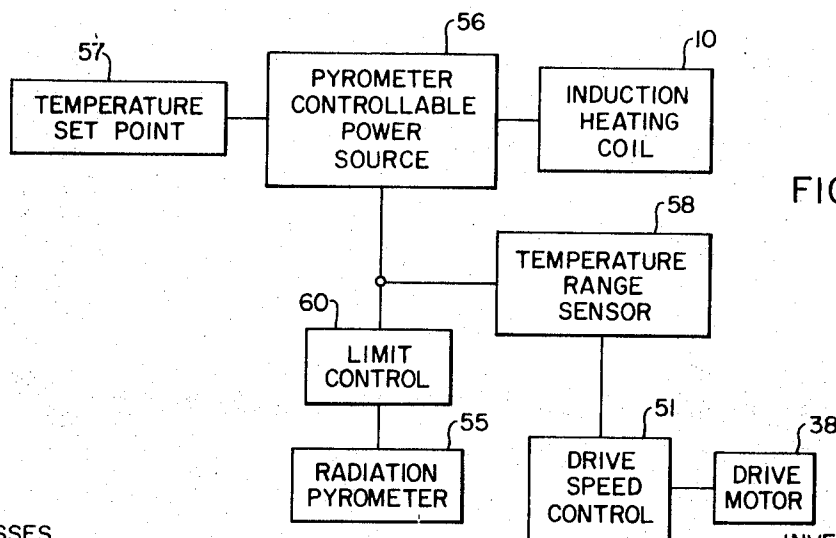


FIG. 5.

WITNESSES

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CAM FEED SCANNER-TYPE INDUCTION HEATING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention—Cam Fed Scansion-type induction heating apparatus.
2. Description of the Prior Art

An induction heating apparatus has been employed heretofore for heat treating metal workpiece rods of a particular length, which includes a magazine that vertically stacks a number of such rods in a horizontal attitude for periodic introduction of the bottom workpiece between a constant rise feed cam at one end and a previously introduced coaxially aligned workpiece at the other for longitudinal actuation in unison to advance such previously introduced workpiece progressively through a workpiece-rotating collet and into an integral-quench induction heating coil where, near the end of such feed cam actuation, a workpiece-rotating rear collet withdraws the remainder of such workpiece through the coil as the cam actuated workpiece ahead of it comes to rest momentarily ahead of the coil during the time that a new workpiece from the magazine stack is being introduced. The location of the induction coil is fixed, and the apparatus has been employed heretofore only with a workpiece length substantially equal to the full rise dimension of the feed cam, and the travel of the rear collet is limited to that merely required to handle the period during feed cam loading.

The present invention contemplates use of such apparatus for heat treating such rod-shaped workpieces throughout a range of different lengths, from a certain minimal length up to the full feed cam rise length heretofore accommodated. Aside from insufficient stroke of the rear collet, certain workpiece lengths within such potential range can result in dwell of workpiece portions within the coil, posing the potential problem of overheating in absence of the scansion movement, and/or inability of the rear cam-actuated collet to obtain sufficient grip on the workpieces and to effectuate their withdrawal through the coil. At the same time, the shorter workpiece lengths tend to introduce periodic delays in cam actuation of the leading workpiece during the time required for the feed cam to bring such shorter workpieces into actuating abutment with the preceding workpieces aligned in the heating path.

SUMMARY OF THE INVENTION

In accord with the present invention, the above limitations are obviated by, in addition to increasing the stroke of the rear collet cam, provision of means, which, in one embodiment, permits of adjustment in the position of the integral quench coil and of the workpiece-grabbing position of the rear collet according to the length of the workpiece being handled and thereby prevent heating coil dwell and inadequate rear collet grasp, while employing adjustable cam-actuated switch means to effect speedup in operation of the feed cam drive motor during workpiece line slack takeup, and, in an alternate embodiment, by provision of an automatic coil-power-regulating means including an infrared pyrometer looking at the workpiece heating region within the coil, operating to prevent workpiece overheating irrespective of a momentary workpiece dwell within the coil while also serving to indicate a lack of workpiece scansion heating by the coil to effect speedup in feed cam drive motor operation until such scansion heating resumes. The latter embodiment renders the apparatus capable of accommodating all workpiece lengths within the handling range without need for the adjustments and cam-operated speed control switches of the first embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation view, partly in outline and partly in section, of a cam-feed collet-withdraw induction heating apparatus improved in accord with one illustrative embodiment of the invention;

FIG. 2 is a plan view showing the profile of the constant-rise workpiece feed cam and rise profile of the rear collet actuating cam of the apparatus of FIG. 1;

FIG. 3 is a block diagram of a control system constructed in accord with the aforesaid one embodiment;

FIG. 4 shows the radiation pyrometer situated to observe the heating area within the coil, in accord with the second embodiment of the invention; and

FIG. 5 is a block diagram of a control system suitable for employment in accord with the second illustrative embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, the apparatus in which the improvements of the present invention are embodied comprises an integral quench induction heating coil 10, arranged to be energized from a suitable power source, not shown, such as a 10-kilohertz motor-generator set, and to be availed of a quenching liquid such as cooling water at its interior. During scanning of a metal workpiece 12 through the coil, it becomes progressively heated and quenched along its length for purposes of such as surface hardening. If the workpiece is cylindrical, a solid rod, for example, the rate of scanning movement is fixed, and the power level is constant, the workpiece becomes uniformly heat treated from its one end to the other.

In the apparatus, the workpiece rods 12 are stacked in a horizontal attitude in a magazine 14 disposed atop an inlet guide surface 16 above which a constant displacement feed cam 17 passes. The feed cam 17, FIG. 2 has a displacement or rise surface 18 that increases in diameter at a constant rate between a minimum radius portion 19 to a maximum radius portion 20 for substantially 360°, and a straight surface portion 21 extends radially from the axis of cam rotation between the inner and outer cam surface radii 19 and 20. The feed cam 17 is arranged such that its inner and outer radii portions 19 and 20 align vertically with opposite ends of the magazine 14 to permit up to a full length workpiece 12 to drop onto inlet guide surface 16 behind straight cam surface 21 during each revolution of such cam and be advanced past the open bottom of the magazine toward coil 10 by sliding abutment of its one end with cam surface 18. If the rate of turning of cam 17 is constant, the rate of displacement of the workpieces 12 will be constant. Successive ones of such workpieces 12 introduced to the inlet guide surface 16 from the magazine 14 become axially aligned in end-to-end abutment and become displaced longitudinally in unison by the feed cam 17 during each of its rotations, subject to periodic halts momentarily during periods of workpiece introduction as well as during the times that a longitudinal gap exists between the previous end-to-end aligned workpieces 12 reposing beyond the magazine and a newly introduced workpiece 12 of less length than the full length of magazine 14, and/or the span between innermost and outermost feed cam surface radii 19 and 20. In such shorter length case, the newly introduced workpiece 12 is actuated alone by cam 17 until it is brought into endwise abutment with such previously introduced momentarily reposing end-to-end aligned workpiece or workpieces, as the case may be.

During actuation of the aligned workpieces in unison by the feed cam 17, they become introduced consecutively to a front rotary collet 24 being rotated by a motor 25, thence into the integral-quench induction heating coil 10; such front rotary collet being employed to effect rotation of the workpiece while it is being subjected to the effect of such heating coil for the usual purpose of assuring an evenly distributed circumferential heat pattern.

At the time the feed cam approaches its maximum lift radius 20, hence its workpiece loading position in which it is shown in FIG. 1, a rear rotary collet 28, constantly being turned by a respective motor 29 is actuated forwardly by a cam 30 toward and in coaxial alignment with the coil 10 to the position in which it is shown in FIG. 1 for sliding over the end of a respective workpiece 12 projecting through such coil, being turned by collet 24 and being advanced by feed cam 17. In accord with the present invention, immediately before the feed cam 17 reaches its loading position, the cam 30, whose functional

profile is represented by the dot-and-dash line 32 in FIG. 2, starts to move the rear collet 28 coaxially away from coil 10 at the same rate as the feed cam 17 advances the opposite end of the aligned workpieces. The rear collet 28 continues such movement for substantially 350° of the feed cam rotation and in exerting a gripping force on the respective workpiece 12 completes its scansion through coil 10, while the preceding workpiece becomes arrested in its longitudinal advance during introduction of a new workpiece to the feed cam 17 and takeup of any aforementioned slack introduced in the line by virtue of the length of such newly introduced workpiece. Upon return of the rear collet 28 to its loading position, any workpiece present therein becomes ejected by introduction of the next workpiece.

The cam 30 is double acting and operatively connected to the rear collet 28 via a cam groove 32, a roller follower 33, an actuating stem 34, and a housing 35 which supports such collet for rotation about its central axis.

Both collets 24 have internal spring fingers, not shown, which project radially inward and extend along the length of such collets to yieldably center and impart turning motion to the workpieces 12. The spring finger force of the rear collet 28 is greater than that of the front collet 24, to permit such rear collet to extract a workpiece from such front collet in cases where a workpiece extends therebetween at the time that the rear collet completes its scansion movement through the coil.

Both the feed cam 17 and the rear collet actuating cam 30 are actuated in unison by a drive means such as exemplified in FIG. 1 essentially including a motor 38, gear reducer mechanism 39, and a rotary shaft 40 operatively connected to such cams.

In accord with other improvements, of the present invention as exemplified in FIGS. 1 and 3, the integral quench coil 10 is mounted on a bracket 45 which can be selectively positioned to adjust the axial position of such coil along the path of travel of the workpieces 12, and the housing 35 for the rear collet 28 is also adjustably positionable along the actuating arm 34 via clamping brackets 47. By virtue of such adjustments it becomes possible to prevent certain shorter length workpieces from coming to rest within the coil 10 during operation of the apparatus. Also, as exemplified in FIGS. 1 and 3, a switch means 50 operated by adjustable position cams 51 driven by shaft 40, are employed to control a drive speed control means 52 for the motor 38 to effect speedup in its operation during the time that the feed cam 17 is actuating a newly introduced shorter length workpiece into abutment with other workpieces in the line; thereby enhancing operating efficiency of the apparatus under such short workpiece operating condition. The cam operated switch means 50 also can be employed in conjunction with a programmed power regulator 53, as per FIG. 3, to effect a programmed reduction in heating coil power during periods of longitudinal arrest of workpiece travel through coil 10, either in adjunct with or in lieu of adjustment in position of such coil. Any adjustments in position of coil 10, rear collet housing 35, and switch operating cams 51, will be made by the operator during setup of the apparatus, in accord with the workpiece length to be accommodated.

In accord with a second embodiment, need for employment of the cam operated switch means 50 and for position adjustment of the coil 10 and rear collet housing 35 can be obviated by provision of a control system as exemplified in FIG. 5, that responds to the dictates of a radiation pyrometer 55, FIG. 4, to stabilize the temperature to which coil 10 heats the workpiece, irrespective of its rate of longitudinal movement, or lack thereof, as well as to effect speedup of the drive motor 38 during periods when workpieces are not being fed at normal rate through the coil.

In operation, a pyrometer controllable power source 56 will respond to output from the radiation pyrometer 55 to regulate power to the heating coil 10 in behalf of satisfying dictate of a temperature set point means 57. When a workpiece 12 may come to longitudinal rest within the coil 10, the radiation pyrometer output will call for a power reduction and this condition will be sensed by a temperature range sensor means 58 to effect a speedup in the cam drive motor 38. Upon resumption of scanning movement of the workpiece, the resultant radiation pyrometer response signal will be sensed by the sensor means 58 to effect return of the drive motor 38 to its normal scan speed. Upon absence of a workpiece 12 from the heating coil 10, as during its withdrawal by the rear collet 28, the pyrometer 55 will reflect such condition and provoke a response by sensor 58 to call for drive motor speedup, followed by automatic return to normal scan speed upon response of pyrometer 55 to introduction of a workpiece into coil 10. In this latter case, runaway of coil power during absence of a workpiece within the coil will be prevented by a limit control means 60.

I claim:

1. An improved induction heating apparatus of the type comprising a magazine for storing elongated workpieces to be fed longitudinally along a heating line including other similarly aligned workpieces, an induction heating coil in said heating line, a rotary constant-rise feed cam for accepting a workpiece from said magazine each revolution and advancing same longitudinally along said line, a reciprocable rear collet in said line at the exit side of said heating coil for gripping the respective end of a workpiece to complete its scansion through the heating coil a rotary collet drive cam for effecting reciprocal movement of said rear collet and having the same workpiece travel rate as that effected by said constant-rise feed cam, and a drive motor means for driving both aforesaid cams in unison; the improvement thereof which permits of use with workpieces of different length:

construction and arrangement of said collet drive cam to provide for workpiece withdrawing movement substantially its full revolution with a quick return movement portion just prior to said feed cam attaining its maximum displacement position, and said apparatus further including,

drive motor speed control means for increasing speed of said drive motor means during periods of longitudinal gaps between workpieces in the heating line, and adjustable means for preventing overheating of a workpiece coming to rest within said heating coil.

2. The apparatus of claim 1, wherein, said drive motor speed control means includes adjustable cam actuated switch means driven by said drive motor means, and said adjustable means includes support means for said heating coil and rear collet which permit of adjustment in positioning thereof along said heating line.

3. The apparatus of claim 1, wherein, said adjustable means includes means responsive to slight variation in temperature of the workpiece within said heating coil to automatically regulate power supplied to said heating coil.

4. The apparatus of claim 1, wherein, both said drive motor speed control means and said adjustable means include a radiation pyrometer in observation of the workpiece region within said heating coil, and means operable to render same automatically responsive to information derived from said pyrometer with respect to both workpiece heating, position, and longitudinal motion.