

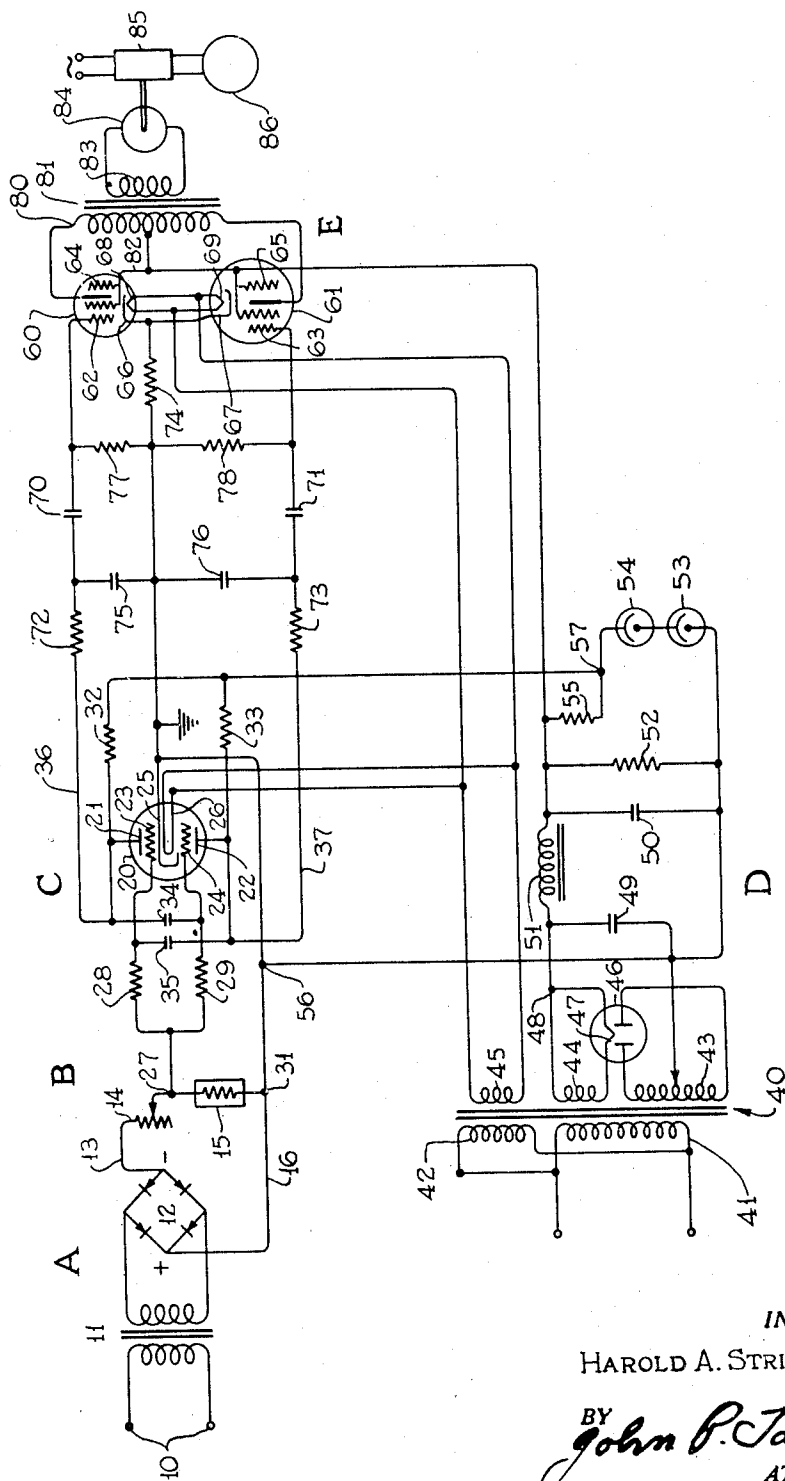
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UNIFORM ENERGY SUPPLY

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UNIFORM ENERGY SUPPLY

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1

This invention relates to a circuit and associated apparatus for maintaining uniform the energy input of a power consuming device, such as a furnace.

In various types of equipment, particularly induction furnaces, it is important from the viewpoint of constant temperature requirements of many types of workpieces as well as efficiency and costs that the input of energy into the furnace be substantially uniform irrespective of source voltage variation, this being of considerable importance when a series of similar unit loads are being successively treated by the furnace.

In accordance with the present method I utilize voltage of the source current to determine the amount of energy transferred to the load.

In accordance with the statement as hereinabove made, an important object of the invention is to provide means which are effective to control the amount of energy received by the load so that the energy input is substantially uniform for successive loads. Another object of the invention is to provide control means for obtaining uniform load heating which is dependent upon the voltage of the heating current. Still another object of the invention is to provide means for uniform load heating which is independent of rotating or movable mechanical parts. An object also is to provide control means that functions through a limited number of electronic devices. An additional object is to provide apparatus for uniform load heating which may readily be adapted to usual standard commercial heating equipment. Other objects of the invention will appear on consideration of the invention as hereinafter described and as shown in the accompanying figure.

Referring to the figure, there is indicated diagrammatically a circuit applicable to a timer of an induction heating unit although the invention is not limited to this particular use. The circuit may be roughly divided into five sections indicated by the capital letters A, B, C, D and E, the letter A referring to the rectifier section, the letter B to the voltage control section, the letter C to the oscillator section, the letter D to the constant potential section, and the letter E to the amplifying section. Connection to the commercial power source is made at 10, current being conducted through the transformer 11 to the bridge rectifier 12. The rectified current is led through conductor 13, variable linear resistor 14 and non-linear resistor 15 to conductor 16. As is known in this art, the current in a non-linear

2

resistor such as Amperite which is iron in a rapid heat conducting atmosphere such as helium, varies as a power of the voltage. This power may be controlled to some extent, units being made having a power which may vary from one to five according to the formula $E_o a E_a^n + K$ where E_o is voltage across the Amperite, E_a voltage across the inlet mains, and K a constant. For the purpose of this invention it is assumed that the resistor has a variation of current in accordance with a value of n between 1.5 and 2.6. Voltage drop through the resistor 14 accordingly will vary in accordance with the voltage impressed on the non-linear element 15 and utilization is made of this non-linear variation in voltage across the resistor 15 to cause a variation in frequency of the oscillator circuit C which will now be described.

The oscillator circuit section C is centered in the oscillator tube 20 which is of the complex type having anodes 21 and 22, control grids 23 and 24 and a single cathode 25 heated by a separate heater coil 26. As shown the control grids are connected to the point 27 intermediate the resistors 14 and 15 through resistors 28 and 29. The cathode of the tube is grounded and also connected to the point 31 on the side of the resistor 15 opposite from the point 27, or to the negative side of the circuit plate voltages for the units 21 and 22; and current for the resistor heating filament 26 is supplied from the power unit D. Use is made of resistors 32 and 33 to limit the power supply to the anodes. Also a capacitor 34 is placed between the grid 24 and the anode 21 and a capacitor 35 between the grid 25 and the anode 22. Anodes 21 and 22 are also connected by circuit conductors 36 and 37 to the amplifying branch circuit E.

The circuit D is more or less conventional in form utilizing a transformer 40 having primary coils 41 and 42, secondary coils 43 and 44 and 45. Secondary 43 at its terminals connects to the anodes of a dual rectifier tube 46, the cathode 47 of which has its ends connected to the terminals of the secondary 44. The mid-point of the transformer secondary 43 and the cathode circuit from point 48 together lead into the filter section of a rectifier circuit including the capacitors 49 and 50 and choke coil 51. The resistor 52 is connected across these two terminals; also the glow tubes 53 and 54 in series parallel with the resistor 52, resistor 55 being in series with the glow tubes to secure the desired voltage point at the glow tube terminals. The one side of the rectified constant potential circuit is connected to the grounded side of the C section as at point

56 while the other side of the D circuit is connected from point 57 to the conductor joining the resistors 32 and 33 in the plate circuit of the C section. There is thus provided a constant potential from the D load supply to the anodes of the oscillator tube. The secondary 45 of the transformer 40 supplies current to the filament 20 of the oscillator tube.

A push-pull amplifier is utilized in connection with the oscillator and comprises two amplifying tubes 60 and 61, each of these tubes being provided with control grids 62 and 63 and double shield grids 64 and 65 as well as cathodes 66 and 67 to independent heaters 68 and 69. The heaters each are connected to the secondary 45 of transformer 40 in the power supply circuit D. The control grids 62 and 63 are connected through capacitors 70 and 71 and resistors 72 and 73 to anode conductors 36 and 37 of the oscillator circuit C. The cathode is connected through resistor 74 to the cathode 25 of the oscillator. Between capacitors 70 and resistor 72 and capacitors 71 and resistor 73 the conductor leads to the cathode circuit through capacitors 75 and 76 respectively. Also between capacitors 70 and the control grid 62, the capacitor 71 and control grid 63, conductors, including resistors 77 and 78 respectively, lead to the cathode 25.

The anodes of the amplifying tubes are connected through the primary 80 of the amplifying transformer 81, the mid-point of the primary having connection to conductor 82 joining the shield grids of the amplifying tubes. The secondary 83 of the amplifying transformer 81 is directly connected to a synchronous motor 84 which in turn is operatively connected to the timer mechanism 85 controlling the switching contacts of the heating unit 86.

The operation of the circuit may now be described. It may be assumed that power is being supplied the sub-circuits A and D from the line and consequently the oscillator tube 20 is transferring oscillations of a definite frequency depending upon the voltage across the resistor 15. The oscillations of the oscillator are moreover amplified and transferred to the synchronous motor which rotates at a speed corresponding to the frequency of oscillation. If a heating operation is in effect and the voltage is maintained constant through the heating operation, the synchronous motor will function at a constant speed and thus heating input into the load will be at a constant rate. Further, should a series of workpieces be subsequently inserted in the furnace and the voltage remain substantially constant, the time period and the amount of heat transmitted to the successive workpieces would be uniform. However, if for any reason the voltage across the resistor 15 should change, the current passing therethrough will vary non-linearly, due to the fact that the resistance of Amperite varies non-linearly, producing a change in the voltage across the oscillator tube. A characteristic of the oscillator described is that the frequency of oscillation is dependent upon the voltage impressed through the circuit; consequently the frequency varies as the power of the voltage in the source circuit. Since the source circuit is applicable to the heating coil of the furnace it is apparent that the synchronous motor will rotate more slowly if the voltage is low and increase its rapidity of rotation as the voltage increases. This functioning of the synchronous motor consequently increases the time interval of heating for lower voltages and de-

creases the time with the power of the voltage for higher values. Thus the energy for a given heating interval will be approximately uniform irrespective of the voltage impressed upon the heating coil.

It is apparent that utilization is made in this circuit of devices and apparatus which are more or less conventional in nature such as the oscillator circuit, the power supply circuit, and the amplifying circuit, and hence modifications of these elements may be made without modifying or detracting from the essential novelty of the invention which centers about the utilization of non-linear resistors for securing a uniform energy input in a series of workpieces independent of variation of voltage. Other modifications may be made, the limits of the invention being defined by the claims as hereto appended.

What is claimed is:

1. In energy supply means, a heating unit, a source of power for said unit, a timer for setting the time period of application of power to said heating unit, and means connected to said timer for modifying the timer period to compensate for changes in power source voltage, said means comprising a non-linear resistor connected to the power source, means for establishing a direct current voltage across said resistor, an oscillator circuit, means for translating voltage across said resistor into current oscillations of a predetermined frequency in said oscillator circuit, and means between said timer and oscillator circuit for changing the timing period inversely as the change in oscillation frequency of said oscillator circuit.

2. In induction heating means, a source of alternating current, a heating unit connected to said source, means connected to said source for rectifying the current thereof, a non-linear resistor connected to said rectifier, an oscillator circuit connected across said non-linear resistor, the frequency of said oscillator circuit being dependent upon the voltage across the non-linear resistor, a synchronous motor connected to said oscillator circuit, and timing means for varying the time period of application of heating current from said electric source to said heating unit in accordance with inverse variation of the frequency of said oscillator circuit.

3. In induction heating apparatus the combination of a source of alternating current, means for rectifying said source current, a non-linear resistor connected across said rectifier, an oscillator circuit connected to said non-linear resistor subject to variation in frequency of oscillation in accordance with variation of the voltage of the source current, a heating circuit, timing means for predetermining the timing period for application of heating energy to said heating means and means connected intermediate the timing means and oscillator circuit for changing the timing period, inversely as the change in frequency of the oscillating circuit.

4. In induction heating apparatus the combination of a source of alternating current, means for rectifying said source current, a non-linear resistor connected across said rectifier, a variable linear resistor connected in series with said non-linear resistor, an oscillator circuit connected to said non-linear resistor subject to variation in frequency of oscillation in accordance with variation of said variable resistor and in accordance with variation of the voltage of the source current, a heating circuit, timing means for predetermining the timing period for appli-

5

cation of heating energy to said heating means and means connected intermediate the timing means and oscillator circuit for changing the timing period, inversely as the change in frequency of the oscillating circuit.

5. In energy supply means a heating unit, a source of power for said unit, a timer for setting the time period of application of power to said heating unit, and means connected to said timer for modifying the timer period to compensate for changes in power source voltage, said means comprising a resistor having a resistance variable non-uniformly with current connected to the power source, means for establishing a direct current voltage across said resistor, an oscillator circuit, means for translating voltage across said resistor into current oscillations of a predetermined frequency in said oscillator circuit, and means between said timer and oscillator circuit for changing the timing period inversely as the change in oscillation frequency of said oscillator circuit.

6. In induction heating means, a source of current, a heating unit connected to said source, and means for maintaining a substantially uniform flow of power to said heating unit irrespective of source voltage changes, said means including a resistor, the resistance of which varies inversely with change of source voltage, a frequency unit connected to said resistor for developing a frequency change variable directly as the source voltage, and a timer unit limiting the time of power flow to the heating unit directly in accordance with frequency change in said frequency unit.

7. In induction heating means, a source of current, a heating unit connected to said source and means for maintaining a substantially uni-

6

form flow of power to said heating unit irrespective of source voltage changes, said means comprising a non-linear resistor connected to said source, an oscillator circuit connected across said resistor, a synchronous motor operably connected to said circuit and a timer operably connected to said motor to change the time period of energy supply to said heating unit inversely as the speed of the motor, whereby substantially equal charges of heat are supplied the heating unit.

8. In induction heating means, a source of current, a heating unit connected to said source, and means for maintaining a substantially uniform flow of power to said heating unit irrespective of source voltage changes, said means including a resistor, the resistance of which varies inversely with change of source voltage raised to a power greater than one, a frequency unit connected to said resistor for developing a frequency change variable directly as the source voltage, and a timer unit limiting the time of power flow to the heating unit directly in accordance with frequency change in said frequency unit.

9. In induction heating means, a source of current, a heating unit connected to said source, and means for maintaining a substantially uniform flow of power to said heating unit irrespective of source voltage changes, said means including a resistor, the resistance of which varies inversely with change of source voltage raised to a power preferably between 1.5 and 2.6, a frequency unit connected to said resistor for developing a frequency change variable directly as the source voltage, and a timer unit limiting the time of power flow to the heating unit directly in accordance with frequency change in said frequency unit.

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