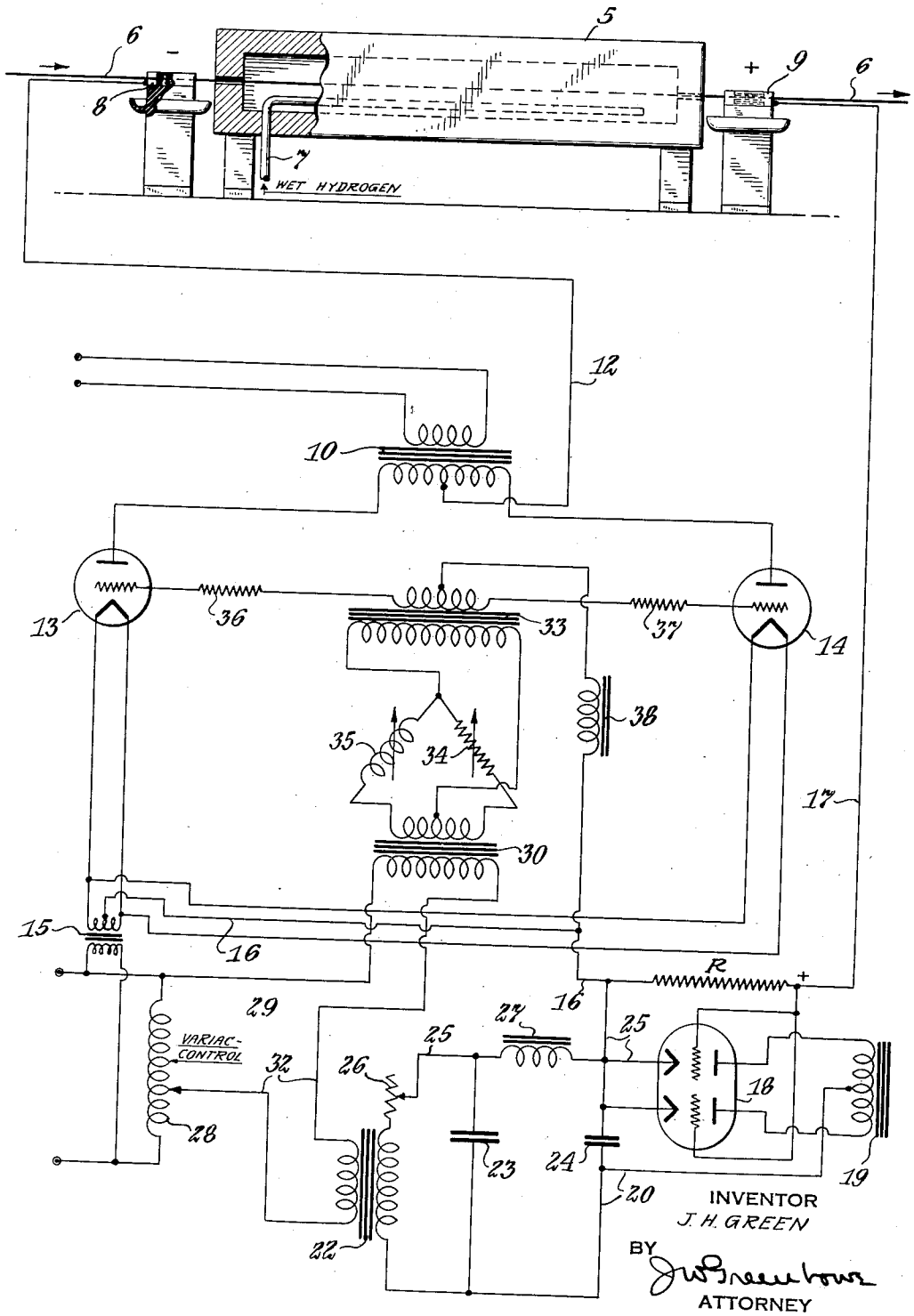
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CONSTANT CURRENT ELECTRICAL SYSTEM

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CONSTANT CURRENT ELECTRICAL SYSTEM

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The present invention pertains to a system for maintaining metal at a constant temperature and has particular reference to the treatment of tungsten wire as customarily employed for incandescent lamp filaments and thermionic cathodes of discharge devices.

In the working of tungsten wire it is essential that, during a portion of its processing, the wire be maintained at the recrystallization point to facilitate further processing and formation into desired shapes. Because of this requirement it is necessary that the tungsten wire be heated to a desired temperature and maintained at this temperature during the entire treatment period in order to complete recrystallization, otherwise the wire becomes brittle and fragile, making it difficult to work.

It is known in the art that such processing is required and various methods and apparatus have been devised for the purpose of heat treating tungsten wire to maintain it at the recrystallization point. However, such apparatus has been subject to the disadvantage that it is not very efficient in operation in that too great a degree of temperature variations results, which inherently affects the quality of the finished wire.

It is accordingly an object of the present invention to provide a system for treating metal to maintain it at a constant temperature.

Another object of the present invention is the provision of a system for maintaining a tungsten wire at a constant recrystallization temperature.

A further object of the present invention is the provision of an electrical system for treating tungsten wire wherein a substantially constant voltage is maintained and applied to the wire so as to heat it to the recrystallization temperature to facilitate further working of the tungsten wire.

Still further objects of the present invention will become obvious to those skilled in the art by reference to the accompanying drawing wherein the single figure is a diagrammatic illustration of the system forming the subject matter of the present invention.

Referring now to the drawing in detail, a gas chamber 5 is shown through which the metal, such as a tungsten wire 6, is passed while subjected to an atmosphere of wet hydrogen admitted through a suitable conduit 7. A pair of terminals 8 and 9, such as mercury pools or the like, form an integral part of the gas chamber 5 and the tungsten wire contacts these terminals as it is treated during passage through the gas chamber.

In order to heat the tungsten wire 6 a rectified source of electrical energy is provided which comprises a transformer 10, having its primary winding connected to a suitable source of alternating current electrical energy as shown, and having a ratio of approximately two to one between its primary and secondary windings. The secondary winding of this transformer has its mid-point connected, by means of a conductor 12, to the mercury pool terminal 8, while the ends of the winding are connected to the anodes, respectively, of a pair of grid controlled rectifier tubes 13 and 14.

The thermionic cathodes of these tubes 13 and 14 receive heating current from a low voltage heating transformer 15, the primary winding of which is connected to a suitable source of alternating current energy as shown, and the cathode electrodes are connected, by means of a conductor 16, resistance R, and conductor 17, to the mercury pool terminal 9. Accordingly, when the transformer 10 is energized and the tubes 13 and 14 are conductive, a negative polarity is impressed upon the mercury pool terminal 8 of the gas chamber through the conductor 12, while a positive polarity is impressed upon the mercury pool terminal 9, through the valve tube 13, conductors 16 and 17, and resistance R during one half wave of the alternating current cycle and through valve tube 14, conductors 16 and 17, and resistance R, during the other half wave of the alternating current cycle.

The wire passing through the gas chamber 5 thus constitutes a load for the rectified source of electrical energy, which load varies in proportion to the thermal coefficient of the tungsten wire, its speed of passage through the gas chamber and the condition of the atmosphere within the chamber 5. As the load varies due to any of these influencing factors, the voltage drop across the tungsten wire or load likewise tends to fluctuate, which naturally affects the voltage drop across the series connected resistance R and the current flowing through the wire 6.

In order to prevent voltage fluctuations across the load with attendant variation in heating current, and thus maintain the temperature of the tungsten wire constant, the varying voltage drop across resistance R is employed to effect, through an additional rectifying and phase shifting circuit, the controlling grids of the valve tubes 13 and 14 so that a constant current and temperature is maintained in the tungsten wire 6, since the voltage drop across the resistance R is directly

proportional to the current flowing through the wire 6.

The additional rectifying system comprises a rectifying tube 18 shown as a single full wave rectifier, although two half wave rectifiers similar to the tubes 13 and 14 may be employed if desired. The two anodes of the tube 18 are connected to opposite ends of the secondary winding of a transformer 19, the primary of which is not shown for simplicity, but which is connected to the same source of supply as that of transformer 10, and the mid-point of this transformer 19 is connected, by means of conductor 20, to one end of the direct current winding of a continuously variable auto-reactance 22 and to one plate of a pair of capacitors 23 and 24.

The opposite end of the direct current winding of the auto-reactance 22 is connected, by means of a conductor 25, variable current limiting resistance 26 and inductance 27, to the remaining plates of capacitors 23 and 24, the two cathodes of rectifying valve 18, and to one end of the resistance R, while the opposite end of resistance R is connected to the two grid electrodes of the valve tube 18. Energy from the transformer 19 thus flows through one portion of valve tube 18 to auto-reactance 22 during one half wave of the alternating current cycle and through the other portion of valve 18 during the remaining half wave, with the capacitors 23 and 24 and the inductance 27 functioning to smooth out the sinusoidal ripple, so that smooth D. C. current flows through the auto-reactance 22 under definite control of the initially set variable resistance 26.

Moreover, since the two grids of the rectifier 18 are connected to one end of the resistance R, while the cathodes are connected to the opposite end thereof, the voltage drop across this resistance thus influences the grid potential supplied, making it more or less positive with respect to the cathodes, which accordingly controls the flow of current through valve 18 to the auto-reactance 22.

Inasmuch as the smooth D. C. current flowing through the direct current winding of the auto-reactance 22 is inversely proportional to the voltage drop across the resistance R, it influences a phase shifting circuit for controlling the grids of the rectifying tubes 13 and 14 included in the heating circuit. The phase shifting portion of the present system comprises what is known as a "variac" control 28, which functions as does an auto-transformer, and the winding of which is connected to the same source of supply as the transformers 10 and 19.

One end of the winding of the variac control is connected by means of a conductor 29 to one end of the primary winding of a transformer 30, while the adjustable contact of the variac control is connected through an A. C. winding of the auto-reactance 22 to the remaining end of the primary winding of transformer 30 by means of a conductor 32. When the variac control has once been set to a desired setting, the voltage supplied directly from the source of supply remains substantially constant. However, the voltage actually impressed upon the primary winding of the transformer 30 will vary in proportion to the current flowing through the A. C. winding of the auto-reactance 22, which current is influenced by the current flowing through the D. C. winding of the auto-reactance. Thus the voltage supplied to the transformer 30 is indirectly influenced by the current through the wire 6 and the attendant voltage drop across the resistance R.

To cause a shift in the phase of the voltage supplied to the grids of the rectifying valves 13 and 14 so that the current leads the voltage, the secondary winding of the transformer 30 has its mid-point connected to one end of the primary winding of an insulating and amplifying transformer 33, while the ends of the secondary winding of the transformer 30 are connected through a phase shifting arrangement consisting of a variable resistance 34 and variable inductor 35 to the opposite end of the secondary winding of the transformer 33. The secondary winding of the insulating and amplifying transformer 33 in turn has its ends connected through current limiting resistances 36 and 37 to the grid electrodes of the respective rectifying valve tubes 13 and 14, while the mid-point thereof is connected through an inductance 38 to conductor 16 and thus to the cathodes of these tubes to make the grid potential more or less out of phase with respect to the anode current.

The system thus described operates in the following manner: upon energization of the transformer 10, rectified alternating current is supplied to the wire 6 through the valve tubes 13 and 14 and resistance R in the manner previously described. After the various adjustable reactances and resistances have been initially set to give a desired temperature, which is at the recrystallization point of the tungsten wire, they need not be further disturbed since a constant temperature is maintained. Any variation in the voltage and consequently the current flowing through the wire 6, due to changes in the thermal co-efficient of the wire or the condition of the atmosphere within the chamber 5, will cause a voltage drop across resistance R directly proportional to the current flowing through the wire 6.

Variation of the voltage across R immediately effects the grids of the rectifying valve 18 in the manner previously stated with the result that the current supplied to the D. C. winding of the auto-reactance 22 by the transformer 19 varies in inverse proportion to the voltage drop across the resistance R. This current variation in the D. C. winding of the auto-reactance 22 accordingly influences the current flowing through the A. C. winding thereof and which is supplied to the transformer 30 by the source of supply under control of the variac 28.

Upon a variation of current through transformer 30, the current through the phase shifting arrangement is caused to lead the voltage and after amplification by transformer 33, is alternately impressed upon the grids of the rectifying valves 13 and 14. The various adjustable components of the system and particularly the auto-reactance 22, in addition to being initially set to give a constant temperature, are also set to definitely fix the phase relation between the grid to plate voltage of the rectifying valves 13 and 14.

Also, since all line voltage fluctuations are substantially eliminated inasmuch as the various parts receive energy from the same alternating current source, the variation in voltage drop across the resistance R is the only variation affecting the phase so that with such voltage drop there is a shifting of the phase relation between the grid and plate voltage. This shifting accordingly makes the grid voltage more or less out of phase with respect to the plate voltage of the valves 13 and 14 consistent with the load demand

on the rectifiers, which thus varies the current in the load circuit inversely as the voltage changes, thereby maintaining a constant temperature in the tungsten wire 6.

It thus becomes obvious to those skilled in the art that I have provided a system for maintaining a constant temperature, particularly of tungsten wire, so as to maintain such wire at the recrystallization point. By causing a shifting of the phase relation between the grid and plate voltage of a pair of rectifying valves included in the load circuit commensurate with any heating current variations, the actual current supplied to the load is substantially constant, which maintains the load at a constant temperature. Moreover, by supplying the various components of the system from a common source of supply, accurate control of the temperature, so as to maintain it constant, is readily achieved.

Although I have shown and described one specific embodiment of my present invention, I do not desire to be limited thereto, as other modifications thereof may be made without departing from the spirit and scope of the appended claims.

I claim:

1. An electrical system for supplying a constant current to a load comprising a source of alternating current electrical energy for supplying energy to said load, an electric discharge device connected to said source and to said load for controlling the flow of current to said load and provided with a grid electrode, an electrical element interposed between said discharge device and said load having a voltage drop thereacross directly proportional to the current flow through said load, a phase shifting circuit connected to the grid of said discharge device for causing a shifting of the phase relation of the grid potential with respect to the potential supplied through said discharge device to said load and including a device having a voltage drop thereacross inversely proportional to the voltage drop across the element connected to said load, and an electrical circuit including said source of alternating current electrical energy, the device of said phase shifting circuit and a rectifying valve having a grid and cathode connected across the element connected to said load, and operable to cause current flow in said circuit in response to variations in voltage drop across the element connected to said load; and said circuit being operable to cause an inverse variation in the voltage drop across the device of said phase shifting circuit accompanied by a variation in the aforesaid phase relation for the purpose of maintaining a substantially constant current flow through said load.

2. An electrical system for supplying a constant current to a load comprising a series circuit including a load, a source of alternating current electrical energy for energizing said load, a pair of rectifying valves provided with grid electrodes, and an impedance device having a voltage drop thereacross directly proportional to the current flow through said load; a second circuit including said source of alternating current energy, a rectifying valve having its grid and cathode connected across the impedance device of said first circuit, and a load comprising an auto-reactance having a voltage drop thereacross inversely proportional to the voltage drop across the impedance device of said first circuit; and a phase shifting circuit including said source of alternating current electrical energy, a winding inductively coupled to the auto-reactance of said second circuit, and a phase shifting arrangement connected to the grids of the rectifying valves of said first circuit; whereby the phase relation of the potential impressed upon the grids of the rectifying valves of said first circuit is varied with respect to the potential supplied to said load, in response to variations in voltage drop across the auto-reactance of said second circuit caused by inverse variations in voltage drop across the impedance device in series with said load.

3. An electrical system for supplying a constant current to a load comprising a series circuit including a load, a source of alternating current electrical energy for energizing said load, rectifying valves provided with grid electrodes, and an impedance device having a voltage drop thereacross directly proportional to the current flow through said load; means electrically associated with said impedance device comprising said source of electrical energy, an auto-reactance, and a rectifying valve having a grid electrode and a cathode connected across said impedance device and operable to cause current flow through said auto-reactance in response to voltage variations across said impedance device, and means for shifting the phase relation of the potential impressed upon the grids of said rectifying valves with respect to the potential impressed upon said load comprising said source of alternating current electrical energy, a winding inductively coupled to said auto-reactance and a phase shifting arrangement including an amplifying transformer, whereby the current is caused to lead the voltage in the phase shifting arrangement in response to variations in said auto-reactance caused by voltage variations across said impedance device in series with said load.

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