United States Patent

Spescha

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[54] **METHOD OF MONITORING THE ELECTRICAL BEHAVIOR OF A HIGH-INTENSITY GLOW DISCHARGE FOR METALLURGICAL PROCESSES**

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Related U.S. Application Data

[62] Division of Ser. No. 677,660, Oct. 24, 1967, Pat. No. 3,579,029.

[52] **U.S. Cl.**.....**317/31,** 317/51, 317/27 R, 215/127

[51] **Int. Cl.**.....**H02h 3/20**

[58] **Field of Search**.....315/127; 317/31, 51, 27 R; 323/20, 4

[56] **References Cited**

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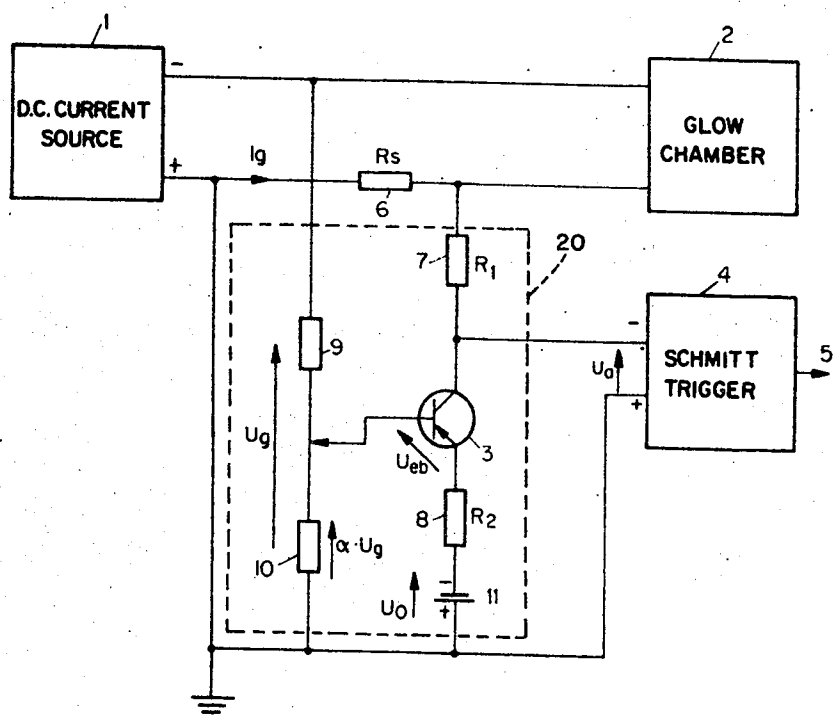
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[57] **ABSTRACT**

The method of monitoring a circuit for a low discharge wherein the voltage and current of the discharge are compared by the circuit and a Schmitt trigger generates a control signal if the voltage-current relationship indicates unsafe operation.

1 Claim, 3 Drawing Figures



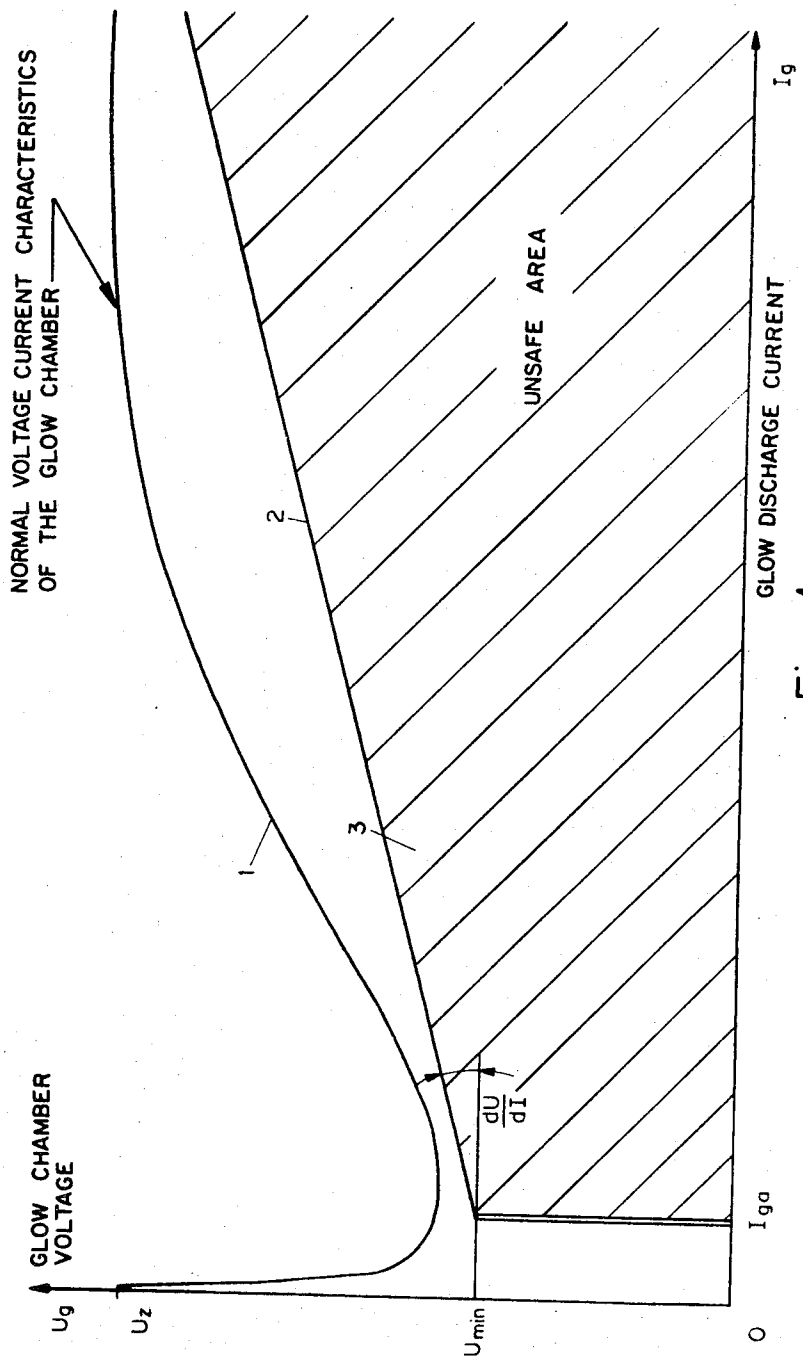
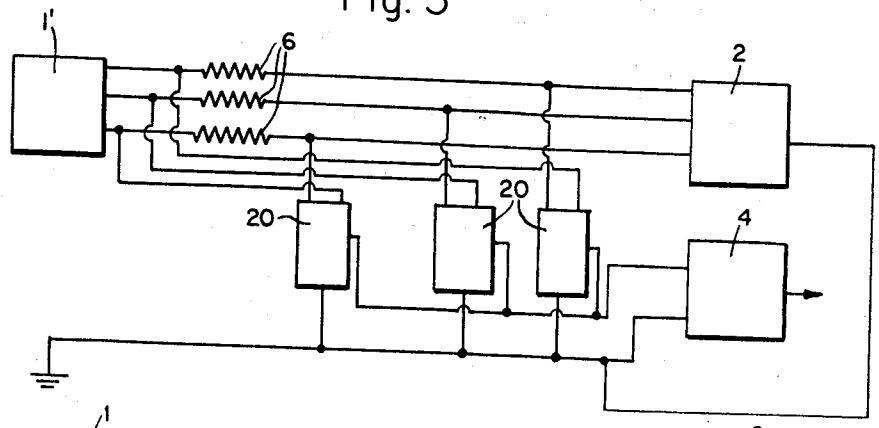


Fig. 1

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Fig. 3



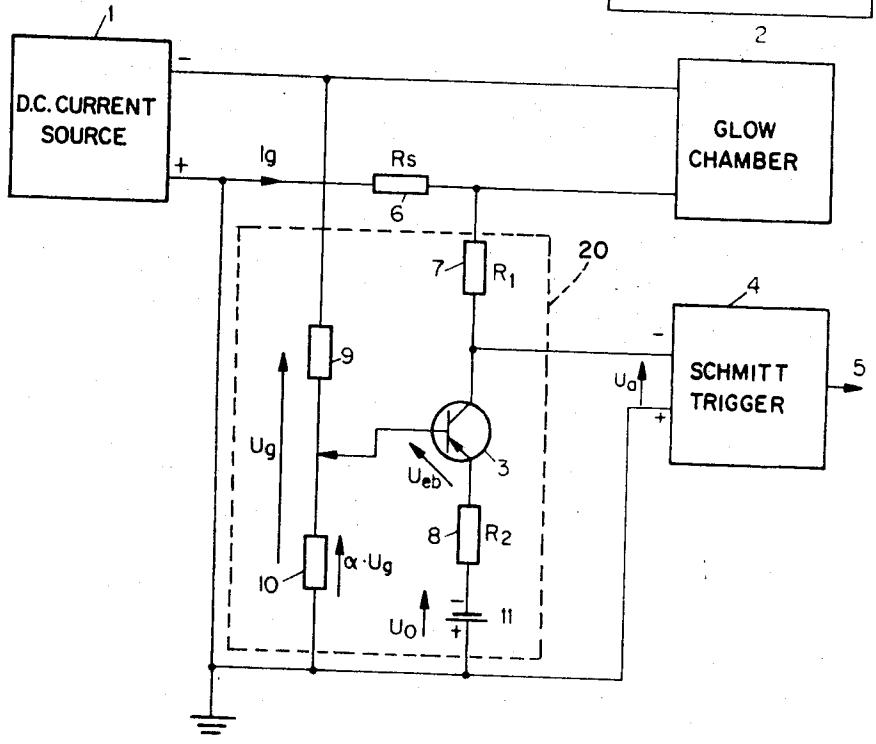


Fig. 2

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METHOD OF MONITORING THE ELECTRICAL BEHAVIOR OF A HIGH-INTENSITY GLOW DISCHARGE FOR METALLURGICAL PROCESSES

This application is a Division of my copending application, Ser. No. 677,660, filed Oct. 24, 1967 now U.S. Pat. No. 3,579,029.

This object is commonly achieved by influencing the electrical supply circuit for the glow discharge, by way of example by brief reductions of the operating voltage or by incorporation of an impedance. Such influencing is performed by suitable control means such as electronic circuits controlled by signals which may, by way of example, be given when the operating current of the glow discharge exceeds a certain rated value. However, it has been found to be difficult so to predetermine this rated value in the operation of a glow discharge employed for metallurgical purposes that economical operation is ensured on the one hand and, on the other, that the supply circuit is influenced dependably and fast enough when a disturbance in the discharge occurs. These difficulties result mainly from the fact that the voltage/current characteristic of such a glow discharge is not a straight line but runs as exemplified in FIG. 1.

The present invention eliminates these difficulties and relates to a method of monitoring the electrical behavior of a high-intensity glow discharge for metallurgical processes such as diffusion processes, cathode sputtering, hardening by nitriding and the like in order to influence the supply circuit by signal-controlled means. It is characterized by the fact that an unsafe area is defined by an adjustable sensor which can be influenced by the supply circuits below the desired rated curve for the operating point of the glow discharge in the voltage/current characteristic family, the said area also comprising the field of unstable discharges and the said sensor supplying a control signal for the said means when the operating point deviates from the rated curve to the extent that it lies within the unsafe area.

The invention further relates to a device for the performance of the said method. This device is characterized by a sensor consisting of a pnp transistor circuit and a Schmitt trigger of a design known per se, by a series resistance in the supply circuit to which an input terminal of the Schmitt trigger and the collector of the transistor are connected via a barrier resistance, by a voltage divider parallel with the voltage source of which the tap is connected to the base of the transistor, and by a series resistance and a bias in the emitter circuit of the transistor, all being arranged in such a manner that the voltage of the resistance in the supply circuit which depends on the discharge current and a counter-voltage depending on the collector current through the barrier resistance are applied to the trigger input terminals, the collector current being so adjusted by means of the partial voltage tapped at the voltage divider and the emitter bias that the response voltage at the trigger input terminals is exceeded only for values of the discharge current and the discharge voltage within the unsafe area of the voltage/current characteristic family of the glow discharge.

An embodiment of this invention is described in greater detail with reference to the drawing in which:

FIG. 1 is a diagram of the voltage/current characteristic family in the operation of an electrical glow discharge;

FIG. 2 is a sensor circuit for the performance of the present method; and

FIG. 3 is a block-type diagram illustrating the invention as applied to a three-phase power source.

The process here disclosed relates to an adjustable safety area located directly below the effective characteristic of the glow discharge, cf. FIG. 1. The current and voltage are continuously measured and the position of the operating point thus determined assessed. If the operating point falls within the predetermined unsafe area, a quick-acting switch responds, i.e., it triggers the contemplated protective measures in the supply circuit. In general, the latter consist in the known manner in a short discontinuation of the supply voltage and, in the event of frequent repetitions of the disturbance, in complete disconnection of the voltage source. Adjustment of the safety line is most commonly effected by two potentiometers. The first is designed to adjust the minimum burning voltage; the other, to adjust the gradient dU/dT. These two adjustments should be adapted depending on the type of gas, pressure, temperature and cathode surface of the discharge. Changes in the operating voltage require no adjustment of the quick-acting switch which is suitable even for extreme impulse operation of the glow discharge.

This quick-acting switch principle is also suitable for three-phase current. Three similar sensor circuits are employed, one for each phase, and the three outlets arranged in parallel. The safety means are then triggered if a disturbance is detected in any one of the three phases. In the device here disclosed it is assumed that the transformer neutral point is not connected and, perspectively, the secondary side of the transformer is connected in delta circuit. The three symmetrical cathodes are each connected to one phase. Current measurement in each phase raises no problems. Schematic FIG. 3 shows how the invention is adapted to a three-phase power source 1' and wherein each line of the three-phase current is connected to a complete sensing transistor and associated circuitry indicated by the blocks 20. The circuitry within each block 20 is the same as that appearing within the dotted rectangle 20 of FIG. 2. Measurement of the proper burning voltage is complex since the discharge is operative alternatively between the three cathodes. It has been found that the gas plasma is approximately at the most positive potential of the three cathodes. Accordingly, at least one of the electrodes is always cathodic and the voltage between it and the positive plasma is decisive for its discharge. The metallic anode assuming approximately the potential of the plasma, has proved to be satisfactory to measure the voltage between each electrode and the anode. The measuring arrangement of each phase is thus formed by measuring the current of the phase involved and the voltage of the respective electrode against the anode, it being sufficient to record the negative values only. Disturbances occur mostly at the cathodically glowing electrodes and every disturbance is thus recorded since the discharge operates without 0-lead so that any disturbing current must pass a measuring point.

FIG. 2 shows an example of a simple circuit with only one transistor in the actual sensing stage. The reference numeral 1 designates the supply rectifier, 2 the discharge anode or glow chamber in which the glow

discharge occurs. The current in the glow discharge I_g causes a voltage drop across resistance 6. This voltage is applied, via the resistance 7, to the input side of a Schmitt trigger 4. This Schmitt trigger of known design responds if its input voltage U_a reaches a certain value and then produces a signal at output 5. Applied to the discharge anode 2 is a voltage U_g so that the portion αU_g is supplied, via the voltage divider 9, 10, to the base of the transistor 3. This transistor forms the essential portion of the sensing circuit. The voltage αU_g applies a bias on the transistor base resulting in a current through the emitter and the collector of the transistor which essentially depends on αU_3, U_o and the resistance 8. The voltage drop in the resistance 7 caused by this current counteracts the voltage caused by current I_g and thus allows the Schmitt trigger 4 to respond only in the presence of an accordingly greater current I_3The safety line resulting from this arrangement and others, which delimits the safety area, is shown in FIG. 1. The reference numeral 1 designates the real characteristic of the glow discharge, 2 the safety line obtained by an arrangement as per FIG. 2, and the hatched area 3 designates the unsafe area. The unsafe area is limited on the left and does not reach current zero, for a minimum current must flow in order to cause the Schmitt trigger to respond. However, this does not constitute a disturbing limitation. The Schmitt trigger responds if the operating point determined by U_g and I_g is located in the hatched unsafe area 3.

I claim:

1. In a method for monitoring the electrical behavior of a high intensity glow discharge apparatus having an input circuit comprising a fast operating means to extinguish the glow discharge when actuated by an electrical control signal derived from the voltage and the current in the input circuit, the improvement comprising: supplying a control signal generator with a first voltage which is a bias voltage (U_0) increased by an adjustable portion (α) of the input voltage (U_g) and a counteracting second voltage which is proportional to the input current (I_g), said generator being normally blocked and excited to produce the said control signal in response to the said second voltage exceeding the said first voltage.

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