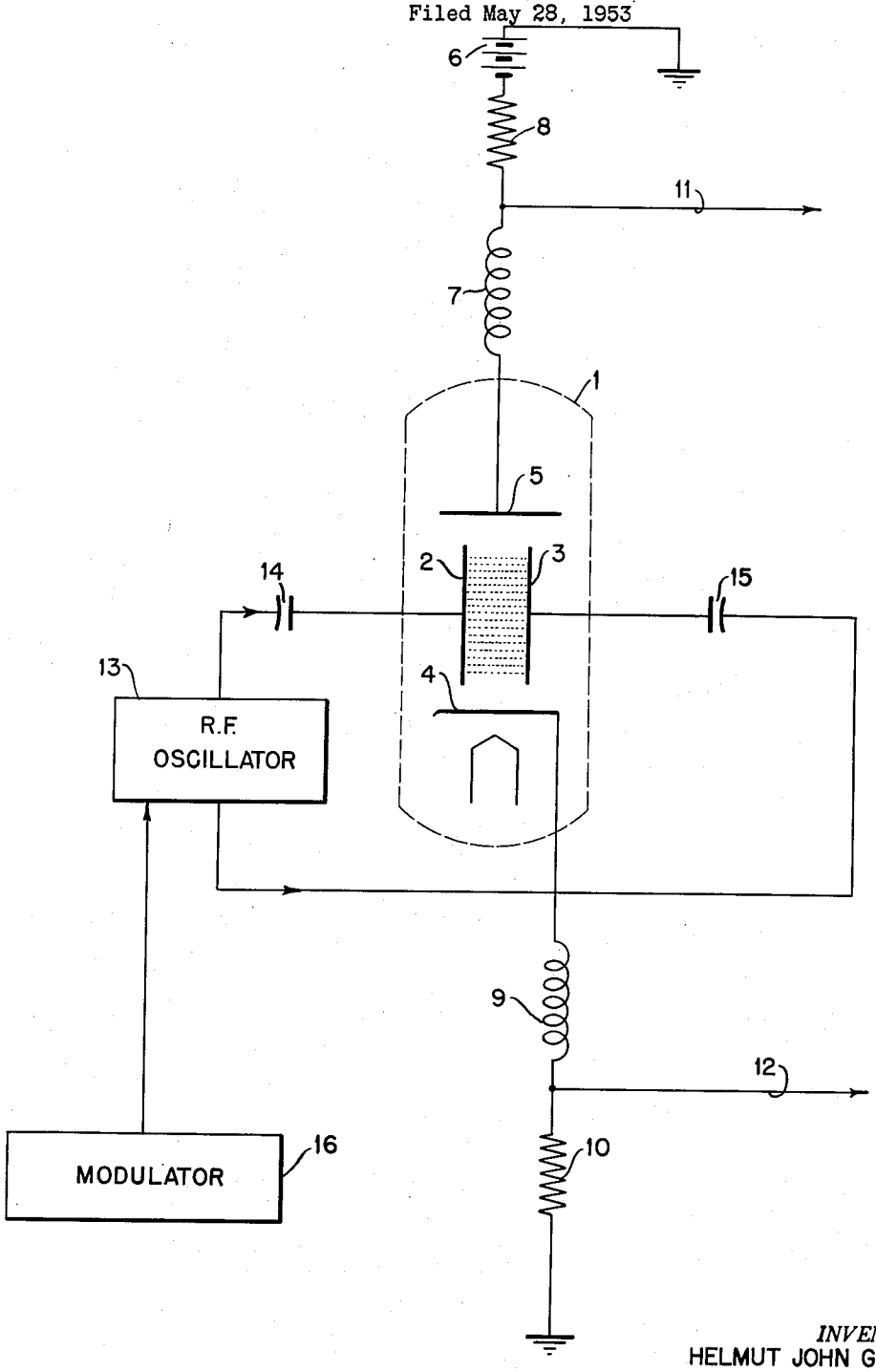
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RADIO FREQUENCY CONTROLLED PLASMATRON

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RADIO FREQUENCY CONTROLLED PLASMATRON

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This invention relates to circuit arrangements for the control of electric currents of substantial magnitude, and is more particularly directed to a gaseous relay tube operable to continuously control the flow of direct current or low frequency alternating current in a load circuit.

Glow discharge tubes in which current flow between a pair of electrodes is controlled, have long been known in the electrical arts, with control obtained, for example, by use of one or more grids between the cathode and anode elements or by elements located on the exterior of the tube envelope. A characteristic of both types is that by impressing a suitable potential on the control element, the starting of an arc discharge between the anode and cathode may be prevented or allowed as desired, however, once the discharge has been initiated, variations in the potential on the control element has little effect on current flow.

In accordance with the principles of the present invention, an entirely new type of amplifier or control device is provided, which device has additional advantages that none of the previously mentioned prior art devices possess.

A feature of the invention resides in the provision of a gaseous discharge tube employing several pairs of electrodes so positioned with respect to one another that at least a portion of the gap between the several pairs of electrodes is common to each. The resistance of this mutual gap region is varied in response to changes in the character of energization of one pair of electrodes with a corresponding variation occurring in the current flow through another pair of electrodes which may be included in a work circuit.

The control circuit which I have devised employs a modulated radio frequency current for energization of the controlling pair of electrodes and operates to correspondingly modulate or control a work circuit connected with another pair of electrodes which is energized, for example, from a direct current source. The arrangement is not limited in use to control of a direct current work circuit, however, but may be employed for control of alternating current systems of low frequency as will appear hereinafter.

An object of the invention is to provide a low impedance device continuously operable to control a direct current or low frequency alternating current circuit.

A further object is to devise a circuit employing a gaseous discharge device wherein current flow through a pair of electrodes connected in a work circuit is controlled in accordance with modulation of a radio frequency energy source included in the circuit of a second pair of electrodes and in which the radio frequency power consumed is substantially negligible in comparison with the work circuit power controlled.

A further object of the present invention is to devise a control circuit of high efficiency for control of considerable amounts of power and in which the control and controlled circuits are substantially isolated from one another.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of example, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawing, the single figure illustrates a radio frequency controlled plasmatron tube and associated electrical system comprising the invention. An arrangement of electrodes is shown diagrammatically in a helium filled tube 1 which is designed to carry out such a system of modulation and control as heretofore described. A first pair of electrodes labeled 2 and 3 are positioned in spaced relationship within the ionization tube 1 and a second pair of electrodes labeled 4 and 5 are arranged within the tube as shown in the figure and are separated by a gap which includes at least a portion of the gap space between the electrodes 2 and 3.

The electrodes 4 and 5 are adapted to be connected in a work circuit and constitute a cathode and anode respectively. The cathode is provided with a coating of alkali metal oxide in accordance with conventional practice and is indirectly heated from an energy source such as a transformer, not shown. The anode 5 is connected to a source of positive potential 6 through a radio frequency decoupling choke 7 and a resistor 8 while the cathode 4 is connected through a similar decoupling choke 9, a resistor 10 and the opposite terminal of the source 6, which is grounded as shown. The potential applied between the electrodes 4 and 5 by the source 6 is such as to be less than ionizing potential. Load circuits 11 and 12 are connected to the junction of the elements 7 and 8 and to the junction of the elements 9 and 10 respectively. The electrodes 2 and 3 are connected in circuit with a radio frequency oscillator 13 with the connections to these electrodes including radio frequency coupling capacitors 14 and 15 respectively. A modulator 16 is connected with the oscillator 13 and serves to vary the magnitude and duration of the radio frequency voltage output which is applied between the electrodes 2 and 3.

Application of energy from the oscillator 13 causes ionization of the inert gas filling of tube 1 in the region between the electrodes 2 and 3. The ionizable medium is selected so as to permit ionization to take place at relatively high radio frequency potentials. This allows use of fairly high load circuit voltages at the source 6 without causing the controlled circuit including electrodes 4 and 5 to maintain conduction independently. Helium, for example, will allow the voltage of source 6 to be maintained at approximately 20 volts without faulty operation.

A plasma, such as that formed between the electrodes 2 and 3, is generally defined in the art as an electrically neutral region of an ionized medium. In accordance with variations in the output of oscillator 13, as controlled by the modulator 16, an increase in voltage applied to electrodes 2 and 3 causes the gas plasma density to increase and the conductivity of the tube as seen from the source 6 is increased proportionately.

Load circuits may be connected to either one or both of the output circuits 11 and 12, however, the voltage swings at these terminals will be of opposite polarity. As the radio frequency voltage is increased and the plasma density increases, a larger current is caused to flow from the anode 5 to the cathode 4 and an increased current also flows through the load circuits. In like manner, as the plasma density decreases, the current flow from anode 5 to cathode 4 decreases so that the waveform of the load current is comparable to the waveform of the modulator output.

The condensers 14 and 15 serve to filter the direct current from the high frequency circuit while the choke coils 7 and 9 serve to filter components of the high frequency from the output circuits so that the control and controlled

circuits are effectively decoupled. The electrodes 2 and 3 must have equal radio frequency impedance to ground in order to prevent direct current components from appearing in the output due to the radio frequency alone.

The electrodes 4 and 5 may be similarly constructed so as to alternately function as anode and cathode elements and low frequency power source may be applied across these terminals in place of the illustrated direct current source 6. With such an arrangement, the filter components are designed to discriminate between the low and high frequencies of the controlled and controlling sources and the low frequency load current is modulated in accordance with the output of the radio frequency modulator 16 with substantial isolation of the load circuit from the controlling source.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. A control system including an electric discharge device comprising a sealed envelope containing helium at a pressure sufficient to support ionization, two pairs of spaced electrodes within said envelope and so positioned that at least a portion of the gap between the pairs of electrodes is common to each, one of said pairs of electrodes comprising an anode and a thermionic cathode, said cathode being coated with an alkali metal oxide, a source of radio frequency energy, a source of direct current energy, circuit means connecting said anode and thermionic cathode across said direct current source, said direct current source having a potential insufficient to produce ionization, load circuits connected to said anode and cathode electrodes, circuit means connecting the other of said pairs of electrodes for energization by said radio frequency source, said other pair of electrodes being balanced to provide equal impedance to ground, and means for modulating the voltage of said radio frequency source whereby direct current flow in said load circuits is comparably modulated.

2. An amplifying system comprising a gaseous discharge device having a sealed envelope containing an ionizable medium and within which are mounted two pairs of spaced electrodes so positioned that at least a portion of the gap between the electrodes of each pair is common to both pairs, a source of direct current energy having a potential insufficient to produce ionization coupled to one of said pairs of electrodes through a choke coil filter, said one pair of electrodes comprising an anode and a thermionic cathode, a source of high frequency energy coupled to the other of said pairs of electrodes through a coupling capacitor filter, said other pair of electrodes being balanced to provide equal impedance to ground, a load circuit connected to said choke coil at a point remote from the associated electrode, and means including a modulator for varying the amplitude of the energy supplied by said high frequency source whereby said load circuit current is correspondingly modulated.

3. An amplifying system comprising a gaseous discharge device having a sealed envelope containing helium at a pressure sufficient to support ionization and within which are mounted two pairs of spaced electrodes so positioned that at least a portion of the gap between the electrodes of each pair is common to both pairs, a source of low frequency energy having a potential insufficient to produce ionization at the gas pressure employed coupled to a first one of said pairs of electrodes, a source of radio frequency energy coupled to the other of said pairs of electrodes and adapted to produce an ionized plasma region in the gap space between said electrodes, said other pair of electrodes being balanced to provide equal impedance to ground load circuit means coupled to the anode cathode circuit comprising said first pair of electrodes, filter means coupled to said pairs of electrodes to effectively isolate the low frequency circuit and radio frequency circuit, and means for modulating the amplitude of said radio frequency energy applied to said other pair of electrodes whereby the load circuit current is correspondingly modulated.

4. An amplifying system comprising a gaseous discharge device having an envelope containing an ionizable medium and within which are mounted two pairs of spaced electrodes so positioned that at least a portion of the gap between the electrodes of each pair is common to both pairs, a source of energy having a potential insufficient to produce ionization coupled to a first one of said pairs of electrodes, said one pair of electrodes comprising an anode and a thermionic cathode a source of high frequency energy coupled to the other of said pairs of electrodes and adapted to produce an ionized plasma region in the gap space between said electrodes, said other pair of electrodes being balanced to provide equal impedance to ground, load circuit means coupled to the anode cathode circuit comprising said first pair of electrodes, filter means coupled to said pairs of electrodes to isolate the load circuit energy source and the high frequency energy source, and means for modulating the amplitude of the high frequency energy applied to said other pair of electrodes to thereby correspondingly modulate the load circuit current.

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