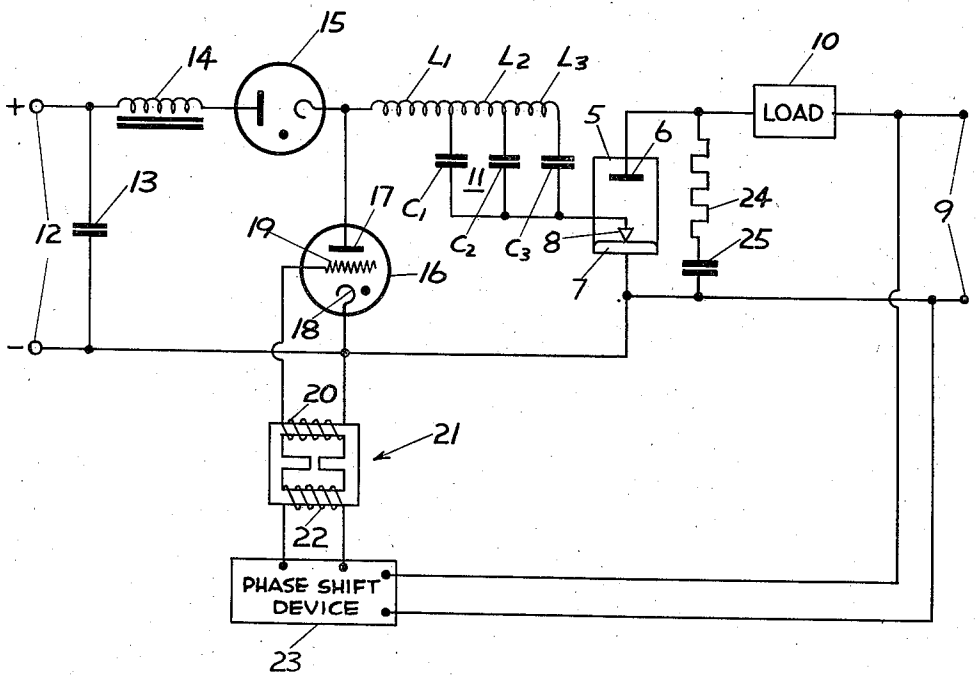
July 13, 1948. J. W. DAWSON ET AL 2,444,921

IGNITION CIRCUITS FOR VAPOR DISCHARGE DEVICES

Filed May 4, 1946



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Patented July 13, 1948 2,444,921

UNITED STATES PATENT OFFICE

2,444,921

IGNITION CIRCUITS FOR VAPOR DISCHARGE DEVICES

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Application May 4, 1946, Serial No. 667,280

3 Claims. (Cl. 315—263)

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This invention relates to circuits for firing an electron space discharge device such, for example, as a mercury-arc rectifier.

In operating discharge devices of the type having mercury pool cathodes, the discharge through the tube is commonly initiated by means of an igniting electrode. The igniting electrode may be of the resistance-immersion type as in devices generally known as "ignitrons" or the electrode may be of the electrostatic type for example as disclosed in the U. S. Patent 2,257,768, issued October 7, 1941, to Percy L. Spencer. It has been shown in the copending application of John W. Dawson, Serial No. 445,467, filed June 2, 1942, for "Circuits for electric space discharge devices and method of operating same," now U. S. Patent No. 2,402,607, that it is possible to fire such devices at frequencies of the order of 1000 times per second or more, provided each of the energizing impulses to the igniting electrode has a certain critical minimum duration which is of the order of a few micro-seconds. It has been shown that the supply of energy to the igniting electrode for periods substantially in excess of the critical minimum duration is undesirable particularly where the device is to be operated at relatively high frequencies. The critical minimum duration referred to is the period during which energy at a certain minimum power value is applied to the igniting electrode.

In the copending application, Serial No. 448,862, filed June 27, 1942, for "Electric space discharge devices and method of operating same," and now patent No. 2,402,608, granted June 25, 1946, it is shown that energizing impulses having the required duration at the desired energy level may be supplied to the igniting electrode by the discharge of a condenser through a critical damped circuit. Such an ignition circuit provides a wave form having a rounded top providing an energy level at or above the required value for the desired duration, and avoids power peaks substantially in excess of the desired minimum value. While such a circuit approximates the ideal wave form in that excessive power peaks are avoided, energy delivered to the igniting electrode during the time the power is rising to the desired minimum value is wasted and merely serves to heat the electrode. Also the energy delivered to the electrode during the time that power is falling to zero, after having been maintained at or above the desired level for the critical period, is wasted, and likewise tends to head up the electrode unnecessarily. Since the declining portion of the damped wave follows a

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characteristic "die-away" curve, this latter portion of the unused energy may be substantial.

It is an object of the present invention to provide an ignition circuit for space discharge devices of the type described, in which the power supplied to the igniting electrode rises abruptly to the desired level, at which it remains substantially constant for the desired critical minimum duration, and thereafter falls abruptly to zero, the power curve having the form of a substantially rectangular wave.

The foregoing and other objects and features of the invention will be made fully apparent to those skilled in the art from a consideration of the following detailed description taken in conjunction with the accompanying drawing which shows a circuit diagram constructed in accordance with the present invention.

Referring to the drawing, reference numeral **5** indicates an ignitron having an anode **6**, a liquid pool type cathode **7**, and a resistance immersion ignitor **8** for initiating an arc discharge through the device. Alternating current from any suitable source and which may be of high frequency may be supplied to the ignitron **5** from the terminals **9** adapted to be connected to the alternating source through a load **10**.

Energizing impulses are supplied to the igniting electrode **8** from a pulse-forming line or equivalent wave-shaping network **11**. The wave-shaping network may be constructed in any suitable manner, and provides a capacitance for storing energy. In the form shown, condensers C_1, C_2, and C_3 provide an energy-storing capacitance distributed throughout the wave-shaping network and also functioning in conjunction with the inductances L_1, L_2, and L_3 for generating a substantially rectangular wave.

The capacitance of the wave-shaping network **11** is adapted to be charged from a suitable source of direct current connected to the terminals **12**. A condenser **13** is connected across the terminals **12**, and an inductance **14**, in one of the connections between the terminals **12** and the wave-shaping network **11**, may be provided to smooth out ripples in the D. C. supply. A rectifier tube **15**, having its anode connected to the positive terminal and having its cathode connected to one side of the capacitance of the wave-shaping network **11**, may be provided to prevent reactions from the wave-shaping network to the source of supply. The other side of the capacitance of the wave-shaping network **11** is connected through the resistance-immersion ignitor **8** and

the mercury pool cathode 7 to the opposite terminal of the D. C. source.

In order to discharge the energy stored in the wave-shaping network through the igniting electrode 8, a gaseous discharge device, such as a thyratron 16, is provided, having its anode 17 connected to the positive charged side of the network and its cathode 18 connected to the opposite side of the wave-shaping network through the igniting electrode 8 and the liquid pool type cathode 7. In order to time the energizing impulses through the ignitor 8 relative to the phase of the alternating voltage across the discharge device 5, the grid 19 of the thyratron 16 is adapted to be energized by impulses from a secondary winding 20 of a peaking transformer 21 having a primary winding 22. The primary winding 22 is supplied with current of the same frequency as that supplied at the terminals 9 through a phase-shifting device 23. By this construction the capacitance of the wave-shaping network 11 is discharged through the ignition electrode 8 at any desired point in the half wave of the positive potential on the anode 6 of the ignitron 5. It will be understood that the degree of phase shift can be varied to control the portion of the half wave of alternating potential through the load 10, and thus control the total quantity of current therethrough.

In order that the incipient arc spot formed in the mercury pool cathode 7 by the energization of the igniting electrode 8 may be picked up and converted into an arc discharge through the ignitron 5, I provide a pick-up circuit comprising a resistor 24 and a condenser 25 across the tube 5. This circuit insures that during the early portion of the positive half wave of voltage across the terminals 9, the condenser 25 will become sufficiently charged to apply the necessary breakdown voltage across the cathode-anode circuit of the ignitron 5, and insures that the incipient arc spot, upon its formation, will be picked up and converted into a true arc. This is desirable, particularly at high frequencies at which the reactance of the load may prevent a sufficiently rapid flow of current from the terminals 9 to permit the discharge from the anode 6 to the cathode 7 to be maintained during the initial portion of such discharge.

By utilizing the capacitance of a wave shaping network as the source of the stored energy for the igniting impulses to the ignitron 5, energy is supplied to the electrode 8 in the form of a substantially rectangular wave. The wave-shaping network may be arranged to supply energy at or slightly above the desired energy level, and after persisting for the minimum duration period falls substantially vertically to zero. Thus substantially no energy is supplied to the igniting electrode 8 at a level below the minimum value. The generation of heat in the igniting electrode and the waste of energy entailed during the time that the energy normally requires to attain the desired value, and during the time in which the energy is declining from this value, are substantially eliminated. The desired energy level required to energize the ignition electrode of any particular tube may be attained by the proper

selection of the parameters of the wave-shaping network.

While there have been herein described certain preferred embodiments of the invention, other embodiments within the scope of the appended claims will be apparent to those skilled in the art from a consideration of the form shown and the teachings hereof.

What is claimed is:

1. In combination, an electrical-space discharge device having an anode, a pool cathode and a resistance-immersion ignitor, means for supplying igniting impulses to said igniter, said means including a source of current, a pulse forming line comprising a combination of inductors and capacitors connected to said source through said ignitor for storing electrical energy from said source, means for discharging said energy to energize said ignitor, said inductors and capacitors being arranged to deliver said stored energy in the form of a substantially rectangular wave of predetermined duration.

2. In combination, an electrical-space discharge device having an anode, a pool cathode and a resistance-immersion ignitor, means for supplying igniting impulses to said ignitor, said means including a source of current, a pulse forming line comprising a combination of inductors and capacitors connected to said source through said ignitor for storing electrical energy from said source, means for discharging said energy to energize said ignitor, said inductors and capacitors being arranged to deliver said stored energy in the form of a substantially rectangular wave having a duration of the order of the critical minimum time required to produce an incipient arc spot.

3. In combination, an electrical-space discharge device having an anode, a pool cathode and an igniting electrode of the resistance-immersion type, means for applying an alternating potential across the cathode-anode circuit of said device, means for supplying igniting impulses to said igniting electrode, said means including a source of current, a pulse forming line comprising a combination of inductors and capacitors connected between said source and said electrode for storing electrical energy from said source, means for discharging said energy in predetermined phase relation to said alternating potential to energize said electrode, said inductors and capacitors being arranged to deliver said stored energy in the form of a substantially rectangular wave of predetermined duration.

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