The present invention relates to gaseous electric discharge arc lamps generally and more particularly the invention relates to such devices in which the arc voltage increases after the starting of the lamp and reaches its full value after the lamp has been operating an appreciable time. One type of lamp having these voltage characteristics is known in the art as a high pressure metal vapor arc lamp.

Such lamps require a series resistance for the successful operation thereof and the series resistance can be in the form of an incandescent filament mounted externally of the container of the lamp. In such a circuit the voltage across the filament varies inversely with the arc voltage. Consequently, when the filament is designed to be heated to incandescence during the starting period of the arc discharge the filament is not heated sufficiently during the operating period of the lamp when the arc voltage increases. On the other hand if the filament is designed to be heated to incandescence during the operating period of the lamp the filament is overloaded during the starting period when the arc voltage is low which causes said filament to burn out and terminate the useful life of the lamp unit.

The object of the present invention is to provide a lamp unit comprising a gaseous electric discharge arc lamp having an incandescent filament connected in series therewith in which the filament is heated to incandescence and not overloaded during the starting and operating period of the gaseous electric discharge device. Further objects and advantages attaching to the device and to its use and operation will be apparent to those skilled in the art from the following particular description.

The invention attains its objects by connecting in series with said lamp device and said filament a resistance element having a high negative temperature coefficient of electric resistance, that is, the resistance of the element varies inversely with the temperature thereof. These elements are mounted in a sealed vitreous envelope and form a lamp unit. When potential is first applied to the lamp unit the current flow through the filament is limited by the resistance element, which is at a low temperature, to a value which is approximately that of the current flowing through said filament when the gaseous electric discharge lamp device has reached operating equilibrium. As the temperature of the lamp device increases and the voltage between the electrodes thereof increases the temperature of the resistance element increases and the resistance thereof decreases. The current load on the incandescent filament is thus substantially constant both during the starting and the operation of the lamp device and the size of the incandescent filament relative to this current value is such that it emits light to complement and supplement the light emitted by said lamp device and has a long useful operating life. The regulation of the current flow through the filament is thus accomplished without the use of complicated switch mechanisms.

In the drawing accompanying and forming part of this specification a lamp unit embodying the invention is shown in a front elevational, partly sectional view.

Referring to the drawing the lamp unit comprises a gaseous electric discharge lamp device having a tubular quartz container 1 having electrode chambers 2 and 3 at the ends thereof. The inside diameter of the tubular part of the container is 4 mm. and the outside diameter thereof is approximately 7.5 mm. Electrodes 4 and 5 are sealed into said container 1 and are mounted in said chambers 2 and 3, respectively. The distance between said electrodes 4 and 5 is about 8 mm. Said electrodes 4 and 5 consist of a coiled wire of high melting-point metal, such as tungsten, supporting, as by being coated with a body of electron emitting material, such as barium oxide, and are heated to an electron emitting, arc discharge supporting temperature by the discharge current thereat. Said container 1 has a starting gas, such as argon, at a pressure of about 20 mm. and a quantity of vaporizable metal, such as mercury, therein.

The lamp device is mounted in an envelope 6 of vitreous material which envelope has a gaseous filling therein, such as nitrogen, at a pressure of about 600 mm. An incandescent filament 7 is also mounted in said envelope 6 and one end of said filament 7 is connected to the electrode 6 by current lead 8. Said incandescent filament 7 is located in a plane normal to the longitudinal axis of the container 1 and substantially surrounds said container 1 at a point midway between the ends of said container 1. Said filament 7 is supported by support wires 9 which are secured to the current lead 8 by the glass bead 10. The other end of the filament 7 is connected by the current lead 11 to one end of the resistance 12. Said resistance 12 has a high negative temperature coefficient of electric resistance. Current lead 13 is connected to the other end of said resistance 12. The electrode 6 of the lamp device is connected to the current lead 14. Said current leads 13 and 14 are fused into the stem 15 of the envelope 6. The lamp device 1, the filament 7 and the resistance 12 are thus connected in series.

The resistance 12 is a rod consisting of a sintered mixture of ceramic material and silicon.
The preferred method of making the resistance 12 consists in the steps of first reducing ferro-silicon, having a high silicon content of about 50%, to a powder form, mixing it with chloride (aluminum silicate) and tragaanat, both of these last named materials being in powder form, adding water to the mixture and working the latter into a homogeneous mass. Small, pressed rods of this mixture are then formed and at the ends of the rods small graphite blocks are pressed, which blocks serve as the contact parts of the resistance 12. These elements are then dried and heated to the sintering temperature of the mixture in an atmosphere of reducing gas. The resistance of the rod at room temperature and at an elevated temperature is determined by the ratio of the components intermixed with each other and also by the temperature at which sintering thereof takes place. The adjustment of these factors makes possible the manufacture of elements 12 having a desired resistance value.

A resistance 16 consisting of a high melting point material, such as tungsten, is connected in parallel with the resistance 12 and is mounted adjacent to the resistance 12. When potential is applied across the terminals of the lamp unit current flows through the resistance 16 and the heat developed thereby raises the temperature of the resistance 12. As pointed out above the resistance of the element 12 decreases as the temperature thereof increases and when the lamp device is at operating equilibrium the element 12 offers but slight resistance to the flow of current.

When the lamp device described above is at operating equilibrium the current consumption thereof is about 0.4 amperes and the voltage across the lamp device is 10 volts. Under these conditions the vapor pressure in the container is about 20 atmospheres. Shortly after the discharge between the electrodes 4 and 5 of the lamp device has started and before the lamp device has reached operating equilibrium the voltage across the electrodes is about 15 volts. When the lamp unit is connected across the terminals of a 220 volt current source the filament 7, the resistance 12 and the resistance 16 are designed in such manner that the filament 7 absorbs 105 volts and the resistance 12 absorbs only 5 volts when the lamp device is at operating equilibrium. When the element 16 has a resistance of 240 ohms the element 12, when hot, must then have a resistance of 13 ohms when the lamp device is at operating equilibrium. When it is desired to consume a current of 0.45 amperes in the lamp unit immediately after potential is applied to the lamp device, when the voltage across the electrodes 4 and 5 is approximately 15 volts, the filament 7 absorbs

\[0.45 \times 105 = 118 \text{ volts} \]

and the resistance 12 together with the resistance 16 absorbs 220 - (15 + 118) = 97 volts. With a resistance of 240 ohms in the element 16 the element 12 must then have, therefore, a resistance of 1000 ohms. The resistance 12, therefore, should be designed so that it has a resistance of 1000 ohms at room temperature and a resistance of 13 ohms at the elevated temperature thereof during the operation of the lamp unit.

The rate at which the resistance of the element 12 changes should be approximately the rate of change in the lamp device voltage. This change is controlled by the distance of the resistance 16 therefrom, when desired. For example, the resistance 16 is mounted about said resistance 12 at a desired distance. When the resistance 16 is omitted the rate at which the resistance of the element 12 changes is regulated by controlling the dissipation of heat from said resistance 12, when desired. For example, the resistance 12 reaches its final resistance value more rapidly in a highly evacuated envelope than when the envelope is filled with a gas.

While I have shown and described and have pointed out in the annexed claims certain novel features of the invention, it will be understood that various changes in the forms and details of the invention and in its use and operation may be made by those skilled in the art without departing from the spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. An electric lamp comprising in combination an hermetically sealed envelope, a gaseous electric discharge lamp device and a series ballast means for said device mounted in said envelope, said ballast means consisting of an incandescent filament partially surrounding said filament and having a high negative temperature coefficient of electrical resistance connected in series with said lamp device and said filament in said envelope to maintain the temperature of said filament substantially constant during the starting and operation of said lamp device.

2. An electric lamp comprising in combination an hermetically sealed envelope, a gaseous electric discharge lamp device mounted in said envelope, an incandescent filament mounted in said envelope and partially surrounding said lamp device, a resistance having a high negative temperature coefficient of electrical resistance connected in series with said lamp device and said filament in said envelope and another resistance having a positive coefficient of electrical resistance connected permanently in parallel with said filament and mounted adjacent to said first named resistance to maintain the temperature of said filament substantially constant during the starting and operation of said lamp device.

3. An electric lamp comprising in combination an hermetically sealed envelope, a gaseous electric discharge lamp device and a series ballast means for said device mounted in said envelope, said ballast means consisting of an incandescent filament and a resistance having a high negative temperature coefficient of electrical resistance connected in series with said lamp device and said filament in said envelope to maintain the temperature of said filament substantially constant during the starting and operation of said lamp device.

4. An electric lamp comprising in combination an hermetically sealed envelope, a gaseous electric discharge lamp device mounted in said envelope, an incandescent filament mounted in said envelope, a resistance having a high negative temperature coefficient of electrical resistance connected in series with said lamp device and said filament in said envelope and another resistance having a positive coefficient of electrical resistance connected permanently in parallel with said filament and mounted adjacent to said first named resistance to maintain the temperature of said filament substantially constant during the starting and operation of said lamp device.

WILLEM ELENAAS.