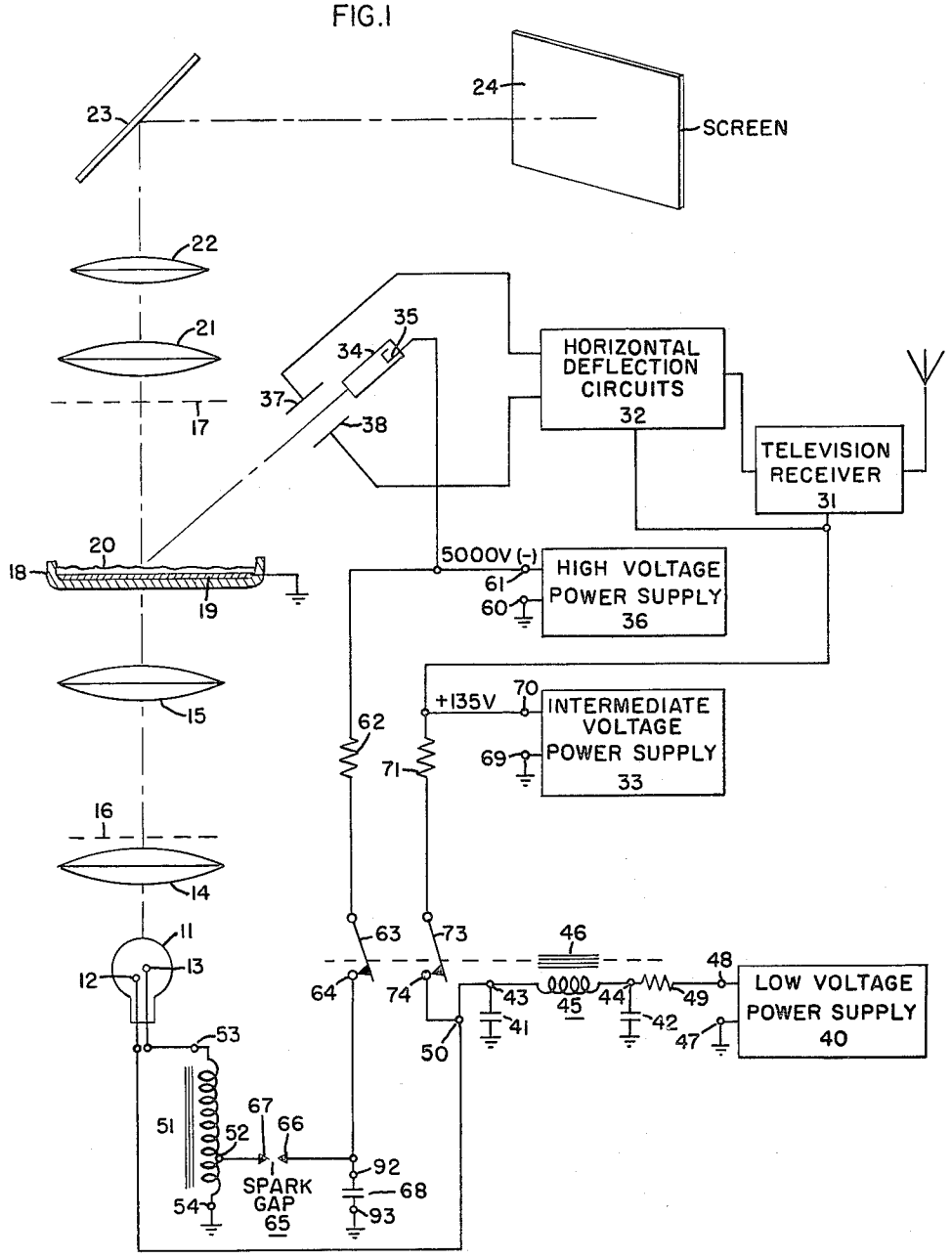
Nov. 23, 1965 A. G. ROUSSIN 3,219,756

IGNITION CIRCUIT FOR AN ARC-DISCHARGE LAMP IN A PROJECTION SYSTEM

Filed March 5, 1962 3 Sheets-Sheet 1

FIG. 1



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FIG. 2

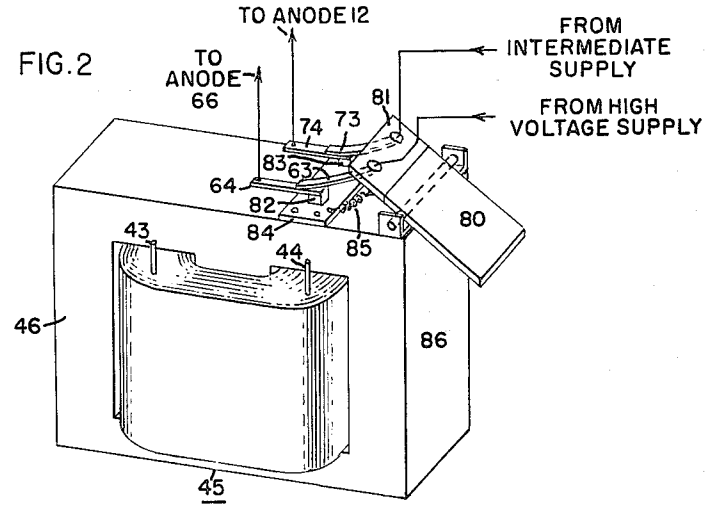
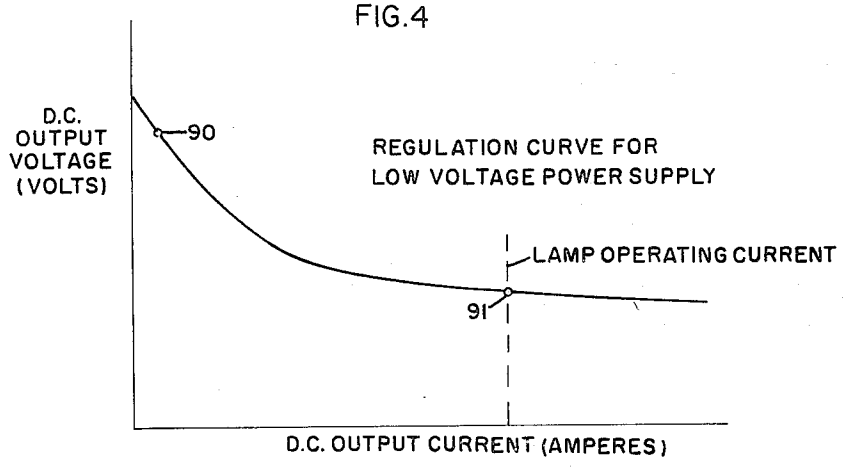


FIG. 4



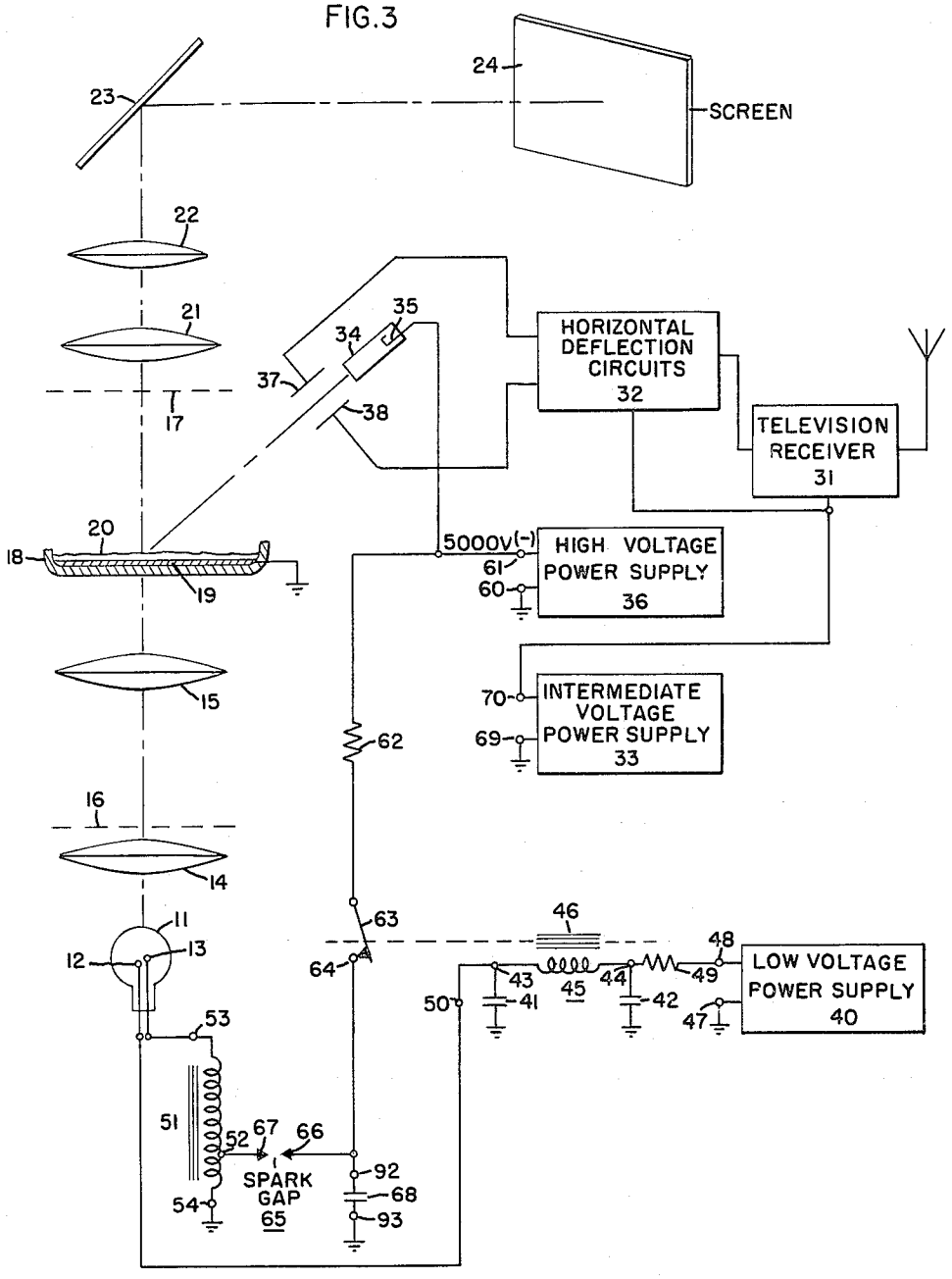
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IGNITION CIRCUIT FOR AN ARC-DISCHARGE LAMP IN A PROJECTION SYSTEM

Filed March 5, 1962 3 Sheets-Sheet 3

FIG.3



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3,219,756

IGNITION CIRCUIT FOR AN ARC-DISCHARGE LAMP IN A PROJECTION SYSTEM

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9 Claims. (Cl. 178—7.5)

This invention relates to a light valve projection system of the type utilizing an arc-discharge lamp as a source of light and more particularly to a means for igniting the arc-discharge lamp.

Arc-discharge lamps have operated satisfactorily as light sources in light valve projection systems and their use in these systems is well known in the art.

Nevertheless, the electrical starting and operating characteristics of an arc-discharge lamp remain substantially alien to the relatively low voltage-low current electronic circuitry associated with light valve projection systems. More specifically, when placing an arc-discharge lamp such as a gaseous Xenon lamp in operation, it is necessary for proper arc striking and maintenance that a sequential three step arc ignition and sustaining proceduce be followed. The procedure consists in coupling a very high voltage to the lamp for causing an ionization of the atmosphere between two lamp electrodes and a consequent arc-discharge therebetween; the coupling of a relatively low direct current voltage, hereinafter referred to as the intermediate voltage, to the electrodes for heating a cathode electrode in order to provide a source of conduction electrons and consequent low impedance path between the electrodes; and the coupling of a relatively low voltage derived from a high current capacity source to the lamp for providing an operating current for the lamp in order to sustain a high brilliance arc which has been "struck" in the prior steps. As an illustrative example, the respective aforementioned voltage requirements for a 500 watt Xenon lamp are approximately 30,000 volts, 100 volts and 25 volts; the latter low voltage source having a required current capacity in an ampere range. Thus, the electrical lamp starting and arc maintenance characteristics range from a requirement for a very high arc-"striking" voltage source to a requirement for a substantially low arc-maintaining voltage source having a relatively high output current capacity.

Since these lamp requirements have been recognized as foreign to the electrical requirements of the generally low energy level electronic circuitry of the light valve system, auxiliary lamp ignition apparatus providing the aforementioned voltages has heretofore been employed. Although the low voltage-high current arc sustaining power supply of such auxiliary apparatus is in continuous use after an arc has been "struck," the high and intermediate voltage sources are utilized only during arc ignition and remain idle during the many hours of lamp operation. In view of the limited although necessary function performed by the power supplies providing the high and intermediate voltages, the auxiliary ignition circuitry is both costly and inefficient in space utilization.

Accordingly, it is an object of this invention to provide a less expensive ignition means for an arc-discharge lamp in a light valve projection system than has heretofore been possible.

Another object of this invention to provide ignition means for an arc-discharge lamp in which the sources of ignition voltage are continuously utilized during the operation of the light valve projection system.

A further object of this invention is to provide means for utilizing available power supplies for performing an additional lamp ignition function.

Another object of this invention is to eliminate the necessity for providing auxiliary high and intermediate

ignition voltage sources and to provide means for automatically igniting an arc-discharge lamp in a light valve projection system when line power is initially applied to the system.

In accordance with the present invention, a source of relatively high D.C. voltage, which is provided for accelerating an electron stream toward a deformable medium in a light valve projection system, is coupled to a pair of electrodes in an arc-discharge lamp for causing ionization and corresponding arc-discharge between the electrodes of the lamp. Means providing an intermediate D.C. voltage for cathode heating and a D.C. operating voltage are also coupled to the electrodes of the lamp. Means are also provided for automatically decoupling the very high voltage and the lamp and for automatically removing the cathode heating voltage from the lamp electrodes when operating current flows in the lamp.

Further objects, features, and attending advantages of the invention will be apparent with reference to the following specification and drawings in which:

FIGURE 1 is a schematic diagram illustrating both the optical arrangement of a type of light valve television projection system and associated electrical circuitry, partly in block form, including an embodiment of the present invention,

FIGURE 2 is a perspective view of an iron core inductance utilized in the circuit of FIGURE 1 along with the necessary mechanism for operating, responsive to the amplitude of lamp current, a pair of contact surfaces which are also utilized in FIGURE 1,

FIGURE 3 is a diagram of a light valve system similar to the system of FIGURE 1 illustrating another embodiment of the present invention, and

FIGURE 4 is a diagram of the desired output voltage versus current regulation characteristic of a low voltage power supply utilized in the embodiment of FIGURE 3.

Referring now to FIGURE 1, a light value system suitable for projecting a television image upon a viewing screen is shown which includes both an optical section and an electrical section. The optical section comprises a Xenon arc-discharge lamp light source **11** having an anode electrode **12** and a cathode electrode **13**, a pair of imaging lenses **14** and **15**, a pair of light masking slit and bar systems **16** and **17**, a transparent vessel **18**, shown in sectional form for clarity, having an accelerating anode **19** positioned therein and containing a deformable medium **20**, a pair of projection lenses **21** and **22**, a deflection mirror **23** and an image viewing screen **24**. Operation of this light valve system wherein light from lamp **11** is transmitted through the enumerated elements of the optical section in order to project upon the screen **24** an image representing surface modulation components of the medium **20** is shown and described in Patent No. 2,957,942 which is assigned to the assignee of the present invention. It will be appreciated that other type light valve projectors may be used for practicing this invention, for example, the type shown and described in Patent No. 2,813,146 which is assigned to the assignee of the present invention.

The electrical section of the system includes conventional television signal processing circuitry **31**, horizontal electron beam deflection circuits **32**, an intermediate voltage source **33** for supplying power to circuits **31** and **32**, an electron gun structure **34** having a cathode **35** for providing an electron beam for modulating the surface of the deformable medium **20**, a high voltage power supply **36** connected between previously referred to anode **19** and cathode **35** for providing an accelerating voltage for the electron beam, and a pair of horizontal deflection plates **37** and **38** for deflecting and modulating the electron beam. Video modulation and horizontal synchroniz-

ing components which are contained in a received television signal are derived from the signal processing circuitry **31** and coupled to the deflection circuits **32** for causing deflection and velocity modulation of the electron beam. Elements of a complete electrical system for a light valve projection system, as for example the vertical deflection system, which would be apparent to one skilled in the art have, for purposes of clarity in presentation, been omitted.

A low voltage, high current capacity power supply **40** which includes the necessary well known elements for rectifying an alternating voltage which is derived from a line source of power, not shown, is provided for supplying operating current to the lamp **11** subsequent to the striking of an arc and the heating of cathode electrode **13** in the lamp. A Pi network for filtering the output voltage of power supply **40** is shown and includes capacitors **41** and **42** which are connected between ground potential and terminals **43** and **44** respectively of an inductance **45** and which inductance includes an iron core **46**. An output terminal **47** of the power supply **40** is connected to ground potential while another output terminal **48** is coupled via a current limiting resistor **49** to an input terminal **44** of the inductance **45**. A direct current output voltage exists between ground potential and an output terminal **50** of the filter which voltage will, in the arrangement shown, be positive with respect to ground potential. The terminal **50** is connected directly to anode **12** of lamp **11**. An autotransformer **51** having a winding including a tap **52** and a pair of output terminals **53** and **54** and whose primary function is described hereinafter, is connected between the cathode electrode **13** of lamp **11** and ground potential. Thus, when an arc has been struck between electrodes **12** and **13**, a complete circuit for current flow between the low voltage supply **40** and the lamp electrodes exists. The winding of transformer **51** consists of wire of a sufficiently large gauge for providing a negligible voltage drop across the winding when an operating current of relatively large amplitude flows in the lamp.

In one aspect of the present invention, the aforementioned high voltage power supply **36** which is provided for accelerating the electron beam toward the anode **19** in the optical section is coupled to the electrodes **12** and **13** of lamp **11** for causing ionization of the atmosphere and a consequent arc-discharge therebetween. A circuit for coupling the high voltage power supply between the electrodes **12** and **13** is arranged in a manner so that the supply **36** is automatically disconnected from the ignition circuit when an operating current flows in the lamp. The aforementioned intermediate voltage power supply **33** which is provided as a source of power for the required electronic circuits of the signal processing and deflection system in coupled between the electrodes **12** and **13** of lamp **11** for causing a heating of the cathode electrode **13** and a consequent electron flow. A circuit for coupling the intermediate voltage power supply **33** between the electrodes is arranged in a manner so that the supply **33** is automatically disconnected from the ignition circuit when an operating current flows in the lamp.

A more detailed description of the aforementioned coupling circuits will now be given with reference to FIGURE 1. A positive output terminal **60** of the high voltage supply **36** is connected to ground potential while a negative output terminal **61** is coupled to a cathode electrode **13** of lamp **11** via a current limiting resistor **62**, a pair of normally closed contacts comprising contact arm **63** and contact terminal **64**, a spark gap indicated generally by numeral **65** having sparking electrodes **66** and **67**, and the tap **52** of the winding of the aforementioned autotransformer **51**. A capacitor **68** having a pair of terminals **92** and **93** is provided. One terminal **92** is connected to the junction of electrode **66** and contact **64** while terminal **93** is connected to ground potential. The high voltage power supply **36** may derive operating power directly from a line source of power. However, it will be understood that other arrangements are equally applicable such as utilizing a tertiary winding on a flyback transformer in the horizontal deflection circuit **32** along with the necessary rectifier and filter. A negative output terminal **69** of intermediate voltage source **33** is connected to ground potential while a positive output terminal **70** is coupled to the anode electrode **12** of lamp **11** via a current limiting resistor **71**, a pair of normally closed contacts comprising contact arm **73** and contact terminal **74**, and the filter output terminal **50**.

As I have previously indicated, when the light valve projection system is initially put in operation, an arc must be struck between electrodes **12** and **13** of lamp **11**, the cathode electrode **13** must be heated from a voltage source having sufficient direct current voltage amplitude and power capacity to maintain the arc, and lamp operating current must be provided. The present invention satisfies these requirements in the following manner. When a voltage from a power line is initially coupled to the system, as for example, when a master power switch, not shown, couples power to the system, the power supplies **33** and **36** rapidly provide their rated output voltages at their respective output terminals. Capacitor **68** will therefore begin to charge to the output voltage of the high voltage power supply **36**, which is indicated in FIGURE 1 as —5000 volts. The capacitor **68** will charge at a rate determined by the parameters of the electrical elements in a time constant circuit consisting of the capacitance of capacitor **68** and the resistance of associated resistor **62**. When the voltage across capacitor **68** reaches a value sufficient to cause arc over between electrodes **66** and **67** of air spark gap **65**, an arc will be struck across gap **65** and the capacitor **68** will rapidly discharge across the gap **65** through the tap **52** on transformer **51** to ground. An impulse voltage is thereby developed between the tap **52** and terminal **54** of the winding and the autotransformer steps up this voltage to a value of voltage between its terminals **53** and **54** sufficient for causing ionization between electrodes **12** and **13** and consequent arc over therebetween. In the present case, electrode **13** will be driven to a sufficiently negative voltage to cause the arc over. This voltage will generally be on the order of 30,000 to 50,000 volts for a Xenon lamp.

Concurrent with the charging of capacitor **68** toward —5000 volts, the capacitor **41** in the low voltage power supply filter circuit will be charging both from the low voltage source **40** through resistor **49** and inductance **45** and from the intermediate voltage source **33** through resistor **71**. After a no-load low voltage source output voltage has been reached, capacitor **41** will continue to charge to the output voltage of the intermediate supply **33** at a rate determined by the parameters of the electrical elements in a time constant circuit consisting of the capacitance of capacitor **41** and the resistance of resistor **71**. This voltage will exist at the anode electrode **12** of lamp **11**. The value of the aforementioned charging time constants provided by resistor **62** and capacitor **68** and by the resistor **71** and capacitor **41** are selected to provide simultaneously the required amplitude D.C. heating voltage at anode **12** and the required arc over voltage between lamp electrodes **12** and **13**. Electrode heating current will thus be available to heat electrode **13** when arc over occurs. The heating of electrode **13** provides electrons for current flow. A decrease in voltage at anode **12** and an increase in the heating of electrode **13** occur cumulatively until the necessary electron flow to maintain the desired arc current at a voltage equal to the output voltage at terminal **50** of the filter is attained.

The previously referred to contact arms **63** and **73** are arranged in a manner described hereinafter so as to be forced away from their corresponding contact terminals **64** and **74** when operating lamp current flows in lamp **11**.

Thus, the power supplies **33** and **36** are automatically decoupled from the lamp when ignition is complete.

Although it is to be understood that various other arrangements may be utilized, a relatively simple and inexpensive means for providing the aforementioned decoupling function is illustrated in FIGURE 2. In FIGURE 2 the contacts **63** and **73** are shown positioned relative to the core of **46** of inductance **45** in a manner so as to be responsive to the leakage inductance of the iron core. A mechanical arrangement is shown therein in which an armature comprising a plate **80** of magnetic material is pivotally mounted by any known and suitable means at an edge of the iron core **46**. Attached to one end of the armature plate **80** is a sheet of electrical insulating material **81** upon which are mounted contacts, designated **63** and **73**, simulating the aforementioned movable contact arms **63** and **73** of FIGURE 1 and which are shown to have leaf type contact surfaces. Associated connecting leads to the corresponding power supplies **36** and **33** are provided. A pair of insulating posts **82** and **83** are provided for mounting the contacts **64** and **74** on, but, spaced away from core **46**. The posts **82** and **83** are mounted on an insulating sheet **84** which is secured to the core **46** by any suitable conventional means. A mechanical spring **85** connected between insulating sheet **81** of the armature and sheet **84** mechanically biases the contacts **63**, **64** and **73**, **74** respectively in electrical contact. When operating lamp current flows through the winding of inductance **45**, leakage flux in the core forces armature plate **80** to pivotally rotate clockwise as viewed in FIGURE 2 toward a surface **86** of the core and thus interrupt electrical contact between the respective contact arms and terminals.

Referring once again to FIGURE 1, it is apparent that various adjustments may be made in the above described circuit in order to satisfy the particular requirements of the arc-discharge lamp which is employed in the light valve projection system. For example, the relative position of the electrodes **66** and **67** may be made adjustable while the charging time constants of the above described time constant circuits may be varied by varying the values of the capacitors or resistors. Thus, I have described a means for utilizing already available high and intermediate voltage power supplies in a light valve projection system for igniting an arc-discharge lamp and for automatically disconnecting the supplies from the ignition circuit when operating lamp current flows.

In various light valve projection systems an intermediate voltage power supply suitable for the aforementioned ignition function may not be available or if available cannot be utilized. FIGURE 3 illustrates such a system wherein only a high voltage supply **36** and low voltage supply **40** are utilized to provide ignition. Numerals representing similar components performing similar functions as shown in FIGURE 1 have been repeated in FIGURE 3. The low voltage power supply **40** of FIGURE 3 is utilized to provide both the previously described necessary electrode heating voltage and to provide lamp operating current. As described above, with relation to FIGURE 1, voltage supply **40** was required to provide the necessary operating voltage and current for the lamp **11**. In order to provide the additionally required electrode heating voltage, the power supply **40** of FIGURE 3 must have an output voltage versus current regulation characteristic as indicated in FIGURE 4. Specifically, prior to ignition and under light current loads, the low voltage power supply **40** of FIGURE 3 must have a distinguishable and marked increase in voltage such as indicated at point **90** on the curve. A typical 500 watt Xenon lamp requires approximately **10** joules of electrical energy to provide the necessary heating of the cathode electrode. Hence, a power supply having the indicated low-load regulation characteristic which can momentarily deliver this energy at the required voltage will provide satisfactory heating. The output voltage must then drop off to lamp operating voltage and lamp operating current as indicated at point **91** on the curve. Various power supply arrangements may be utilized in order to provide an effective intermediate voltage source and to automatically remove the effective supply from the lamp electrodes when operating current flows in the lamp. For example, similar to that described in U.S. Patent 2,286,499 might be employed.

Operation of the circuit of FIGURE 3 is similar in all other respects to operation of the circuit of FIGURE 1 which has been adequately described above. It is of course apparent that the intermediate voltage source decoupling means described with relation to FIGURE 1 is unnecessary in the ignition circuit of FIGURE 3 since automatic removal of the effective intermediate voltage from the lamp electrodes is provided by the regulation characteristic of the low voltage power supply **40**.

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

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

1. In a light valve projection system having a deformable medium, a source of electrons for striking said deformable medium and a light source comprising an arc-discharge lamp including a pair of arc-discharge electrodes having a desired atmosphere therebetween, a means for providing an ionizing voltage for the lamp comprising: a source of relatively high direct current voltage for accelerating a stream of electrons from the electron source toward the deformable medium, means coupling said source of high voltage between the electrodes of said lamp for causing ionization of the atmosphere therebetween, said coupling means including means for automatically decoupling said high voltage source from said lamp when an operating current flows in said lamp.

2. In a light valve projection system including a deformable medium, a source of electrons for striking said deformable medium and a light source comprising an arc-discharge lamp including a pair of arc-discharge electrodes having a desired atmosphere therebetween, a means for providing an ionizing voltage for the lamp comprising: a source of relatively high direct current voltage for accelerating a stream of electrons from the electron source toward the deformable medium; means for coupling said source of high voltage between the electrodes of the lamp for causing ionization of the atmosphere therebetween, said coupling means including an electrical network having a time constant, a pair of normally closed contacts, a pair of electrodes for providing a spark gap, and a voltage transformer; and electromagnetic means for separating said contacts automatically thereby decoupling said high voltage source and said lamp, when an operating current flows in said lamp.

3. In a light valve projection system having an optical section including a deformable medium, a source of electrons for striking said deformable medium and a light source comprising an arc-discharge lamp including a pair of arc-discharge electrodes having a desired atmosphere therebetween, said lamp requiring the application of ionizing, heating and operating voltages between the electrodes, an ignition circuit for the lamp comprising: a power supply having output terminals providing a direct current output voltage between said terminals, a resistor, a capacitor having first and second electrodes, a pair of normally closed contacts, means connecting said resistor, said capacitor and said contacts in series, means connecting said series connected resistor, capacitor and contacts between said power supply output terminals, a pair of spaced electrodes for providing a spark gap, means coupling one of said spark gap electrodes to said first

capacitor terimnal, an autotransformer having a winding including a tap and a pair of output terminals, means coupling said winding output terminals between said lamp electrodes, means coupling one of said winding output terminals to said second capacitor terminal, means coupling said other spark gap electrode to said tap on said winding, means providing electrode heating and lamp operating voltages, means coupling said electrode heating and lamp operating voltage means to the lamp electrodes, and electromagnetic means for interrupting electrical contact between said normally closed contacts when operating current flows in said lamp.

4. In a light valve projection system, an ignition circuit for an arc-discharge lamp light source comprising: a source of relatively high direct current voltage for accelerating a beam of electrons from an electron source toward a deformable medium, means providing electrode heating and lamp operating voltages, means coupling said high voltage source to said lamp electrodes, means coupling said electrode heating and lamp operating voltage source means to said lamp electrodes, said high voltage source coupling means including means for automatically decoupling said high voltage source and lamp when operating lamp current flows between said electrodes, and means automatically removing said electrode heating voltage from said lamp when lamp operating current flows between said electrodes.

5. In a light valve projection system, an ignition circuit for an arc-discharge lamp light source comprising: a source of relatively high direct current voltage for accelerating a beam of electrons from an electron source toward a deformable medium, a source of intermediate direct current voltage for providing an operating voltage for said projection system, an arc-discharge lamp light source for said projection system having a pair of arc-discharge electrodes, a source of operating voltage for said lamp, means coupling said source of operating voltage for said lamp to said lamp electrodes, and means coupling said high and intermediate direct current voltage sources to said electrodes for respectively causing ionization of a gas between said electrodes and for heating one of said electrodes, said high and intermediate voltage source coupling means including means for decoupling said high and intermediate voltage sources and said lamp when operating current flows in said lamp.

6. The apparatus of claim 5 wherein said high and intermediate voltage decoupling means includes a first and a second pair of normally closed contacts for decoupling said high and intermediate voltage sources respectively from said lamp, and electromagnetic means for automatically interrupting electrical contact between said first and second pair of contacts when operating current flows in said lamp.

7. The apparatus of claim 6 wherein said source of operating voltage includes an iron core filter inductance, an

armature pivotally mounted and positioned relative to said core for being activated by leakage inductance from said core and said first and second pair of normally closed contacts each includes a movable contact positioned on said armature.

8. In a light valve projection system having an optical section including a deformable medium, a source of electrons for bombarding said deformable medium, and an arc-discharge light source, an ignition circuit for the light source comprising: a direct current high voltage source for accelerating electrons from said electron source toward said deformable medium; an arc-discharge lamp having first and second arc-discharge electrodes; first coupling means for coupling said high voltage source between said lamp electrodes for causing ionization and arc-discharge therebetween, said coupling means including means providing an air spark gap having an arc-over voltage and first and second electrical elements for providing a predetermined buildup in voltage at said air spark gap; a source of lamp operating voltage including a filter having an output terminal and a third electrical element; means connecting said filter output terminal to said first lamp electrode; a source of intermediate direct current voltage for said light valve projection system; a second coupling means including a fourth electrical element for coupling said intermediate voltage source to said filter output terminal for providing an electrode heating voltage for said lamp; said third and fourth electrical elements being of such nature as to provide a separate constant circuit with said capacitor and thereby providing a predetermined buildup in voltage at said filter output terminal; said first and second electrical elements and said third and fourth electrical elements having electrical parameters selected to provide simultaneously a required electrode heating voltage at said first lamp electrode and an arc over voltage at said air spark gap respectively; said first and second coupling means including a pair of normally closed electrical contacts; and electromagnetic means for causing separation of said contacts and decoupling of said high and intermediate voltage sources and lamp when operating current flows in said lamp.

9. The apparatus of claim 8 wherein said first and third electrical elements each comprise a capacitor, and said second and fourth electrical element each comprise a resistor.

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