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TUNGSTEN CONCENTRATED ARC LAMP

2,882,434

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FIG. 1

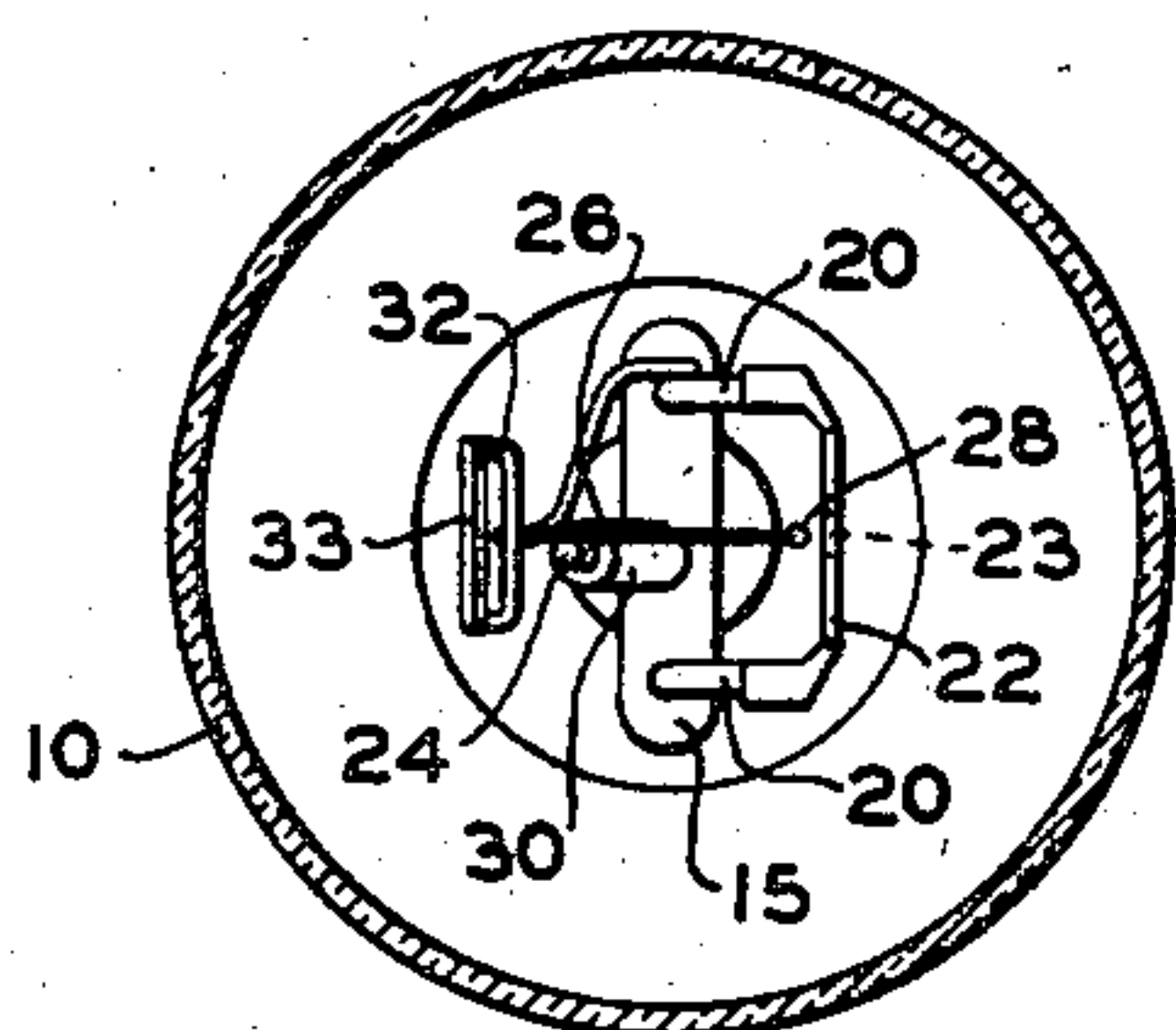


FIG. 2

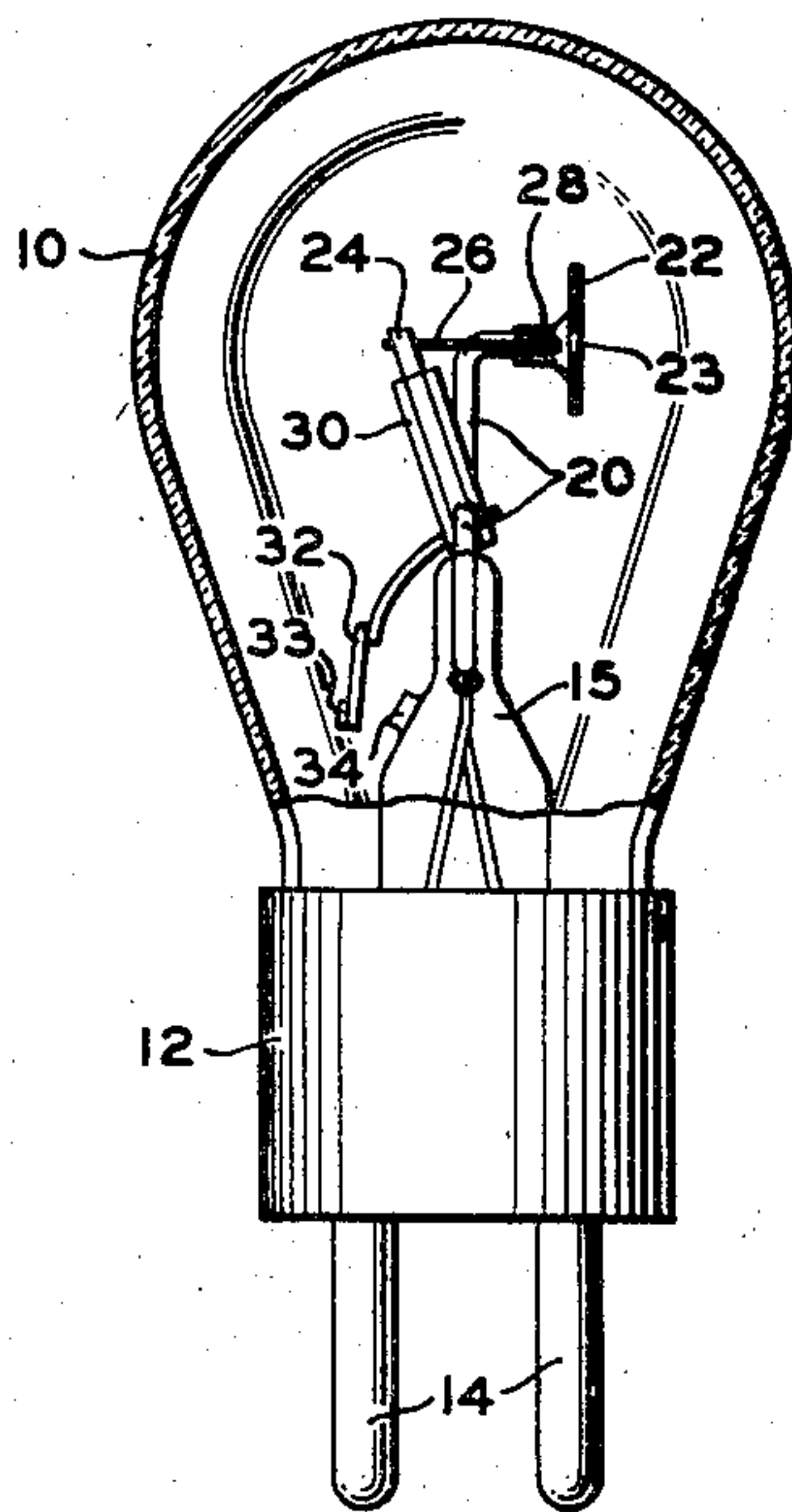
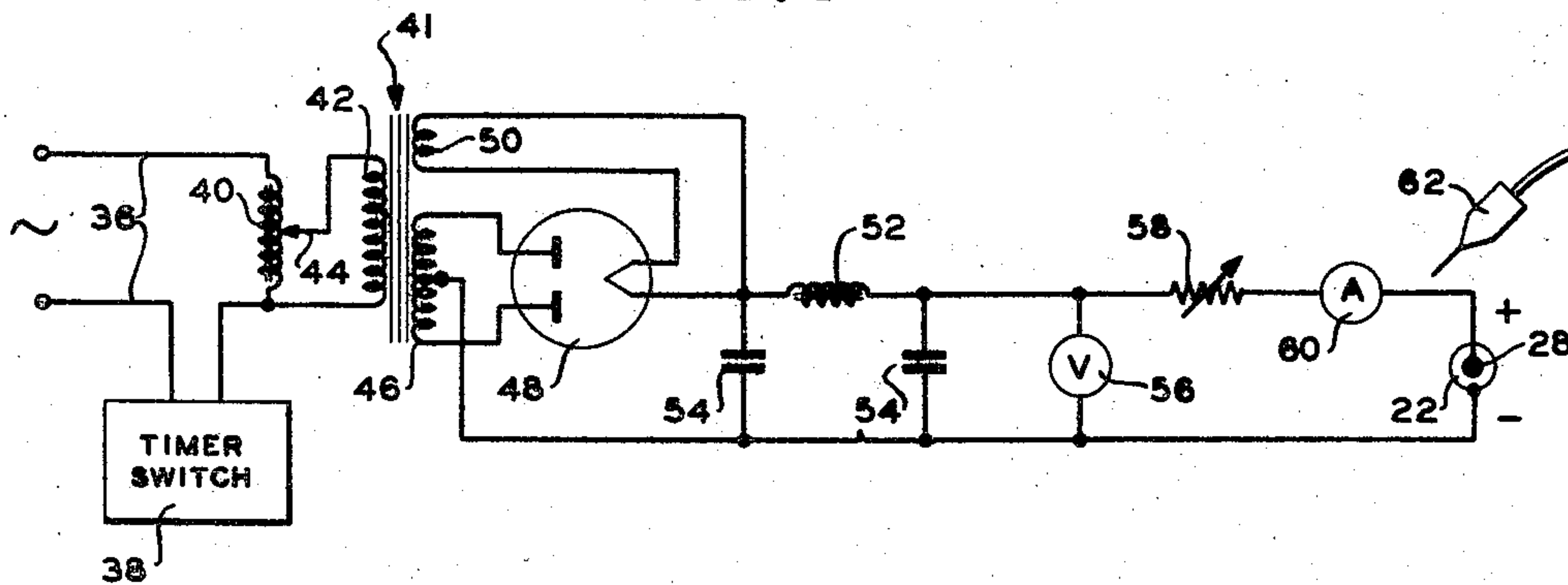


FIG. 3



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TUNGSTEN CONCENTRATED ARC LAMP

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3 Claims. (Cl. 313-213)

This invention relates to a tungsten concentrated arc lamp for producing a light source of high intrinsic brilliancy and particularly adapted for narrow beam projection purposes.

The use of a tungsten filament lamp for producing a light beam for optical projection systems involves certain disadvantages. In an attempt to get the maximum amount of light from the source through an opening or light gate, it is usual to image the light source at the opening. Unfortunately this image is that of the filament or coil of the lamp, and to prevent such an image from passing through the projection lens of the system, it is often necessary to reduce the diameter of the opening, and this undesirably restricts the amount of light that can pass.

In accordance with the present invention the light source is provided by a small round ball of tungsten operating as a cathode upon which an arc impinges in a gas-filled envelope, the tungsten ball being raised to a very high temperature by ion bombardment during operation of the lamp. The source of light is obtained from the incandescent surface of the tungsten ball which provides a small round spot of light of high uniform brilliancy. The tungsten ball is formed on the front end of a small tungsten wire after the electrode elements are mounted in their permanent positions within the envelope of the lamp. The diameter of the ball is made substantially larger than that of the tungsten wire in order that the ball will shield the optical system from any light emitted from the length of the wire at the rear of the ball, and thus prevent any blurring or halo effects around the edge of the round light image produced.

An object of the invention is to provide a gas-filled tungsten concentrated arc lamp in which a small round spot of light of uniformly high brilliance is produced by the cathode of the lamp, and in which blurring or halo effects around the light spot are obviated.

Another object resides in a method of making a lamp of the foregoing character in which the active cathode spherical element of the lamp may, if desired, be formed while the anode and cathode electrodes are in their permanent positions in the lamp structure.

The light beam produced by the incandescent ball of the cathode structure is admirably adapted for use in a simple and inexpensive flat bed facsimile scanning system, in which the light beam is caused to oscillate back and forth to scan the subject matter on a transmitting blank for producing facsimile signals in accordance therewith, or for scanning a light-sensitive recording blank to produce a record in accordance with incoming facsimile signals. In such case, and as disclosed in the application of W. W. Buckingham for Facsimile Telegraph Scanning Apparatus, Serial No. 454,750, filed concurrently herewith, the light source and the surface of the blank where the scanning beam impinges each may be located substantially at the optical center of curvature of a spherical oscillating mirror, and the scanning beam that is directed onto the blank will have the same diameter as that of the incandescent ball of the lamp, so that lenses are not re-

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quired for focusing the beam. A lamp in accordance with the present invention is also well adapted for simulated target practice or "dry shooting" when mounted on, or within the bore of, a rifle, revolver, or other gun, in view of the small size and relatively high brilliancy of the spot of light impinging on a target, and the ability of the lamp to flash in response to an electrical discharge controlled by the trigger or other firing mechanism, so that the need for a shutter is eliminated.

The invention will be more fully understood from the following detailed description of one embodiment thereof, taken in connection with the accompanying drawings in which:

Fig. 1 is a top plan view of a lamp embodying the principles of the invention;

Fig. 2 is a side view, in elevation, of the lamp of Fig. 1; and

Fig. 3 shows a circuit for forming the active cathode element of the lamp.

Referring to Figs. 1 and 2 of the drawings, the lamp comprises a gas-filled envelope 10 cemented to a base 12 of Bakelite or other suitable material, the base carrying terminal prongs 14 to enable the lamp to be plugged into an electrical power socket. While the lamp requires but two such prongs for supplying power to the electrodes, a third prong may be used for polarizing the lamp so that it will invariably be inserted with the proper polarities applied to the anode and cathode elements. Within the glass envelope and sealed thereto is a reentrant stem having a press portion 15 which seals and supports the lead-in wires of the lamp. These wires where they pass through the press are preferably composed of Dumet, which is iron coated with copper, so as to have a temperature coefficient of expansion substantially the same as that of the glass of the press 15. The upper portions of the lead-in wires may be composed of nickel, and are welded to the Dumet sections. Two of the lead-in wires 20 support a disk-shaped anode plate member 22 secured to the wires in any suitable manner, as by spot welding; one of these wires is shown broken away in Fig. 2 in order to disclose more clearly other details. The anode or plate member 22 is composed of a suitable metal such as zirconium, tungsten, tantalum or, preferably, molybdenum, and has a small central hole of light aperture 23 which, in the case of a 2-watt lamp, is approximately 25 to 30 mils in diameter.

The middle lead-in wire 24 has a fine tungsten wire 26 spot welded thereto, and on the other, or fore, end of the tungsten wire is formed a tungsten ball 28 that provides the active incandescent cathode element of the lamp, the ball being centrally positioned just behind the aperture 23 of the plate 22. In a 2-watt lamp the diameter of the tungsten wire is approximately 4 mils. The tungsten ball is made sufficiently large in diameter, for example, 8 to 10 mils, in order to shield the optical system from any light emitted from the length of the tungsten wire 26 at the rear of the ball, thereby to cause a sharp round light image having the same diameter as that of the ball to be produced. The light beam therefrom projects outwardly in a straight line through the light aperture 23 of the anode and through the side wall of the envelope of the tube. Surrounding the middle lead-in wire 24 is an insulating sleeve 30 in order to obviate any tendency for an arc to strike over between the anode and cathode lead-in wires. A small closed loop of wire 32 which includes a getter pill 33 is supported by one of the lead-in wires 20, although the loop 32 is not in the anode circuit of the lamp. A small glass tube 34 projects into the envelope and passes through the stem to enable the envelope to be evacuated and also to be filled with an inert gas, after which the tube is sealed off.

In constructing the lamp, the three lead-in wires are

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sealed into the stem. Before use the nickel wires in the completed stem are cleaned, for example, dipped in hot concentrated nitric acid and then washed in tap water and dried in an air blast. The plate is degreased in trichlorethylene, rinsed in alcohol and fired in a dry hydrogen furnace for approximately one half hour at 1000° C.

The cathode is formed from a thin tungsten wire which is sheared off in a cutter. For a 2-watt lamp the wire is approximately 4 mils in diameter and 5/16 of an inch long. The wire is fired in a dry hydrogen furnace two to three hours at 1000° C. in order to clean the wire of graphite or other foreign substance. The plate element 22 is spot welded on top of the lead-in wires 20, and the cathode wire 26 is spot welded on the upper end of the lead 24 so that the tungsten wire comes just up to the plate 22. In order to facilitate starting of the lamp, a small amount of radioactive material is applied to the press 15. This material may comprise radioactive cobalt or radium bromide; cobalt is less expensive and hence is preferred. Only one half a microgram of radium bromide is required. Radioactive cobalt may be applied as a solution in water in which there is approximately one microcurie per cc. of water, and only a drop of this is put on the press of the lamp and allowed to dry.

The stem is sealed to the bulb and the envelope evacuated, through the tube 34, at a temperature of approximately 750° F. for a half hour at a vacuum of one micron or better, after which the plate 22 is bombarded by a high frequency bombarder to a cherry red for a few seconds. The envelope is then filled with an inert gas, preferably 99.8% pure argon, to just below atmospheric pressure.

The ball 28, which is the active cathode element, is formed on the end of the wire 26 by connecting the lamp to a direct current voltage supply capable of delivering at least .7 ampere at 1000 volts. Sufficient resistance is inserted in series with this direct current power supply to limit the current to approximately .7 ampere when the leads going to the lamp are short-circuited. The lamp is connected with the negative lead of the cathode-forming circuit connected to the plate 22 and the positive lead connected to the tungsten wire 26, which connections are the reverse of those in the normal operating condition of the lamp. A timer switch is employed to give pulses of a predetermined duration, for example, 1/4 second long, and is connected in series with the power supply so that short cathode-forming pulses of current can be applied to the lamp to form the tungsten ball. A Tesla coil held adjacent to the lamp will facilitate the starting of the forming arc between the electrodes. Due principally to ion bombardment the end of the tungsten wire is melted and a ball formed thereon. It may require several successive flashes to achieve the desired diameter of the ball, but with proper voltage and current values in the forming circuit, the ball will not exceed the desired diameter regardless of the number of flashes, since the size which the ball attains is, for given values of voltage and current, determined by the length of each individual pulse. An example of the relative values of voltage and current required when pulses of a given length, for example, 1/4 second each, are applied is as follows:

Diameter of Ball	Voltage	Current, ma.	Time, sec.
.008"	840	640	1/4
.009"	950	720	1/4
.010"	1,000	770	1/4

During this forming operation the lamp is held in a position such that the end of the tungsten wire 26 on which the ball is to be formed is held downwardly thereby to insure that the ball will be centrally located and

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hence have uniform shielding effects. After the ball is formed to the desired diameter, the lamp is evacuated to 1 micron or better, the getter pill 33 is flashed in response to bombardment by high frequency which induces a current in the loop 32 sufficient to vaporize the getter material, and the lamp is refilled with a suitable inert gas, preferably argon, to a pressure just below atmospheric, and then sealed off.

Referring to Fig. 3, there is shown a suitable circuit for forming the tungsten ball. A source 36 of alternating current is connected in series with a timer switch 38 and thence through the winding of an autotransformer 40. The timer switch, which is capable of measuring the precise length of each forming pulse applied to the lamp, may be of any suitable type known in the art, for example, as disclosed in U.S. Patents Nos. 2,175,864 and 2,175,865. A transformer 41 has its primary winding 42 connected to the adjustable arm 44 of the transformer winding 40, whereby the voltage in the transformer 41 may be stepped up to any desired value. A secondary winding 46 is connected to a full wave rectifier 48 to provide a source of direct current for the forming circuit. A thermionic rectifier is illustrated, but any other type of rectifier suitable for the purpose may be employed. In the case of a thermionic rectifier the filament is energized from a small transformer winding 50.

Connected to the output circuit of the rectifier is a filter composed of an inductance 52 and condensers 54 to filter out any ripple in the rectified current. A voltmeter 56 connected across the direct current circuit indicates when the proper voltage is present and a milliammeter 60 connected in series with the circuit indicates when the proper current value obtains. An adjustable resistor 58 controls the value of the forming current. The tungsten ball or cathode element 28 is connected to the positive side of the forming circuit, and the plate 22 is connected to the negative side of the forming circuit since the ball is formed when acting as an anode in the forming circuit, although in the normal operation of the lamp it acts as a cathode. A Tesla coil 62 facilitates starting of the forming arc between the electrodes 22 and 28.

The lamp operates with a voltage drop of 25 to 30 volts across its electrode, depending upon the particular inert gas or gases employed as a filling. In a lamp having a tungsten ball 10 mils in diameter, the initial life of the lamp is approximately 200 hours; with a 9 mil tungsten ball the lamp initially will operate approximately 125 hours, and with an 8 mil ball the initial life of the lamp is approximately 80 hours. The life of the lamp depends upon the amount of material in the tungsten ball, which is proportional to the cube of the diameter of the ball. The life is determined by the length of time that the lamp will operate before the ball evaporates to an extent such that it does not sufficiently shield the length of the tungsten wire at the rear of the ball. However, as hereinafter set forth, the ball may be reformed repeatedly to give additional life spans each substantially equal to the initial life span.

In the form illustrated in Figs. 1 and 2, the sleeve 30 which surrounds the lead-in wire 24 may comprise uranium glass tubing which further facilitates starting of the lamp. If desired, the lead-in wires 20, which support the plate, may be surrounded with pieces of uranium glass tubing instead of, or in addition to, such tubing on the cathode lead-in wire, and in this case the two pieces of uranium glass are slipped over the two supports of the anode before the anode is spot-welded thereto.

In operation, the lamps are burned at a current value of approximately 90 ma. direct current, and the ball operates at the temperature, and has the brightness, of a tungsten filament lamp which is from 2800° to 3000° K. Considerable variations in the operating current do not materially affect the brightness of the spot produced by the incandescent tungsten ball lamps so that a voltage regulator is not required, whereas in a tungsten filament lamp small

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variations in current materially affect the light emitted by the lamps. When starting the lamp a higher voltage is employed to establish the arc between the ball and the inner edge of the anode, after which a lower voltage will maintain the lamp in operating condition. Various starting and running circuits for gas-filled lamps are well known in the art, for example, as disclosed in Patents Nos. 2,453,118, 2,543,227 and 2,608,675, which show circuits that operate either from alternating current or direct current power sources. A ballist resistance in series with the lamp is required since it has a negative volt-ampere characteristic.

The lamp may be operated in any physical position. Furthermore, the tungsten wire 26 need not be disposed at an angle to its lead-in wire 24, since it may be disposed in alignment with its lead-in wire, and this is likewise true with respect to the lead-in wires 20 and the plate structure 22, so long as the aperture or sight 23 is in alignment with the tungsten ball. The form illustrated in the figures is merely to enable the light beam to be emitted from the side of the envelope, whereas the light beam may be emitted upwardly or through any other portion of the envelope depending upon the arrangement of the optical system with which it is employed. Preferably, and as hereinbefore stated, the gas pressure in the envelope is of the order of 1 atmosphere, although for certain purposes the pressure may be as low as 100 millimeters of mercury and up to above 1 atmosphere.

When the lamp has been operated for a length of time such that the tungsten ball has diminished in size, the ball may again be restored to its original size by connecting the lamp to a forming circuit such as that illustrated in Fig. 3, and thus the useful life of the lamp may be extended until the length of the tungsten wire 26 has decreased to a point such that the ball is spaced too far behind the plate 22 to maintain the concentrated arc necessary to provide the desired high temperature values of the ball.

It will be obvious to those versed in the art that the tungsten concentrated arc lamp disclosed herein has many applications other than those specifically mentioned, and that various changes and modifications may be made without departing from the spirit of the invention which is not to be regarded as limited except as indicated by the scope of the appended claims.

What is claimed is:

1. A tungsten concentrated arc lamp adapted to provide a light source of high intensity for an optical system, comprising a light-transmissive envelope enclosing a metallic anode and a metallic cathode with lead-in wires thereto and a gas filling at a pressure sufficiently high to maintain a concentrated arc discharge between the anode and cathode, said anode comprising a metallic plate on which the arc discharge terminates and having a light aperture therein through which the light passes to the optical system, said cathode essentially consisting of

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a tungsten wire having a tungsten ball formed on the fore end thereof and positioned immediately behind and in alignment with said light aperture in the plate, said ball forming a restricted active surface area on which the arc is concentrated and which is heated to a state of high incandescence by ion bombardment when the lamp is in operation to provide a round light source of high uniform brilliancy, the diameter of said ball being greater than that of the tungsten wire and positioned to optically shield substantially the entire portion of the wire that emits light during operation of the lamp in a manner to shield the optical system from the light emitted by the tungsten wire at the rear of the ball and prevent blurring or halo effects around the edge of the light image produced.

2. A lamp according to claim 1, in which the diameter of the tungsten ball is at least twice the diameter of the tungsten wire.

3. A tungsten concentrated arc lamp adapted to provide a light source of high intensity for an optical system, comprising a light-transmissive bulb having a re-entrant stem and enclosing a metallic anode and a metallic cathode and a gas filling at a pressure sufficiently high to maintain a concentrated arc discharge between the anode and cathode, lead-in wires sealed in a press portion of said stem, said anode comprising a metallic plate on which the arc discharge terminates, said plate being supported by at least one of said lead-in wires and having a light aperture therein through which the light passes to the optical system, said cathode essentially consisting of a tungsten wire supported by another of said lead-in wires and having a tungsten ball formed on the fore end thereof and positioned immediately behind and in alignment with said light aperture in the plate, said ball forming a restricted active surface area on which the arc is concentrated and which is heated to a state of high incandescence by ion bombardment when the lamp is in operation to provide a round light source of high uniform brilliancy, the diameter of said ball being greater than that of the tungsten wire and positioned to optically shield substantially the entire portion of the wire that emits light during operation of the lamp in a manner to shield the optical system from the light emitted by the tungsten wire at the rear of the ball and prevent blurring or halo effects around the edge of the light image produced.

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