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2,687,471

CONCENTRATED ARC DISCHARGE DEVICE

Filed May 1, 1948

2 Sheets-Sheet 1

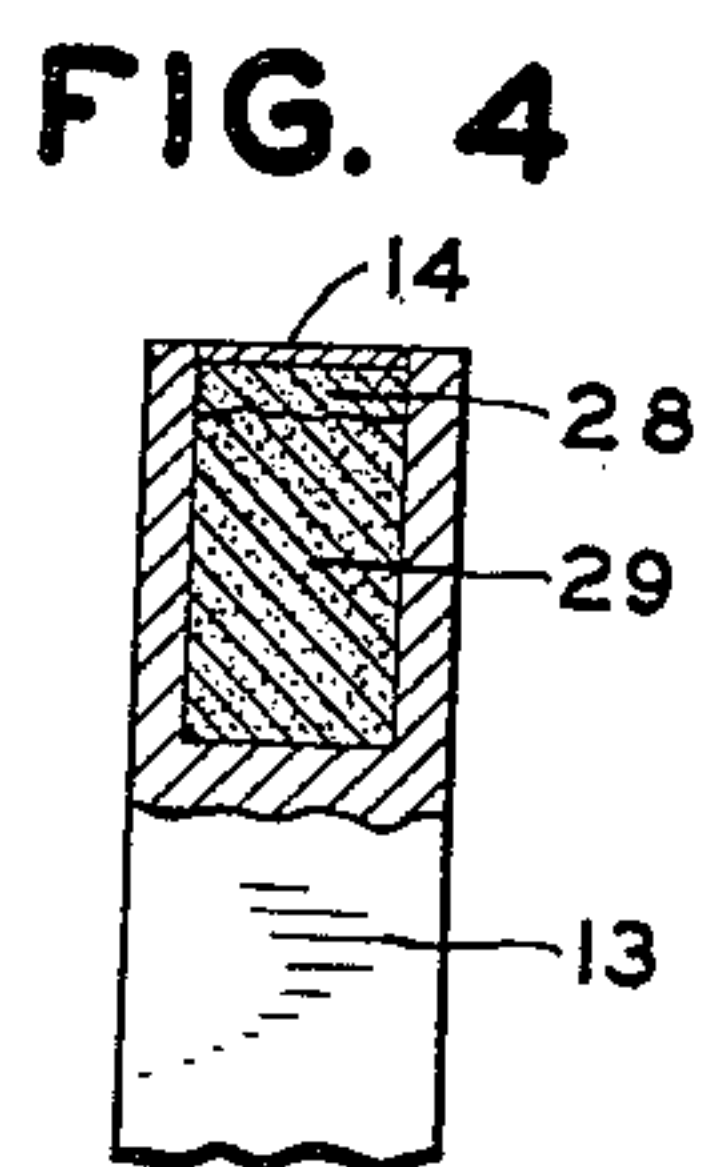
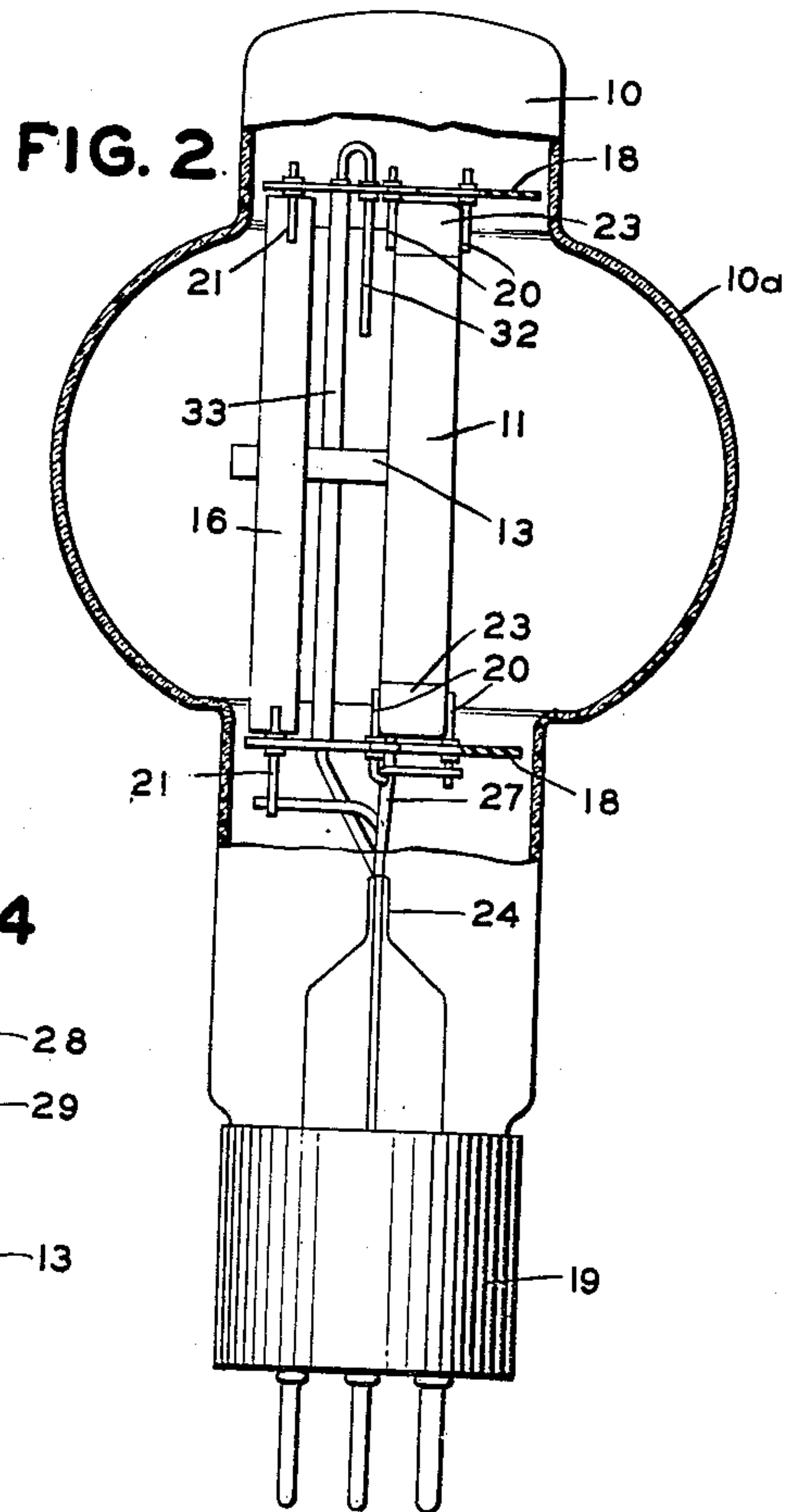
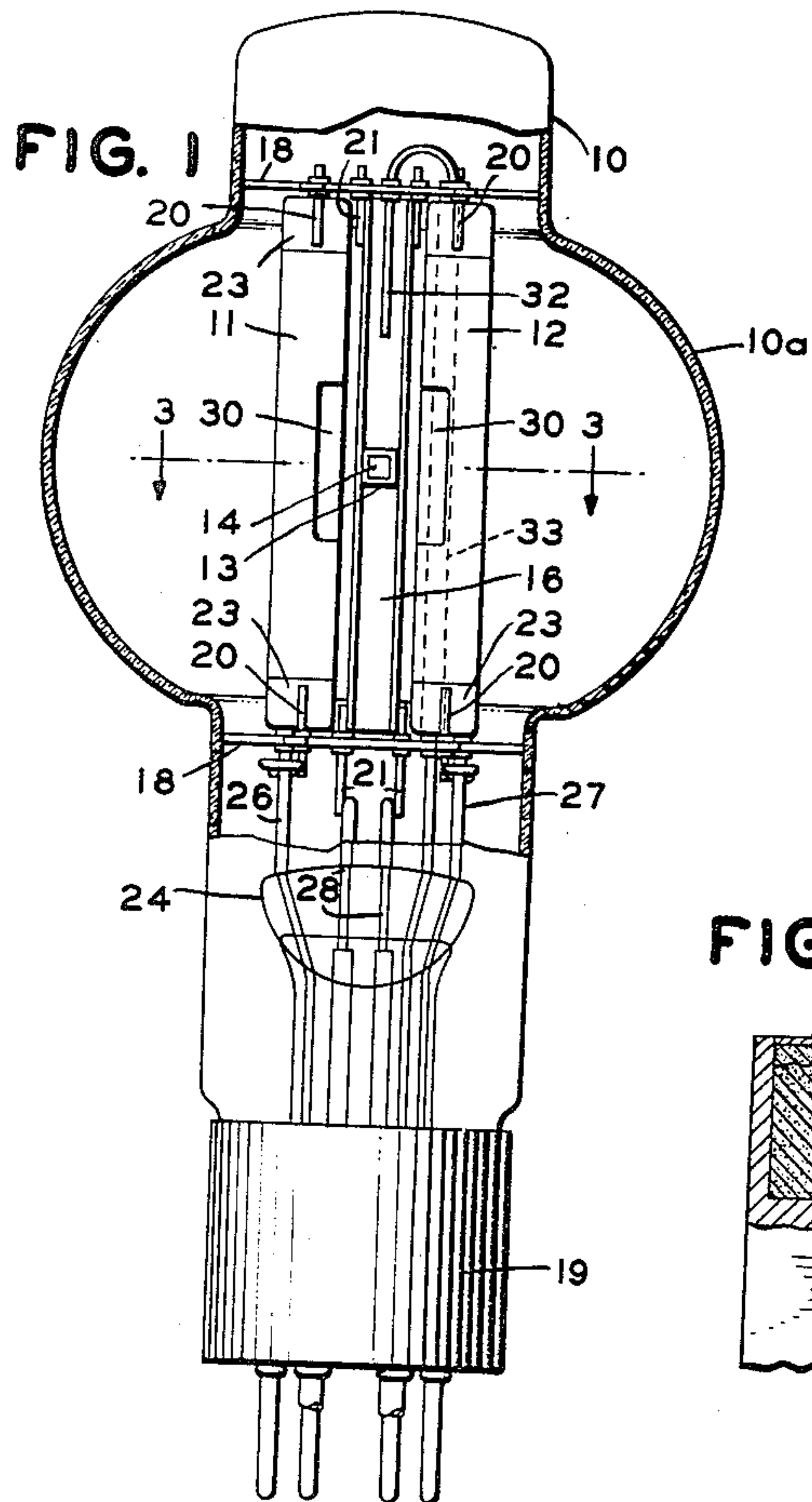


FIG. 3

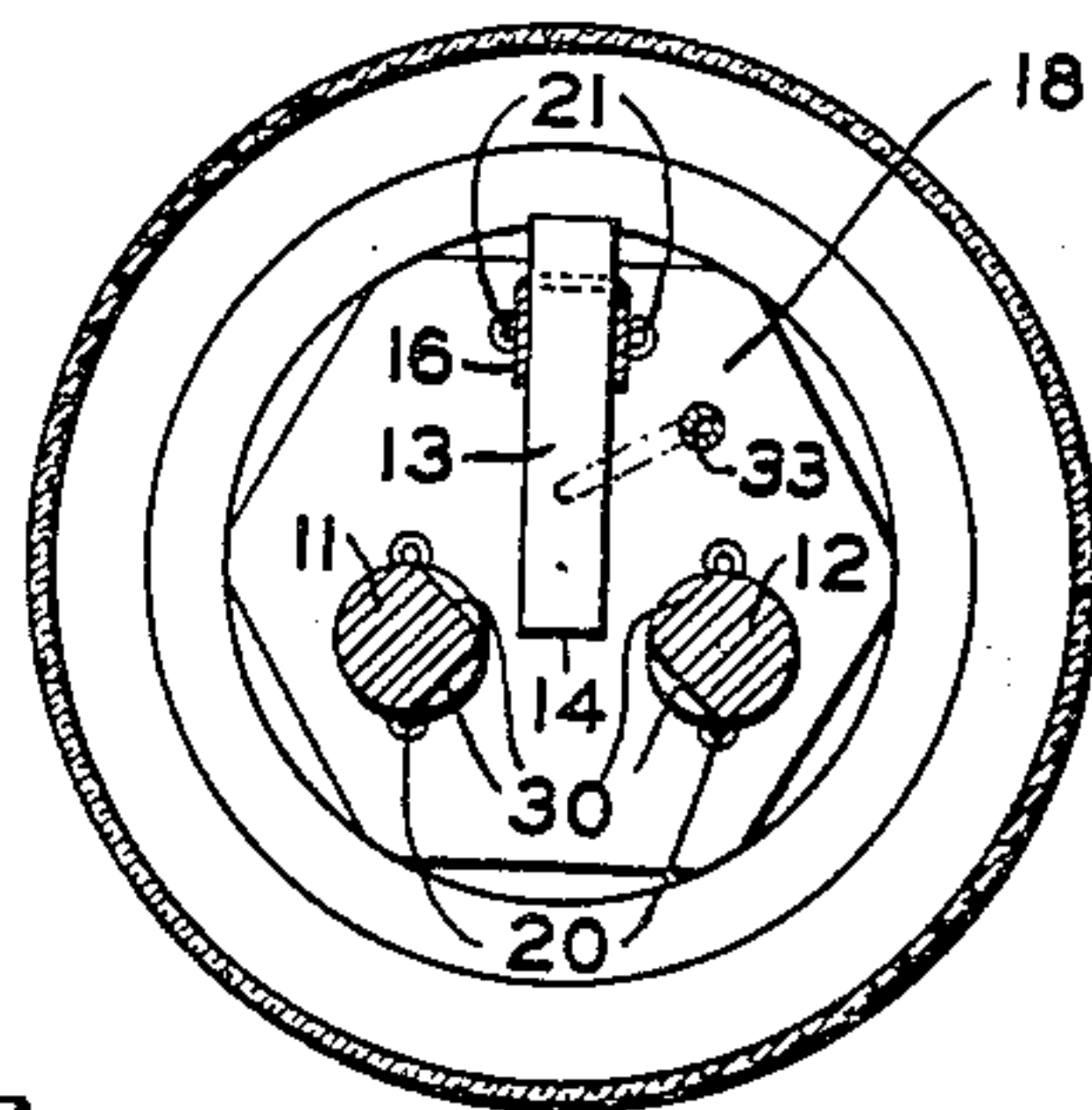


FIG. 5

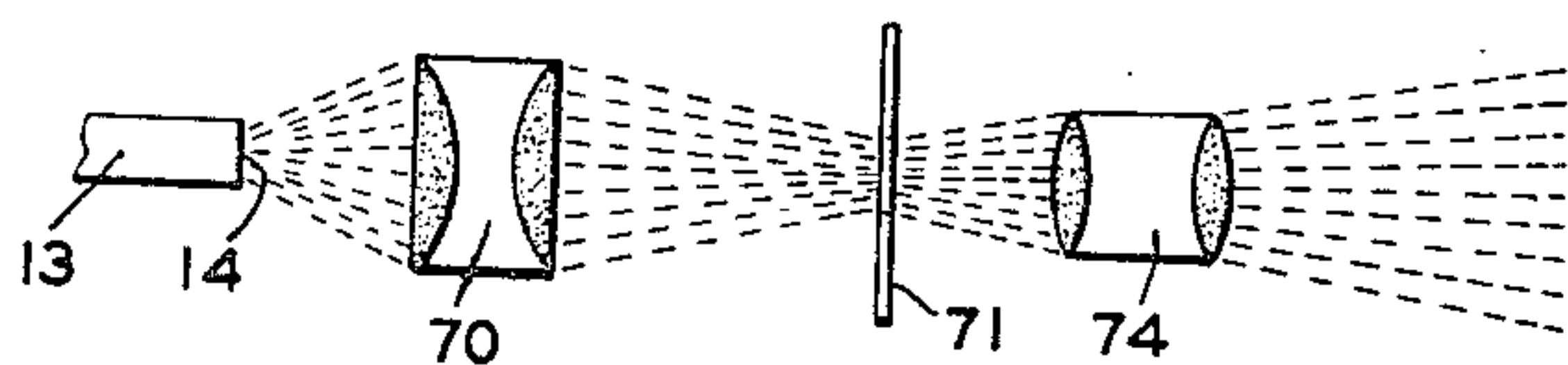


FIG. 6

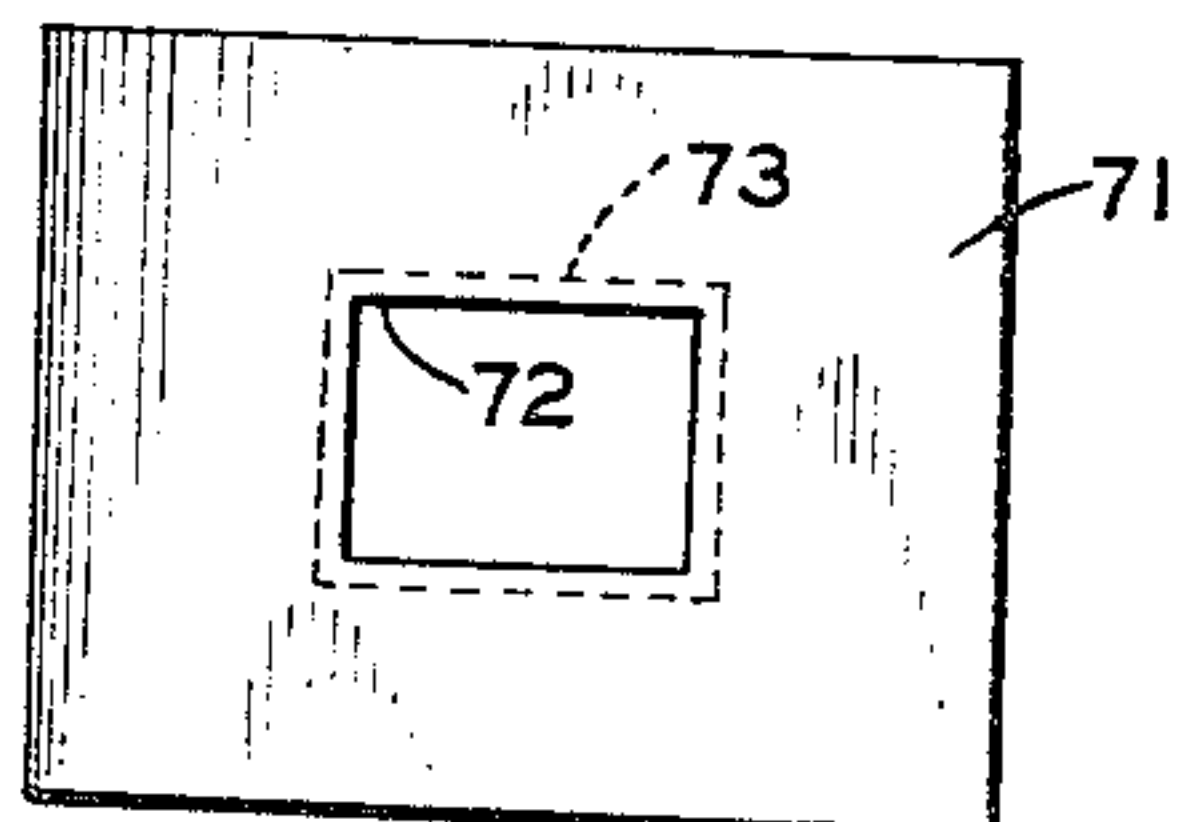
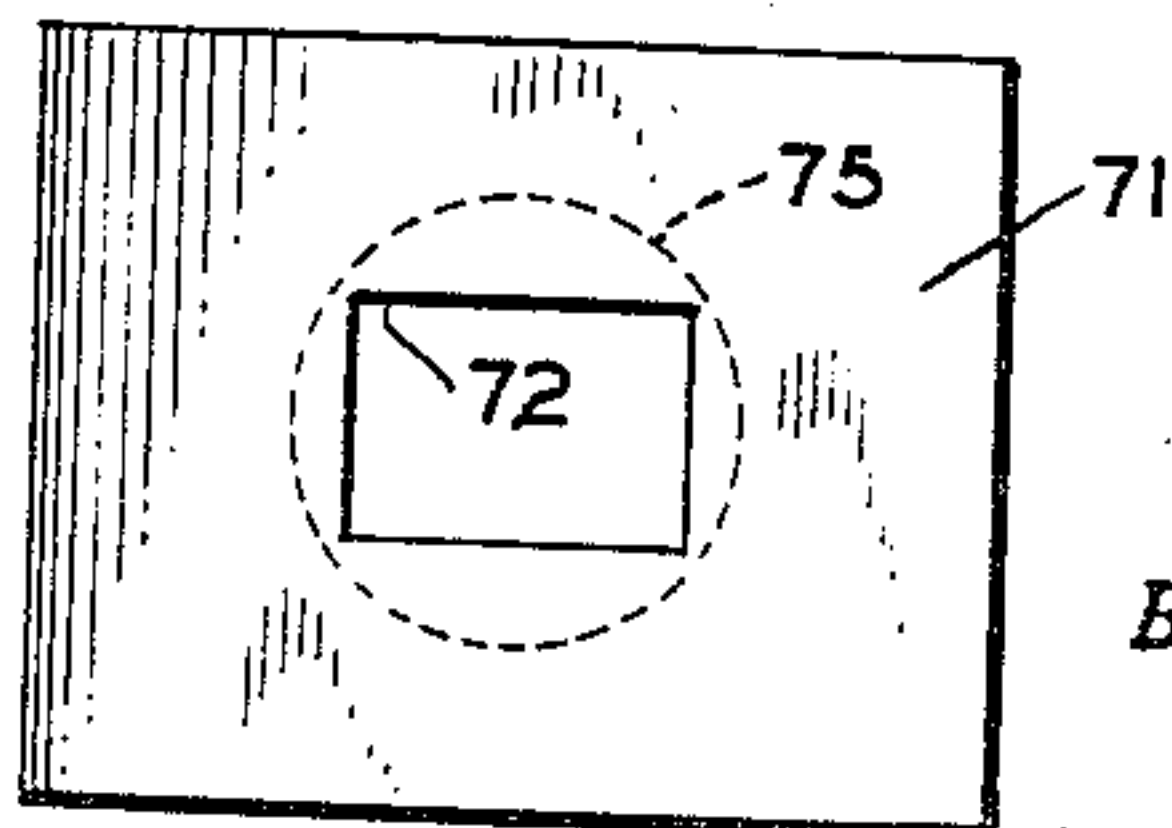


FIG. 7



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2 Sheets-Sheet 2

FIG. 8

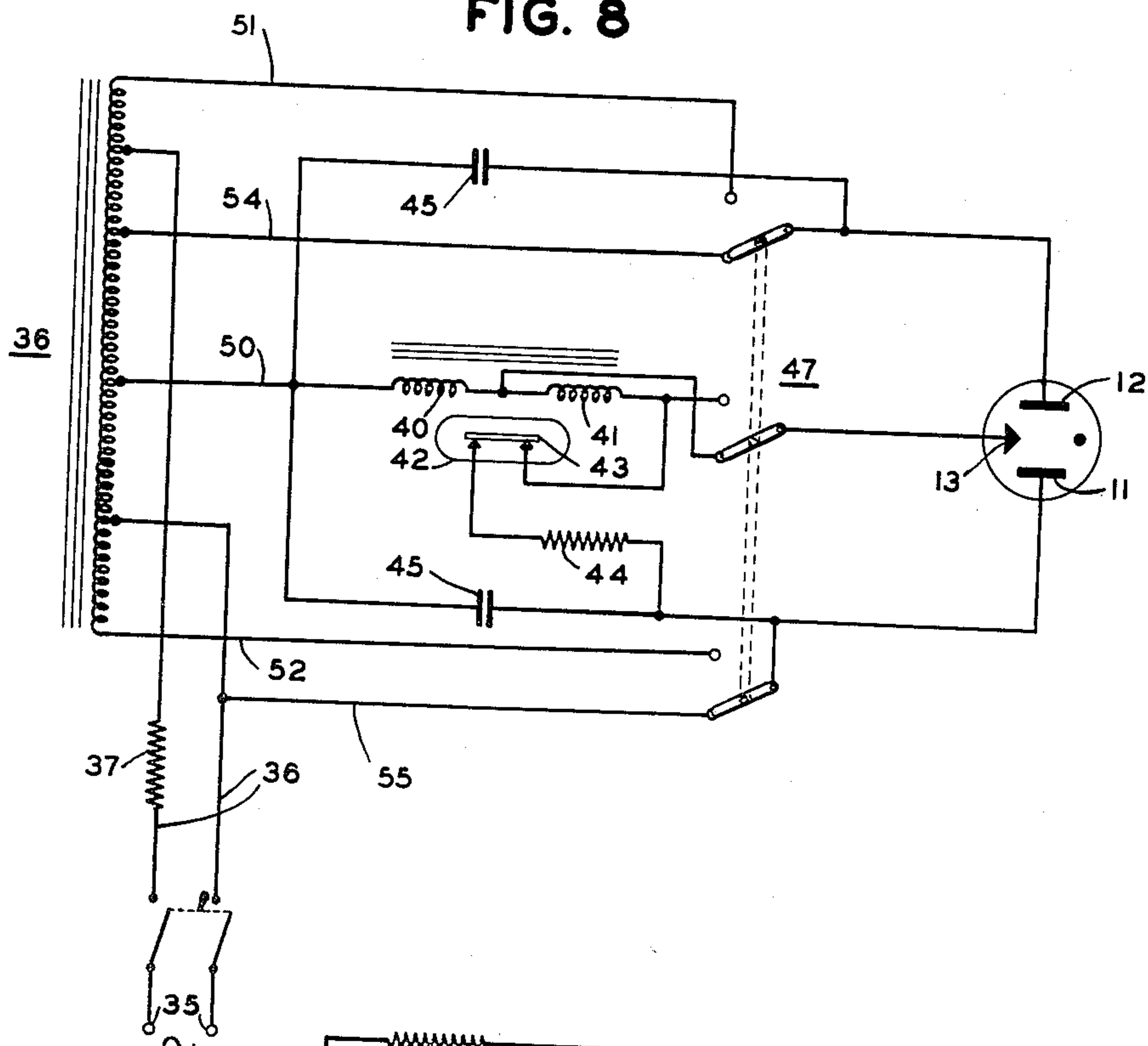
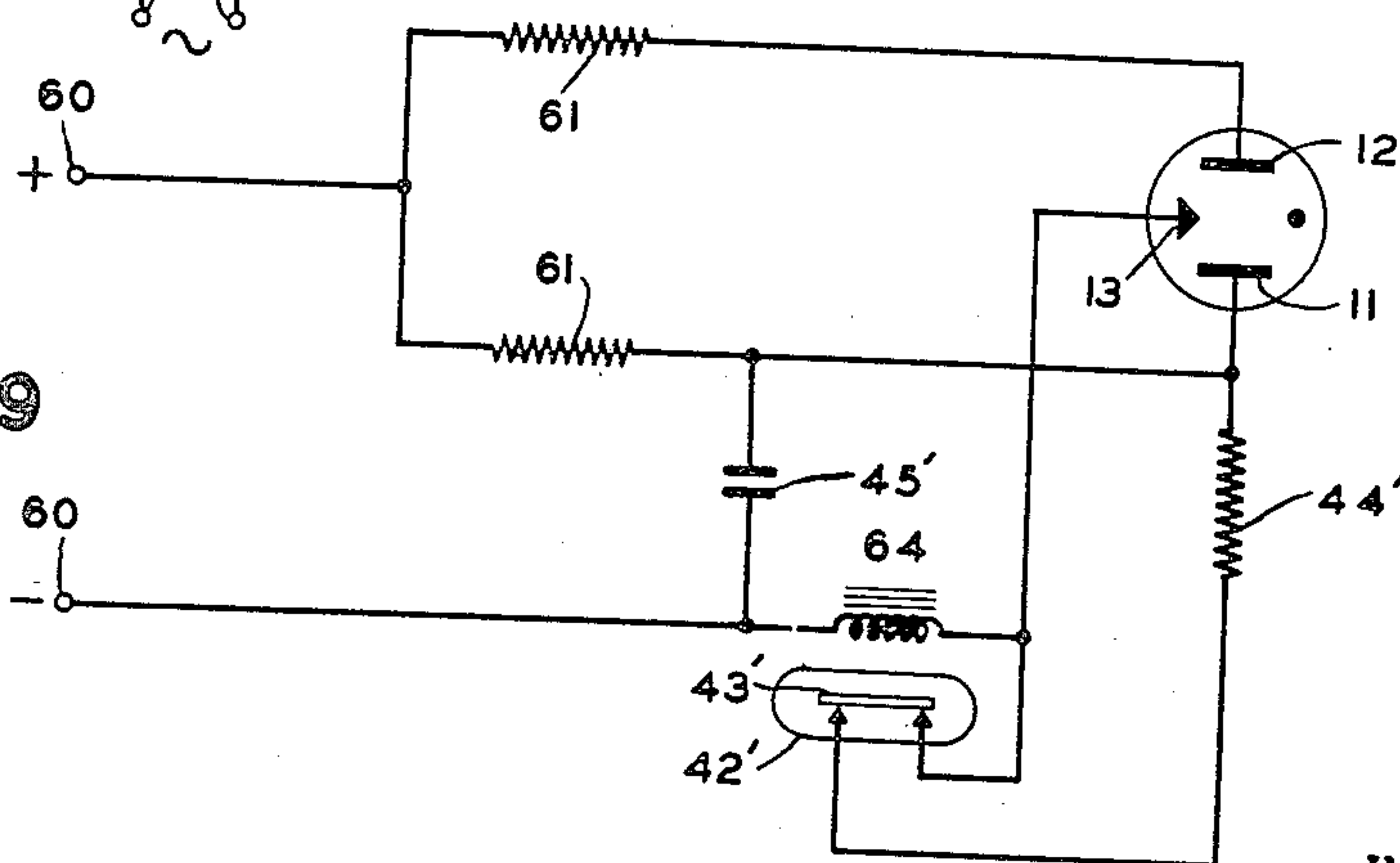


FIG. 9



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CONCENTRATED ARC DISCHARGE DEVICE

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7 Claims. (Cl. 240—46.01)

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This invention relates to a concentrated arc discharge device in which the cathode has a restricted active fused surface portion formed by an arc of high current density which is concentrated thereon when the device is in operation and which produces a highly concentrated light source of high intrinsic brilliancy, and more particularly to improved electrode structures in such a device. The arc discharge device is of the type disclosed in the Buckingham and Deibert application Serial No. 668,092, filed May 8, 1946, now Patent No. 2,453,118, issued November 9, 1948, the disclosure of which is incorporated herein by reference, and the instant invention represents certain improvements in such a device.

In practice, the cathode in a concentrated arc discharge lamp of the character described is formed from a rod or tube of suitable material, such as molybdenum, into which is packed a suitable cathode material, for example, zirconium oxide or hafnium oxide, and heretofore the anode generally has comprised a sheet of a suitable metal such as molybdenum, having either a central apertured portion or an outer edge portion on which the positive end of the arc terminates. This construction has proved adequate and satisfactory in these lamps in sizes from 2 to 100 watts, but in lamp sizes larger than 100 watts the anode or plate structure may become overheated and vaporized to some extent, thus impairing the efficiency and reducing the life of the lamp. The use of either water-cooled anodes or cooling fins to avoid overheating undesirably complicates the construction, manufacture and operation of the lamps and moreover appreciably increases their cost.

One of the objects of the invention is to provide an improved electrode structure in a device of the character described, in which the danger of overheating or vaporization of the anode structure is obviated.

Another object is an electrode structure which causes such an arc device to be especially well adapted for operation with an alternating current power supply.

A further object is an electrode structure in a concentrated arc discharge device which causes the device to operate equally well on either alternating or direct current power.

Still another object is an electrode structure which facilitates the assembly and support thereof within the envelope of the tube.

A further object is a cathode construction which provides a light image having a configuration that corresponds to that of the aperture of

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a stop or film gate in a projection system, thereby to increase the efficiency of the light source for projection purposes.

Additional objects and advantages will be apparent from the following detailed description of an illustrative embodiment of the invention, taken in connection with the accompanying drawings, in which:

Fig. 1 is a front view, in elevation, of a concentrated arc lamp constructed in accordance with the invention with a portion of the glass envelope broken away;

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

Fig. 3 is a cross-sectional view taken along the line 3—3 of Fig. 1;

Fig. 4 is an enlarged fragmentary view showing details of a preferred form of cathode employed when the lamp is to be used in a projection system;

Fig. 5 is a diagrammatic view showing the lamp employed in a film projection system;

Fig. 6 shows the outline of the light image relative to the film gate in the projection system of Fig. 5 when the cathode shown in Fig. 1 is employed;

Fig. 7 is a view similar to Fig. 6, showing the outline of a light image from a cathode having a circular cross-section;

Fig. 8 shows a suitable power supply circuit for the lamp when operating from alternating current; and

Fig. 9 shows a suitable power supply circuit when the lamp is operating from direct current.

Referring to Figs. 1 to 3 of the drawings, the embodiment of the lamp there illustrated comprises a sealed envelope 10 composed of a glass, quartz, or other suitable heat-resistant transparent material. If desired, and as illustrated, a bulb portion 10a may be blown in the glass tube in order to space the envelope from the arc stream a distance sufficient to prevent overheating and softening of the glass or other material of the envelope.

The envelope contains a pair of longitudinally extending solid rods 11 and 12 which operate as anodes, and a cathode pencil or tube 13 which extends transversely with respect to the anodes, the front end 14 of the cathode pencil 13 comprising an active cathode surface area positioned intermediate, and preferably midway between, the anodes 11 and 12, as seen in Figs. 1 and 3. The cathode pencil 13 is rigidly supported by a channel-shaped member 16, preferably of nickel, the rear end of electrode 13 passing through an

aperture in the member 16 and being clamped, and preferably spot-welded, to and between the sides of the channel member, as seen in Figs. 2 and 3. The anodes 11, 12 and cathode support 16 are held in fixed spaced relation with respect to each other by a pair of mica washers or spacers 18 which respectively are received within and engage the upper and lower tubular portions of the glass envelope. As shown in Fig. 3, instead of circular the washers may be hexagonal or other non-circular shape so as to insure firm contact with the tubular portions of the envelope and yet not offer too much resistance to the insertion of the electrode assembly into the envelope. The stem of the lamp terminates in and is firmly cemented to a base 19 of suitable insulating material such as a phenolic condensation product commonly employed in the art for this purpose, the contact prongs being firmly embedded in the base.

The anodes 11 and 12 may be identical in construction, and are secured to the mica washers 18 by means of short pieces 20 of wire, preferably nickel, the wires passing through small holes in the washers and being spot-welded to the electrodes 11 and 12 and also spot-welded to the lead-in conductors 26 and 27 which are hermetically sealed in the press 24 of the tube in known manner. As hereinafter set forth, the anodes preferably are composed of molybdenum, which is not readily susceptible of being spot-welded to the supporting wires 20; therefore, tightly fitting nickel caps or shells 23 are forced on the ends of the anodes, and the nickel wires spot-welded to the nickel caps. Similarly, the cathode supporting member 16 is secured to the mica washers by means of short pieces 21 of nickel wire which are spot-welded to the member 16 and also to the lead-in conductors 28 which pass through and are supported by the press of the lamp. To facilitate carrying the current, two lead-in conductors 28 are employed, which conductors are connected in parallel in the external circuit with which the lamp operates.

It will be seen that the entire electrode assembly in the lamp is firmly supported against lateral movement by means of the tight fitting mica washers 18, and is prevented from longitudinal movement by means of the lead-in conductors sealed in the press of the lamp, thereby providing a simple and rugged structure.

Fig. 4 is an enlarged fragmentary view of a cathode pencil 13 formed from a rod or wire of tantalum, molybdenum or like metal having high melting and volatilization point temperatures. In the end of rod 13 a hole has been drilled which extends inwardly a distance of approximately three-eighths of an inch, and this hole is filled with an electron emissive material that is inserted and treated in a manner hereinafter disclosed, so as to form the cathode. The filling material, when properly treated or activated, has the characteristic of being a good electron emissive substance at very high temperatures only; as disclosed in the aforesaid Buckingham et al. application an important characteristic of a substance which will give optimum results is that it is not a sufficiently good electron emitter at lower temperatures to cause electrons to be emitted in sufficient quantity to support an arc of high current density until the material, or at least the surface 14 thereof, has reached incandescent temperatures, well above the melting point of the base metal of which the substance is composed. Preferably, zirconium oxide or hafnium oxide is em-

ployed as the electrode material. Either of these oxides or a mixture thereof, in the form of oxide powder, is packed into the hole in the cathode pencil 13. After the hole has been filled to the top thereof with the oxide powder, the electrode assembly is inserted within the glass envelope of the lamp. The envelope and assembly are connected to a vacuum pump and heated in an oven to a temperature of approximately 900° F., the heating being effected while the envelope is evacuated to as high degree as practicable, for example, evacuated down to a fraction of a micron of mercury pressure. The envelope and assembly are removed from the oven, while maintaining the high vacuum thereon, and treated further to assure the degassing of the various parts, as by inserting the envelope and electrode assembly within a high frequency coil for heating and treating the same.

After the heating and degassing operations above referred to, the envelope is filled with a suitable gas or vapor which is inert with respect to the material of the electrodes, such as neon, argon, krypton, and the like. Argon is preferred because it operates exceedingly well in the tube when used as a source of an intense light, and also enables a lower starting voltage to be employed than do others of the inert gases. The gas pressure in the envelope preferably is of the order of one atmosphere or higher. The cathode is activated or formed by connecting one of the anodes 11 or 12 of the tube in circuit with a suitable source of direct current of adjustable potential; for example, so that potentials up to 1000 volts may be obtained. In one side of the forming circuit is connected a variable resistance so that the resistance of the circuit may progressively be reduced. Starting with a high value of resistance in the circuit the voltage is gradually increased until an arc discharge appears, the arc striking between the anode and the end 14 of the cathode. After a few seconds the cathode tube 13 becomes red hot and heats the oxide packed in it to a temperature where the oxide becomes electrically conducting. The arc then strikes between the anode and the oxide and raises the temperature of the surface 14 of the oxide to or above its melting point, so that the molten oxide on the surface flows and bonds itself to the sides of the metal tube 13, forming a smooth glassy surface on the end of the cathode material.

Under the intense ionic bombardment of the arc some of the oxide in molten state is reduced or decomposed to metallic zirconium or hafnium depending upon which oxide, zirconium or hafnium was packed in the cathode pencil, forming a very thin layer of such metal over the surface of the cathode. Either zirconium metal or hafnium metal is a better electron emitter at high temperatures than is its oxide, and it also has a lower melting temperature; thus as soon as the metallic zirconium or hafnium surface layer is formed, the temperature of the cathode drops slightly and the underlying oxide solidifies and supports the film of molten metal on its surface. It is this film of molten metal which appears to be the chief source of the visible radiation from the lamp. The film, once formed during manufacture, remains to be heated and to become incandescent whenever the lamp is relighted. The film is so thin that apparently surface tension holds it to the oxide backing so that the lamp may be burned in any position. The film 14 of Fig. 4 is supported by the semi-fused layer of oxide 28 immediately beneath, and this layer

merges into the white powder 29 of the original oxide. The oxide powder 29, and also to some extent the semi-fused layer 28, thermally insulates the active surface layer 14 to the extent that it reaches a temperature which is much higher than the melting point of the metal of which the oxide is composed.

The anode of a concentrated arc lamp serves to locate and fix the positive end of the arc stream and therefore must dissipate the heat released there without getting hot enough to vaporize or to produce any considerable radiation due to its own incandescence, even at the point where the arc stream strikes. If any part of the anode becomes hot enough to vaporize, the vapor so released will migrate to the cathode and in time spoil the lamp. The use of two anodes, each of which is operative only during one half cycle of the alternating current supplied thereto, divides the heating effect between the anodes. Moreover, since the active surface area 14 of the cathode is positioned intermediate, and preferably midway between, the ends of the anode rods 11 and 12, this causes the heat to flow away from the point of arc contact in two directions in each of the anodes, i. e., from the middle portion of the anode to both of its ends, and this greatly facilitates the removal and dissipation of heat. It will be seen from Figs. 1 to 3 that the active surface area of the cathode is quite close to the adjacent point on each anode rod where the positive end of the arc terminates, thereby to cause a concentrated arc of high current density to be maintained, and that the length of each anode rod is at least several times greater than the length of the arc stream. Since only a very short length of the anode rod is heated directly by the arc, this enables the remaining portions of the rod to efficiently conduct the heat away in opposite directions from the point where the arc stream impinges thereon. In lamps of the larger sizes, such as the 300 watt lamp illustrated in the drawings, the plate construction formerly employed became in many instances hot enough to vaporize, but with the anode construction disclosed herein this is obviated. Preferably, although not necessarily, each of the anodes has two portions 30, Figs. 1 and 3, cut away or formed so as to present a wedge-shaped surface to the end of the cathode. This facilitates striking of the arc to the active area 14 when current is supplied to the lamp, and the cut-away portions 30 at the front of the lamp give a wider angle of light output. Tungsten, tantalum, and molybdenum commonly are used for anodes because of their high melting and volatilization point temperatures. Of these, however, tantalum has relatively low thermal conductivity; tungsten makes excellent anodes but is difficult to work; and thus molybdenum is preferred for the anode structure.

In the molten state and under the intense ionic bombardment of the arc, some of the surface metal or metallic compound comprising the active cathode surface is vaporized during the operation of the lamp. Due to the electric field established in the vicinity of the cathode, the greater portion becomes ionized and positively charged and returns and condenses on the cathode surface 14, thereby renewing the active surface area. There is the possibility, however, that some of the vaporized metal ions will not return to the cathode surface and therefore, if desired, a wire 32, Fig. 2, preferably of nickel, may be employed to collect any metal ions which

otherwise would be deposited on the inner surface of the glass envelope or other parts of the lamp. As is well known, a negative potential when applied to such a conductor, for example, a potential of the order of 100 volts, will cause deposition of vaporized cathode material. A resistor is placed in series with the source of potential applied to the wire 32 in order to limit any current flowing to a very few milliamperes. The wire 32 depends from the upper mica washer 18, and may conveniently be looped back and through the upper washer, passing to and through the lower washer to a contact prong on the lamp base 19. A sleeve or tube 33 of glass or other suitable insulating material may be employed to surround and insulate that portion of the wire 32 which passes between the upper and lower mica washers.

Fig. 8 illustrates a suitable starting and running circuit for the concentrated arc lamp when it is operated from a source 35 of alternating current power supply. When the line switch 36 is closed the current is applied to a transformer, such as the autotransformer 36, and since the lamp has a negative-volt-ampere characteristic a suitable ballast resistor 37 is inserted in the supply circuit. The arrangement includes a choke coil having two sections 40 and 41, a magnetically operated vacuum switch 42 which is positioned in the magnetic field of the choke coil, a current limiting resistor 44 in series with the vacuum switch contacts, two condensers 45 connected between the choke coil and the two anodes 11 and 12 of the lamp, and a double-throw, three-pole switch 47. When the switch is thrown to its upper position the circuit is in the starting condition, and when the switch is in its lower position, as shown in the figure, the circuit is in the running condition.

Assume that the line switch 36 is closed and the switch 47 thrown upward to its starting position. The transformer then acts to step up the voltage induced across conductors 50 and 51, and conductors 50 and 52, during successive half-cycles of the alternating supply current; thus, with a 110-volt supply source the potential across each of the pairs of conductors may be of the order of 150 volts. Current now flows momentarily through a circuit comprising conductor 50, both windings 40 and 41 of the choke coil, closed contacts of the vacuum relay 42, resistor 44, lower blade of switch 47, and conductor 52 to transformer 36. The vacuum switch 42 is of the type in which the circuit is made and broken between solid contacts in a vacuum in response to a magnetic field, such a switch having been found to be unusually effective to provide the surge required in starting vapor arc lamps. Various kinds of such switches are well known; one suitable for the purpose is disclosed in the Ruth Patent No. 2,076,162, issued April 6, 1937. The choke, comprising coils 40 and 41, has an open air gap and hence a magnetic field which attracts the magnetizable bar or armature 43 of the switch 42, opening the circuit formerly through the switch contacts. This collapses the field in the choke coils and causes a potential of about 1000 volts to appear across the arc lamp, the condensers 45 readily permitting the voltage surge to pass to the anodes 11 and 12 of the lamp.

If the gap breaks down on the first voltage surge, current flows through the lamp limited by the resistance of the choke. If the arc does not strike on the first voltage surge, the armature 43 is released and again closes the circuit through

the relay contacts, and the choke and relay repeat the operation until ignition takes place. When ignition occurs, the switch 47 is manually moved downward to its running position whereupon coil 48 of the choke maintains a magnetic field which attracts the armature 43 and keeps the relay contacts open so long as the lamp is operating, the coil 41 being out of the circuit at this time. Coil 40 which carries the current during the operation of the lamp has fewer turns, and is constructed to heavier wire than coil 41 which carries the current only when the lamp is being started. During the running periods the transformer 35 acts as a step-down transformer, and the potential impressed across the conductors 50 and 54, and conductors 50 and 55, will usually be of the order of 35 volts.

Fig. 9 shows a suitable starting and running circuit for the lamp when it is operated from a source of direct current supply 60. Ballast resistors 61 are inserted in the positive side of the circuit to the anodes 11 and 12 respectively. A choke coil 64, connected to the cathode 13, controls the vacuum switch 42', the circuit through the switch including the current limiting resistor 44'. When starting the lamp, current through the choke coil 64 causes the switch 42' to open its contacts, and the inductive surge produced by the choke 64 due to operation of switch 42' is impressed across the arc lamp, the condenser 45' readily permitting the inductive surge to be impressed upon the anodes.

When the gap breaks down, current flows through the ballast 61 in parallel so that the arc stream is divided between the two anodes 11 and 12, the return path from the cathode including the choke 64 which attracts the armature 43' and maintains the switch 42' in open circuit position so long as the lamp is operating. Since the arc stream is divided between the anodes, only one-half of the current flowing passes through each anode and the heating effect on each anode is correspondingly decreased; moreover, the heat flows away from the point of arc contact in two directions in each of the anodes, as in the case of a lamp operated from alternating current.

As set forth in the aforesaid Buckingham et al. application, one of the general fields of application of the concentrated arc lamp is in projection systems. The problem in many such systems is to get the maximum amount of light from the source through a small opening or light gate, such as a film gate, and on through the projection lens onto the screen. Optically, the way to get maximum light through a small opening is to image the source at the opening, and since the concentrated arc lamp has a uniformly brilliant area of light, this image when placed at the opening or light gate results in a uniformly illuminated screen.

Fig. 5 shows the lamp employed in a film projection system diagrammatically indicated by a condenser 70, a plate 71 which contains the film gate or other light gate, and a projection lens 74. If a lamp is employed having a cathode which produces a disk of light, it will be seen from Fig. 7 that the circular light image 75 placed at the rectangular light gate 72 results in an appreciable wastage of the light, nearly 50% in most cases. By the use of an active surface area 14 which is rectangular in outline, as indicated in Fig. 1, and hence has the same configuration as the light gate 72, it will be seen from the rectangular light image 73 in Fig. 6 that a greatly

increased efficiency results therefrom. To effect this, that portion of the cathode pencil 13 adjacent the drilled end thereof, shown in Fig. 4, may be swaged or otherwise formed so that the interior of the hole and hence the configuration of the active surface area 14 will be rectangular thereby to correspond to that of a light gate in a projection system in which the lamp may be used.

In addition to its use as a concentrated light source, the device may also be employed for various circuit functions such as those of a relay, rectifier, voltage regulator, power tube, and the like, and various of the advantages of the electrode structure disclosed herein will likewise be obtained in such devices.

While there is shown and described herein a preferred embodiment of the invention, many other and varied forms and uses will present themselves to those versed in the art without departing from the invention, and the invention, therefore, is not limited either in structure or use except as indicated by the scope of the appended claims.

What is claimed is:

1. A concentrated arc discharge device comprising an envelope enclosing at least one anode and a cathode and a gas filling at a pressure higher than several centimeters, said cathode having a restricted active surface portion formed by an arc of high current density which is concentrated thereon when the device is operating, said active surface portion comprising a metallic substance which forms a molten incandescent pool of a metal of the class consisting of zirconium and hafnium when the device is in operation, said anode comprising a rod composed of a metal having high melting and volatilization point temperatures, said restricted active surface portion of the cathode and said anode rod being positioned sufficiently close to each other to maintain a concentrated arc stream between the adjacent portions of the electrodes when current is supplied thereto, the length of said anode rod being at least several times greater than the length of said arc stream, and means for preventing the anode from overheating due to termination of the positive end of the arc thereon which comprises structure for supporting the active surface portion of the cathode in a position to cause the positive end of the arc to terminate on the anode rod at a place intermediate the ends of the anode rod so that the heat produced in the rod flows outwardly from a central portion thereof toward both ends of the rod.

2. A concentrated arc discharge device comprising an envelope enclosing a pair of spaced anodes and a cathode and a gas filling at a pressure higher than several centimeters, said cathode having a restricted active surface portion formed by an arc of high current density which is concentrated thereon when the device is operating, said active surface portion comprising a metallic substance which forms a molten incandescent pool of a metal of the class consisting of zirconium and hafnium when the device is in operation, said anodes each comprising a rod composed of a metal having high melting and volatilization point temperatures, said restricted active surface portion of the cathode and each anode rod being positioned sufficiently close to each other to maintain a concentrated arc stream between the adjacent portions of the electrodes when current is supplied thereto, the length of each anode rod being at least several

times greater than the length of said arc stream, and means for preventing the anodes from overheating due to termination of the positive end of the arc thereon which comprises structure for supporting the active surface portion of the cathode at a place substantially equidistant from said anode rods and in a position to cause the positive end of the arc to terminate on the anode rods at places intermediate the ends of the anode rods so that the heating effect of the arc is divided between the anode rods and the heat in each of the rods flows outwardly from a central portion thereof toward both ends of the rod.

3. A concentrated arc discharge lamp comprising an envelope enclosing a pair of spaced anodes and a cathode and a gas filling at a pressure higher than several centimeters, said cathode having a restricted active surface portion formed by an arc of high current density which is concentrated thereon when the device is operating, said active surface portion comprising a metallic substance which forms a molten incandescent pool of a metal of the class consisting of zirconium and hafnium when the device is in operation, said anodes each comprising a rod composed of a metal having high melting and volatilization point temperatures, said restricted active surface portion of the cathode and each anode rod being positioned sufficiently close to each other to maintain a concentrated arc stream between the adjacent portions of the electrodes when current is supplied thereto, the length of each anode rod being at least several times greater than the length of said arc stream, and means for preventing the anodes from overheating due to termination of the positive end of the arc thereon which comprises structure for supporting the active surface portion of the cathode at a place substantially equidistant from said anode rods and in a position to cause the positive end of the arc to terminate on the anode rods at places intermediate the ends of the anode rods so that the heating effect of the arc is divided between the anode rods and the heat in each of the rods flows outwardly from a central portion thereof toward both ends of the rod, each of said rods having wedge-shaped body portion with opposed outwardly tapering sides of the wedge-shaped portions at the front of said lamp and adjacent to said active surface portion of the cathode to provide a wider angle of light output from the lamp.

4. A concentrated arc discharge device comprising an envelope enclosing a pair of spaced anodes and a cathode and a gas filling at a pressure higher than several centimeters, said cathode having a restricted active surface portion formed by an arc of high current density which is concentrated thereon when the device is operating, said active surface portion comprising a metallic substance which forms a molten incandescent pool of a metal of the class consisting of zirconium and hafnium when the device is in operation, said anodes each comprising a rod composed of a metal having high melting and volatilization point temperatures, said restricted active surface portion of the cathode and each anode rod being positioned sufficiently close to each other to maintain a concentrated arc stream between the adjacent portions of the electrodes when current is supplied thereto, the length of each anode rod being at least several times greater than the length of said arc stream, and means for preventing the anodes from overheating due to termination of the positive end of the arc

thereon which comprises structure for supporting the active surface portion of the cathode at a place substantially midway between said anode rods and in a position to cause the positive end of the arc to terminate on the anode rods at places substantially midway between the ends of the anode rods so that the heating effect of the arc is divided between the anode rods and the heat in each of the rod flows outwardly from a central portion thereof toward both ends of the rod.

5. A concentrated arc discharge device comprising an envelope enclosing a pair of spaced anodes and a cathode and a gas filling at a pressure higher than several centimeters, said cathode having a restricted active surface portion formed by an arc of high current density which is concentrated thereon when the device is operating, said anodes comprising substantially parallel rods composed of a metal having high melting and volatilization point temperatures, said restricted active surface portion of the cathode and each anode rod being positioned sufficiently close to each other to maintain a concentrated arc stream between the adjacent portions of the electrodes when current is supplied thereto, the length of each anode rod being at least several times greater than the length of said arc stream, said cathode comprising a metal rod extending transversely to said anode rods and having an opening in one end thereof and a core of cathode material embedded therein and forming said restricted active surface portion, said active surface portion comprising a metallic substance which forms a molten incandescent pool of a metal of the class consisting of zirconium and hafnium when the device is in operation, and means for preventing the anodes from overheating due to termination of the positive end of the arc thereon which comprises structure for supporting said active surface portion of the cathode rod at a place substantially midway between said anode rods and in a position to cause the positive end of the arc to terminate on the anode rods at places substantially midway between the ends of the anode rods so that the heating effect of the arc is divided between the anode rods and the heat in each of the rods flows outwardly from a central portion thereof toward both ends of the rod.

6. In combination, a concentrated arc discharge lamp and an associated light gate in optical alignment therewith, said light gate having a non-circular opening with the length thereof substantially greater than its width, said lamp comprising an envelope enclosing an anode and a cathode and a gas filling at a pressure higher than several centimeters, said cathode comprising a cathode body substantially composed of a material having good electrical and thermal conductivity and high melting and volatilization point temperatures, the cathode body having an opening substantially corresponding in configuration to that of the opening in said light gate, and a core embedded in said opening and extending substantially to the surface of the cathode body at said opening, said core having a fused active surface portion comprising a metallic substance having thermionic emission properties and which forms and maintains a molten incandescent film of a metal of the class consisting of zirconium and hafnium when the lamp is in operation, said incandescent film substantially corresponding in configuration to that of said opening in the cathode body whereby a light image is projected

which has an outline substantially corresponding to that of the opening in the light gate.

7. In combination, a concentrated arc discharge lamp and a rectangular light gate in optical alignment therewith, said lamp comprising an envelope enclosing an anode and a cathode and a gas filling at a pressure higher than several centimeters, said cathode comprising a cathode body substantially composed of a material having good electrical and thermal conductivity and high melting and volatilization point temperatures, the cathode body having a rectangular opening substantially corresponding in configuration to that of the opening in said light gate, and a core embedded in said opening and extending substantially to the surface of the cathode body at said opening, said core having a fused active surface portion comprising a metallic substance having thermionic emission properties and which forms and maintains a molten incandescent film of a metal of the class consisting of zirconium and hafnium when the lamp is in operation, said incandescent film substantially corresponding in configuration to that of the rectangular opening in said cathode body

whereby a light image is projected which has an outline substantially corresponding to that of the opening in the light gate.

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