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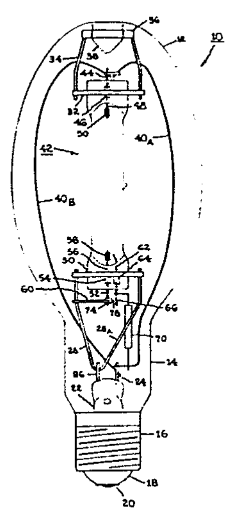
(54) Improved metal halide lamp and lighting systems particularly suitable for architectural lighting.

(57) A metal halide lamp having a relatively high anticipated life and particularly suitable for architectural lighting is disclosed. The metal halide lamp has a double-ended arc tube serving as its light source. The arc tube has a halogen gas formed from vaporized metal halides along with a mercury vapor. The amount of mercury contained in the arc tube is selected to effectively establish an A.C. operating voltage in the range of about 100 volts to about 150 volts. The metal halide develops a vapor during the operation of the arc tube. The halide is selected from the group of metals consisting of sodium, scandium, thorium, and mixtures thereof. The halide is further selectable as a compound cadmium iodide. Further disclosed are various embodiments of illuminating lighting systems that provide beam patterns particularly suitable for illuminating a limestone building.



IMPROVED METAL HALIDE LAMP AND LIGHTING SYSTEMS PARTICULARLY SUITABLE FOR ARCHITECTURAL LIGHTING

CROSS REFERENCE TO RELATED APPLICATION

This invention is related to U.S. Patent Application Serial No. _______ having attorney Docket No. LD 9150, entitled "Improved Metal Halide Lamp and Lighting Systems Particularly Suitable for Architectural Lighting," filed concurrently herewith and assigned to the same assignee as the present invention.

BACKGROUND OF THE INVENTION

This invention relates to metal halide lamps, and more particularly, to metal halide lamps and lighting systems suitable for architectural lighting.

Metal halide lamps currently available can be broadly divided into two classes. One class of lamps has a quartz envelope housing a very compact electrode-stabilized arc used as its light source. The quartz envelope is generally spheroidal with a wall loading characteristic in the range of 50 to 100 watts/sq. cm of arc tube surface which typically yields a useful life of a few hundred hours. The other class of lamps is referred to as general purpose metal halide lamps having a cylindrical quartz envelope housing a wall stabilized arc. A typical wall loading characteristic for these lamps is in the range 5 to 15 watts/sq. cm of arc tube surface which yields a very long useful life typically 15,000 hours.

The lamps having a compact light source are used frequently in stage and studio applications. The compact light sources are desirable when used in cooperation with reflectors because the compact light sources afford a great deal of freedom to lighting designers in the selection of desired beam patterns. That is, a lamp may be provided having a beam pattern which is very narrow, such as preferably used in a spot light, or if desired, a lamp can be provided having a diffused beam pattern which is accomplished by locating the compact light source off-center from the focal point of the reflector of the lamp or by using appropriate diffusing lenses.

The compact light source when used with a spherical or parabolic reflector usually provides a symmetrical beam pattern which can have certain limitations. For architectural lighting it is considered important that asymmetrical beam patterns be provided which permit overlapping of the beam illuminating patterns so that, for example, particular features of a building may be highlighted. The overlapping is further advantageous in that a failure of one of the plurality of illuminating lamps does not cause a complete loss of the illumination of the building related to the failed lamp.

Metal halide lamps while having desired illuminating characteristics also have certain disadvantages which have heretofore hindered their usage for architectural lighting. The metal halide technology used in the development of compact light sources necessitates that the chemistry of the lamp be such that the compact light source, as previously mentioned, has relatively high wall loading characteristics, which ordinarily result in short life, typically 50 hrs. to 500 hrs.

The relatively short life of these compact light sources is not disadvantageous for stage and studio applications. However, the typical 50 to 500 hours life is disadvantageous for architectural lighting where it is desired that metal halide lamps be provided having a life expectancy of at least approximately 2000 hours and somewhat greater than approximately 4000 hours.

In other applications such as for general lighting, metal halide lamps are relatively larger in size; this provides a more diffused pattern when used in cooperation with a selected reflector. Ordinarily when a high intensity discharge lamp, such as a metal halide lamp, is employed in general lighting applications, the arc tube serving as the light source is placed within an outer envelope in order that it can be surrounded by an inert gas atmosphere to control the temperature and to remove oxygen from the environment. Further, ordinarily in general lighting, lamps utilizing a relatively large envelope provide their desired function, but the large outer envelope presents several disadvantages. For example, the large outer envelope may distort the beam pattern and can, on many occasions, prevent the light source from being advantageously placed relatively close to the reflector surface and thereby hinder the attainment of a desired beam pattern. The lack of beam control normally encountered with general lighting devices having large outer envelopes and providing diffused light patterns hinder their usage in architectural lighting.

In addition to the above-described drawbacks of general purpose metal halide lamps, when lamps with a relatively large light center length are used for architectural lighting, any small misalignment in the base of the lamp produces a relatively large displacement of the light source relative to the focal point of the reflector which commonly causes the desired beam pattern to be unfavorably altered. This unwanted displacement typically necessitates realignment of the light source in the fixture and can in some cases necessitate realignment of the fixture itself. It is therefore considered important to provide lamps which have accurate mounting and which lamps can be easily mounted in such a way that deviations from a desired position of the light source within the reflector do not occur even during lamp replacement procedures. Additionally, since the light fixtures and sources are initially carefully aligned, it is desirable that readjustment and realignment be unnecessary each time light sources are replaced.

A further factor which should be considered with regard to architectural lighting is the overall size of the light source and the overall size of the outer envelope. Attempts to reduce the overall size of the outer envelope encounter a problem related to an increase in the electromagnetic field to which the arc discharge is subjected from the current return lead located in proximity to the arc tube. The increased electromagnetic field creates a condition in which the arc is forced close to the walls of the arc tube leading to excessive temperatures. The walls of subjected arc tube begin to bulge outward and thus shorten the life of the arc tube. It is desired that means be provided which allow compacting the size of the outer envelope without encountering the typically expected shortening of the life of the arc tube.

With regard to the size of the light sources, if the light sources are relatively large necessitating a relatively large fixture, the light sources along with the fixtures need to be placed a relatively long distance away from the building exterior desired to be illuminated in order not to interfere with the aesthetics of the architecture. The remote location may cause the illuminated features of the building often to appear as washed out due to inadequate illumination, and further, much of the illuminating light spills out of desired beam patterns so as to be wasted light which does not illuminate the exterior of the building.

Accordingly, objects of the present invention are to provide a metal halide lamp not having the previous mentioned limitations but which are particularly suited for architectural lighting having, (1) particular applicability to building exteriors, (2) an asymmetrical beam pattern so as to provide overlapping and highlighting of the features of the building being illuminated, (3) accurate mounting of the metal halide lamps in their related fixtures so as to provide a desired uniformity of beam patterns and also to provide for reproducibility of the beam patterns upon subsequent replacement of the metal halide lamps, (4) a relatively compact outer envelope having means to substantially reduce the typically expected shortening of the life of the arc tube housed in such an envelope, and (5) a relatively high anticipated life of approximately 2000 to approximately 4000 hours and even greater.

These and other objects of the present invention become more apparent upon consideration of the following description of the invention.

SUMMARY OF THE INVENTION

In accordance with the present invention a metal halide lamp particularly suitable for architectural lighting is provided. The metal halide lamp comprises an arc tube rigidly supported in an outer envelope having at least a pair of electrically conductive leads located on opposite sides of the arc tube and connected to a primary electrode of the arc tube. The arc tube comprises an inert gas, and a mercury vapor in the range of about 170 mg to about 180 mg effective to establish an A.C.

operating voltage for the arc tube in the range from about 250 volts to about 300 volts. The arc tube further comprises a halide which develops a vapor during operation. The halide is selected from the group consisting of (1) sodium iodide, scandium iodide, thorium iodide, cadmium iodide, and mixtures thereof, (2) sodium iodide, scandium iodide, thorium iodide, cadmium iodide, mixtures of the selected halide iodide, and the metal cadmium additive to the selected halide iodide and to the mixture of the selected halide iodides, and (3) the metal cadmium.

The present invention may best be understood by reference to the drawing and the detailed description of the preferred embodiments shown therein.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows a metal halide lamp in accordance with one embodiment of the present invention.

FIG. 2 shows the arc tube of the present invention.

FIG. 3 illustrates the functional arrangement of the metal halide lamp of FIG. 1 relative to a reflector so as to provide a desired oblong beam pattern related to the present invention.

FIG. 4 illustrates the oblong beam pattern projected on a typical building.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates one embodiment of the present invention of a metal halide lamp 10 particularly suitable for architectural lighting. The lamp 10 comprises a glass outer envelope or jacket 12 of an ellipsoidal shape with a relatively narrow diameter typically of 12 cm and having a neck 14 to the end of which is attached a screw base 16. The neck 14 is closed by a reentrant stem 22 having a press portion through which extends relatively stiff inleads 24 and 26. The inleads 24 and 26 are connected externally to the contact surface of the base, namely the insulated center contact or eyelet 18 and the base shell 20.

The lamp 10 further comprises an inner arc tube 42 which is provided at opposite ends with a pair of main discharge supporting electrodes 50 and 58. The main electrode 50 is connected to one inlead by means of an inlead 48, a foil portion 46, an external lead 44, and a pair of fly-leads 40_A and 40_B. These fly-leads 40_A and 40_B are of primary importance to the present invention as to be described.

The main discharge electrode 58 is connected to the other inlead 26 by means of an inlead 56, a foiled portion 54, an external lead 52, an electrically conductive member 60, and a side rod 28. The foiled portions 46 and 54 are comprised of molybdenum and have a desired coefficient of expansion to provide respectively for proper sealing of the opposite ends of arc tube 42.

The side rod 28 is welded to the inlead 26 and has a loop portion 28 which provides, by means of support and strap member 30, support for one end of the arc tube 42. The other end of arc tube 42 is supported within the outer envelope 12 by a cross member 32 which is attached at each end to a U-shaped support member 34 anchored to a dimple 38 at the dome of the envelope 12 by engagement of a loop clip 36.

The arc tube 42 further comprises an auxiliary electrode 62 which is connected to the relatively thick inlead 24 by means of a foil member 64 similar to foil members 46 and 54 of arc tube 42, an inlead 66 of arc tube 42 and a series resistor 70. In operation the auxiliary electrode 62 is connected to a main electrode 58 by means of a thermal switch 78 which is connected to a conductor member 60, which, in turn, is connected to the previously described side rod 28 having a connection to the relatively thick inlead 26. The thermal switch 78 short-circuits the starting electrode 62 to the main electrode 58 after the arc tube 42 has warmed up and achieved its starting. Such a thermal switch is described in U.S. patent 3,965,387 which is assigned to the same assignee as the present invention and is herein incorporated by a reference.

The arc tube 42 shown in detail in FIG. 2 is of the double-ended type and has typically dimensions of a length of 120 mm, a width of 20 mm, and a thickness of 2 mm and is designed to operate at 1500 watts. The arc tube 42 is comprised of a material selected from the group consisting of fused silica, mullite and alumina.

The arc tube 42 contains a filling comprising metals and halide along with a mercury vapor. The halide and the mercury vapor droplet have respective weight ratios of about 1:7 to about 1:3. The halide develops a vapor during the operation of the arc tube. The halide is selected from the group consisting of sodium iodide, scandium iodide, thorium iodide, cadmium iodide and halide mixtures of the selected halide iodide. Still further, for one embodiment to be described, the halide is preferably selected as a compound sodium iodide including cadmium.

As discussed in the "Background" section above, attempts to reduce the overall size of the outer envelope housing an arc tube such as arc tube 42 have encountered an increase in the electromagnetic field to which the arc tube is subjected causing a decrease in the life of the arc tube itself. It is of primary importance that the present invention provides means to substantially reduce the unwanted effects of the increased electromagnetic field while still housing the arc tube 42 in a relatively compact outer envelope 12.

Initially in our housing of the arc tube 42 into the relatively compact envelope 20 it was discovered that the walls of the operating arc tube 42 developed an outward bulge detrimental to the life of the arc tube 42. The initial housing for the arc tube 42 had a single fly-lead such as 40_A shown in FIG. 1. It was discovered that the increased electromagnetic field from the current in the single fly-lead were causing the arc within the arc tube to undesirably be dislocated from the axial central region of the arc tube toward the walls of the arc tube. This dislocation was causing the detrimental bulging of the arc tube 42. In order to substantially prevent this dislocation it was determined that effects of the increased electromagnetic fields needed to be reduced. Such a reduction is accomplished by the practice of the present invention.

The lamp 10 of FIG. 1 by means of at least a pair of fly-leads 40_A and 40_B, positioned on opposite sides of the arc tube 42, provide a pair of current return leads for one of the primary electrodes effective to reduce the electromagnetic field to which the arc tube 42 is subjected. The effect of a pair of looped wires 40_A and 40_B is to cause the arc of the arc tube 42 to be substantially maintained in its desired axial central region of the arc tube effective to substantially inhibit any reduction in the life of the arc tube with regard to the increased electromagnetic field.

As further discussed in the "Background" section above, it is desired to have a compact light source, such as arc tube 42, for architectural lighting that provides a warm incandescent light color temperature. As further discussed, the obtainment of an incandescent-like color for arc tube containing a metal halide, such as arc tube 42 usually creates undesired high wall temperatures of the arc tube, which, in turn, decreases the operating life of the arc tube and the metal halide lamp itself.

In the practice of the present invention the arc tube 20 provides an incandescent-like color achievable without elevating the wall temperatures of the arc tube that would result in the usually expected decreased life of the arc tube 42. This is primarily achieved by the particularly advantageous group of metal halides given above, including the compound sodium iodide, in combination with the use of cadmium which additionally lowers the color temperature nearer to incandescent. It is preferred that the metal halide and cadmium have respective percentage weight ratios of about 40 and about 1. The combination of these features not only achieves the desired color, but also increases the efficacy of the light source with only a relatively small reduction in the useful life.

Another factor of the present invention related to useful life of the metal halide lamp 10 is the A.C. operating voltage of the arc tube 42. This operating voltage is primarily determined by the amount of mercury contained in the arc tube 42. The amount of mercury vapor contained in the arc tube 42 is selected to effectively establish an A.C. operating voltage for the arc tube 42 in the range of about 250 volts to about 300 volts. For the dimensions previously given for arc tube 42 and for this range of about 250 volts to about 300 volts, the selected amount of the mercury vapor is in the range of about 170 mg to about 180 mg.

The arc tube 42 having the A.C. operating voltage range, the mercury vapor, the halide gas and the dimensions all noted above, although having a relatively high wall loading characteristic such as 20 watts per cm^2, yields an anticipated life of approximately at least 2000 hours and somewhat greater than approximately 4000 hours which is particularly advantageous for architectural lighting related to the present invention. This 2000 to 4000 hour anticipated life is intermediate between stage and studio lamps, having an anticipated life of about 50 to 500 hours, and the general purpose metal halide lamps having an anticipated life in the order of 15,000 hours.

The metal halide lamp 10 of FIG. 1 is of a relatively high wattage in the order of 1500 watts which is particularly advantageous for architectural lighting desiring an intense illuminating light source so that the exterior features of the building may be highlighted. The high wattage lamps allow for a lower number of fixtures to illuminate the building.

The operating arc tube 42 yields a warm incandescent-like color which is particularly suitable for illumination of the outside of buildings and various architectural construction. For example, the metal halide lamp 10 of FIG. 1 having the arc tube 42 is particularly suitable for certain types of limestone exteriors found on buildings. The operating halide lamp 10 has a correlated color temperature of about 3400°K to about 3900°K which substantially approaches that of an incandescent lamp.

A further feature of the present invention is the accurate and fixed positioning of the light source 42 in the metal halide lamp 10 so as to obtain uniformity in the beam pattern transmitted by one or more lamps 10. The present invention accomplishes uniformity by, (1) a double-ended light source 42 so that each of its ends is correctly positioned and aligned relative to a reflector cooperating with lamp 10 to achieve desired illumination, and (2) a light source 42 having a relatively small light center length.

The double-ended light source 42 is shown in FIGS. 1 as rigidly clamped and is positioned relative to the focal point of lamp 10 by an accuracy in the range of about 3 mm. This accurate positioning of light source 42 in turn provides an accurate and predetermined placement of the metal halide lamp 10 relative to the desired location of a reflector for which the metal halide lamp 10 is advantageously employed.

The lamp 10 has a light center length which is meant to represent the distance between the center of the arc and the bottom base contact of the lamp 10 which is about 160 mm. This relatively small light center light provides a compact light source 42 that may be accurately positioned within the lamp 10. The midsection of the arc tube 42 may be predeterminedly located within a range of about 1 to about 20 mm, relative to the focal point of the reflector for which it is utilized so as to develop an asymmetrical beam pattern particularly suitable for architectural lighting. This arrangement develops an oblong light source which results in an asymmetrial beam pattern. The asymmetrical beam pattern allows for overlapping of the light transmitted by a plurality of metal halide lamps 10 so that desired features of the exterior of the building being illuminated may be highlighted and also preventing a complete loss of a portion of the building being illuminated from occurring upon a failure of any one particular metal halide lamp 10.

The metal halide lamp 10 substantially reduces the misalignment problems of the light source location relative to the focal point of the reflector which would otherwise cause the desired beam pattern emitted by the cooperation between the lamp and reflector to be undesirably altered. Further, the metal halide lamp 10 by its accurate and rigidly fixed light source 42 provides for repeatable and accurate mounting from fixture to fixture thus eliminating any misalignment problems between the metal halide lamp 10 and its cooperating reflector that may otherwise occur during lamp replacement procedures.

It should now be readily understood that the present invention provides architectural lighting designers with a metal halide lamp 10 used with a reflector unit which can be accurately positioned at the time of the original installation. Further, if a metal halide lamp burns out and maintenance is necessary, the replacement light source used with the reflector is accurately positioned relative to the reflector unit.

Another important feature of the present invention is the outer envelope 12 of the halide lamp 10 which reduces interference with the beam pattern. This is accomplished by an outer envelope 12 having a relatively narrow diameter such as an E37 hard glass bulb.

The metal halide lamp 10 is functionally illustrated in FIG. 3 for an illuminating lighting fixture 84 having a reflector device 74. The reflector may have an aperture of 60 cm and a radius of curvature of 20 mm. The metal halide lamp 10 is preferably positioned so that the midsection of the arc tube 42 is located at the focal point 76 of reflector 74. The ballast circuitry for operating the metal halide lamp 10 is lodged in a housing 80 and the necessary power and control functions related to the ballast circuit are routed to the metal halide lamp by cabling 78.

The metal halide lamp 10 in cooperation with reflector 74 transmits a plurality of rays 86_A, 86_B, 86_C and 86_N that combine into an oblong beam pattern 86 shown in FIG. 3 which is particularly suited for architectural lighting. More specifically, the oblong beam pattern 86 does not have the limitation of a narrow beam pattern or a diffused beam pattern both as discussed in the "Background" section. More particularly, the oblong beam pattern 86 is particularly suited for illuminating the exterior of a limestone building as illustrated in FIG. 4.

FIG. 4 illustrates a portion 88 of an exterior of a building having limestone bricks 90. The beam pattern 86 developed by the 1500 watt metal halide lamp 10 provides for up to 60 footcandles depending on the number of fixtures and distance of the fixtures away from the building being illuminated. The high wattage of lamp 10 allows for locating the lamp 10 and their related fixtures away from the illuminated building which, in turn, allows the metal halide lamps 10 to be hidden in structures away from the building themselves and at places where the maintenance of metal halide lamps 10 along with the reflectors 74 may be easily achieved. Further, a plurality of metal halide lamps 10, each having a respective reflector 74, can be arranged to form a lighting system so as to produce overlapping beam patterns shown in FIG. 4 as phantom lines 92 and 94. The overlapping is accomplished by suitable alignment of the various fixtures 84. The overlapping of the beam patterns provides for desired illumination of the building even in the event of a lamp 10 failure.

In accordance with the present invention the metal halide lamps 10 were tested in experimental fixtures and provided desired beam control with a Correlated Color Temperature of 3600°K.

It should now be appreciated that the practice of the present invention provides a metal halide lamp 10 particularly suitable for architectural lighting and having: (1) particular applicability to the exteriors of buildings; (2) when used in cooperation with a reflector unit, in accordance with the hereinbefore given description, provides an asymmetrical beam pattern so that overlapping and highlighting of the building being illuminated are achieved; (3) accurate mounting for related reflector units so as to provide a desired beam pattern and also provide for reproducibility of the beam pattern upon subsequent replacement of the metal halide lamp 10; (4) a relatively compact outer envelope having means to reduce the effects of the electromagnetic field to which the arc tube is subjected so as to substantially inhibit the typically encountered shortening of the life of the arc tube itself for such an envelope; and (5) a relatively high anticipated life of at least approximately 2000 hours and slightly greater than 4000 hours.

CLAIMS

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

1. A metal halide lamp particularly suitable for architectural lighting comprising a light-transmissive outer envelope, an arc tube rigidly supported within the outer envelope and having primary thermionic electrodes sealed in the opposite ends thereof and an auxiliary electrode located adjacent to one of said primary electrodes;

said rigidly supported arc tube having at least a pair of electrically conductive leads located on opposite sides of said arc tube and connected to one of said primary electrodes;

said arc tube further comprising;

an inert gas;

a mercury vapor in the range of about 170 mg to about 180 mg effective to establish an A.C. operating voltage for said arc tube in the range from about 250 volts to about 300 volts; and,

a halide which develops a vapor during operation said halide being selectable from the group consisting of (1) sodium iodide, scandium iodide, thorium iodide, cadmium iodide and mixtures thereof, (2) sodium iodide, scandium iodide, thorium iodide, cadmium iodide, mixtures of the selected halide iodide, and the metal cadmium additive to the selected halide iodide and to the mixture of the selected iodides, and (3) the metal cadmium.

2. A metal halide lamp according to claim 1 wherein the metal halide is preferably sodium iodide and cadmium having respective percentage weight ratios of about 40 and about 1.

3. A metal halide lamp according to claim 1 wherein said arc tube is a double-ended type and has a length of about 120 mm, a width of about 20 mm and a thickness of about 2 mm.

4. A metal halide lamp according to claim 1 wherein the metal halide and the mercury vapor have a respective weight ratio of about 1:7 to about 1:3.

5. A metal halide lamp according to claim 1 having an anticipated life of at least 2000 hours and somewhat greater than 4000 hours.

6. An illuminating light fixture comprising a metal halide lamp according to claim 1 and a reflector;

said metal halide lamp being located relative to said reflector effective to position the midsection of said arc tube substantially at the focal point of said reflector fixture.

7. An illuminating lighting system comprising a plurality of metal halide lamps according to claim 1 and a reflector for each of said lamps;

each of said lamps being located relative to its respective reflector effective to position the midsection of each arc tube substantially at the focal point of said respective reflector.

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Fig. 1

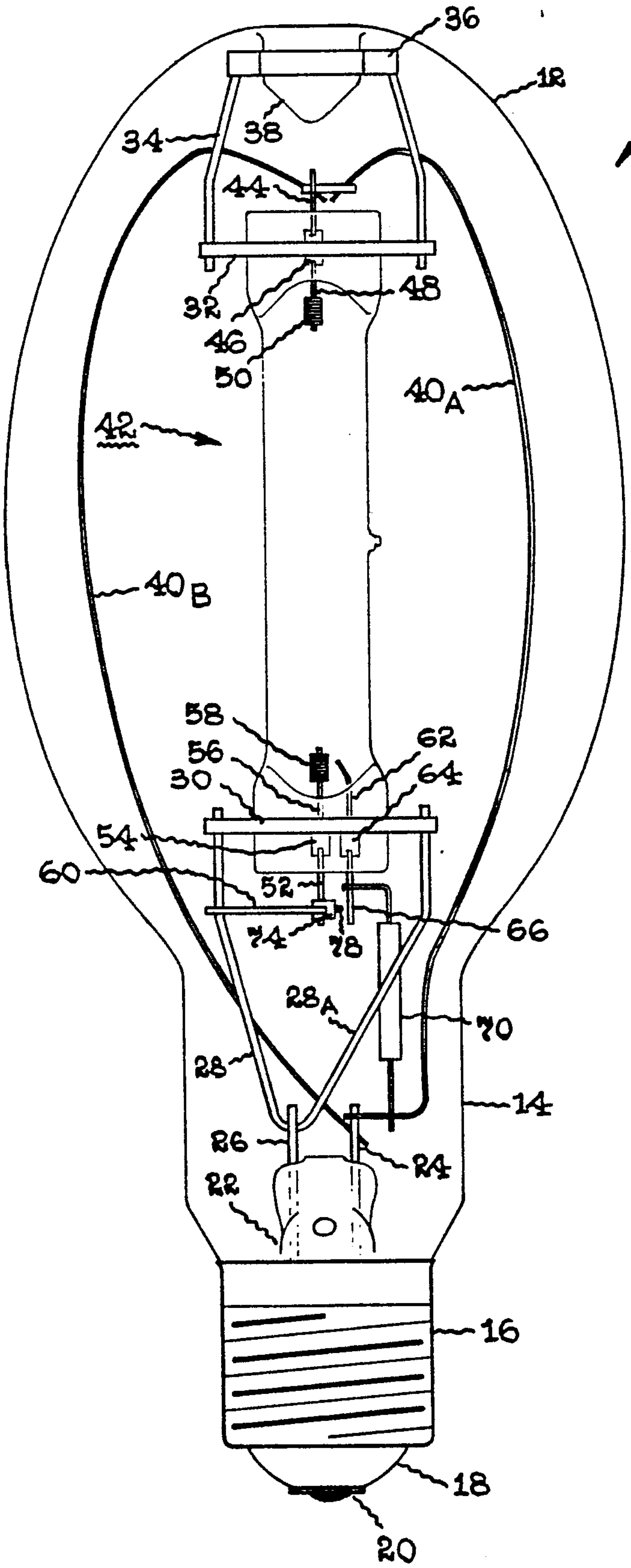

Fig. 2

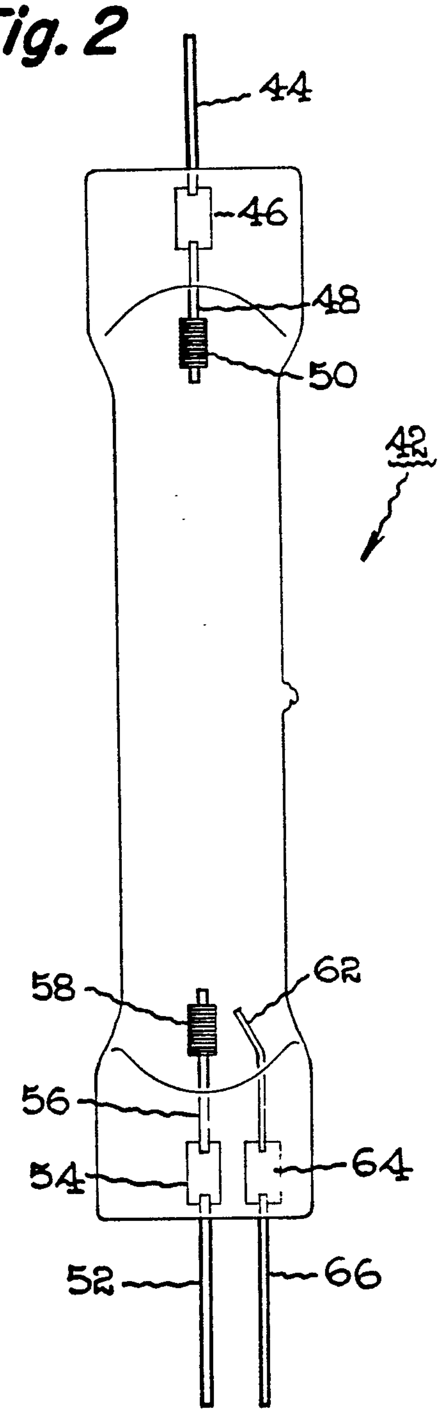

Fig.3

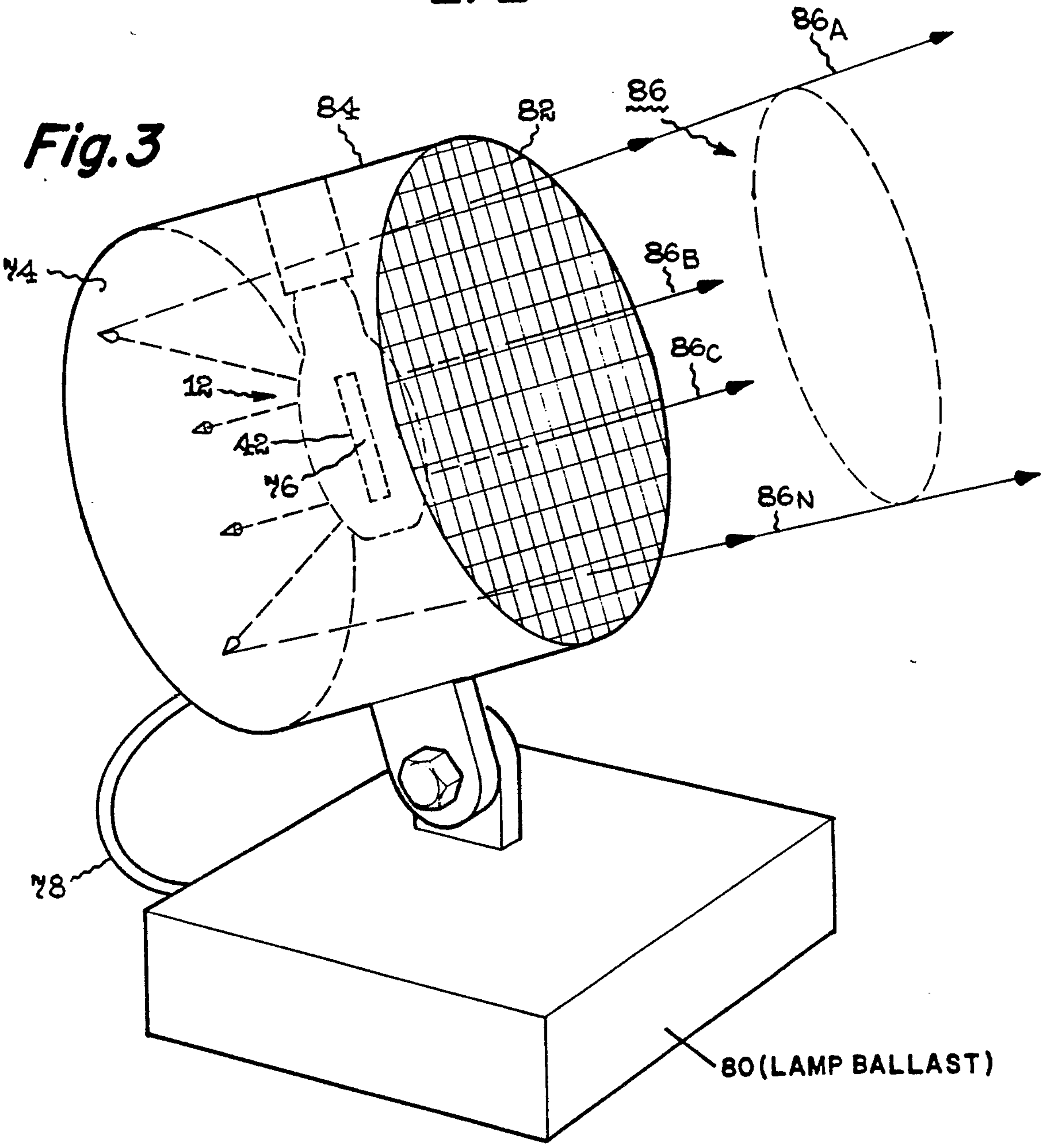

Fig.4