

May 5, 1959

A. W. WAINIO ET AL

2,885,587

LOW PRESSURE DISCHARGE LAMP AND METHOD

Filed June 13, 1956

Fig. 1.

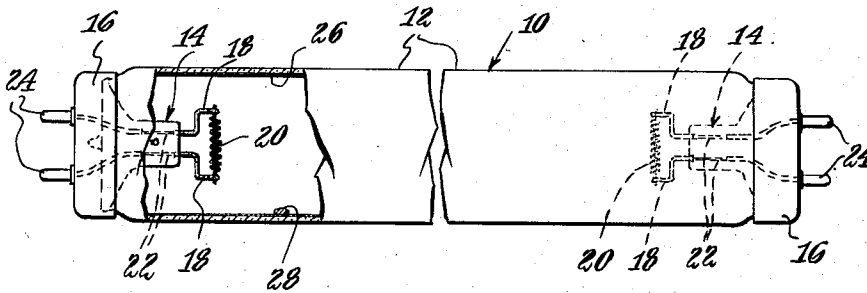


Fig. 2.

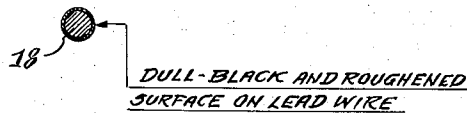


Fig. 3.

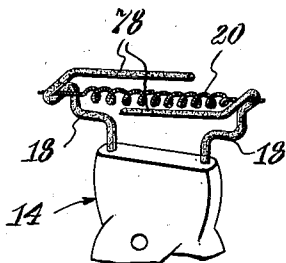
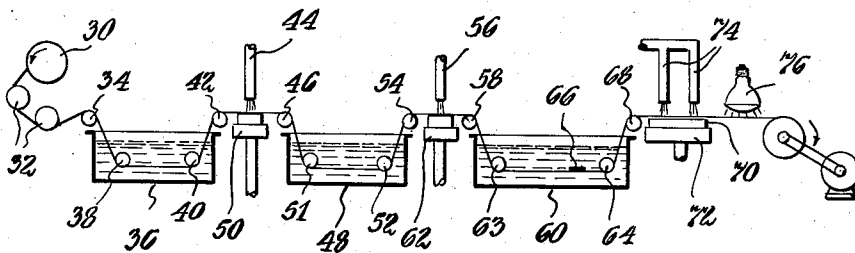


Fig. 4.

INVENTORS
ALBERT W. WAINIO and
FREDERIC E. SUTTER.
BY *John J. Kelly*
ATTORNEY.

1

2,885,587

LOW PRESSURE DISCHARGE LAMP AND METHOD

Albert W. Wainio, Pompton Plains, and Frederic E. Sutter, West Caldwell, N.J., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application June 13, 1956, Serial No. 591,206

5 Claims. (Cl. 313—107)

This invention relates to discharge devices and, more particularly, to low-pressure, positive-column discharge devices, particularly of the fluorescent type, lead conductors therefor and to a method for improving same.

Low pressure, positive-column discharge devices, and especially fluorescent lamps, display a marked tendency to form spots and other blackening at the ends of the envelope adjacent the lamp electrodes. Analysis of the spots reveals that they are composed primarily of barium, which collects the mercury and blackens. This barium presumably emanates from the emission mixture which is carried by the electrodes, since this is often the only source of barium which is present in the fabricated lamp. Such spots and end blackening usually manifest themselves after the lamp has been operating for some time and then become increasingly pronounced during the remainder of the life of the lamp. These end discolorations are objectionable from the appearance aspects as well as cutting down somewhat on the emitted light.

It is the general object of this invention to avoid and overcome the foregoing and other difficulties of and objections to prior art practices by the provision of lead conductors which will inhibit the tendency for fluorescent and other low-pressure, positive-column, mercury-discharge lamps to form end spots and blackening during operation of the lamp.

It is a further object to provide a method for inhibiting the formation of end spots and blackening in low-pressure, positive-column, mercury-discharge lamps.

It is another object to provide specific coating materials for coating the leads of low-pressure positive-column mercury-discharge lamps which will inhibit the formation of end spots and blackening.

The aforesaid objects of the invention, and other objects which will become apparent as the description proceeds, are achieved by providing at least a portion of the lamp lead conductors with a coating having a dull-dark color and a roughened surface, which will give these coated lead conductor portions a relatively high thermal emissivity.

For a better understanding of the invention, reference should be had to the accompanying drawing wherein:

Fig. 1 represents a fluorescent lamp provided with lead conductors which have a high thermal emissivity in accordance with this invention;

Fig. 2 is a cross-sectional view of a lead conductor which has been provided with a thermally-emissive coating;

Fig. 3 is a side view of plating equipment for applying the preferred thermally-emissive coating to the lead-conductor wire;

Fig. 4 is a perspective view of an alternative lead conductor arrangement.

The invention is usually employed in conjunction with fluorescent lamps, that is, low pressure, positive-column, mercury-discharge lamps which carry a coating of phosphor material on the interior surface of the lamp envelope and hence it has been so illustrated and will be

2

so described. It should be understood, however, that the invention is equally applicable to low-pressure, positive-column, mercury-discharge lamps which do not carry a fluorescent coating on the interior surface of the envelope, but are intended to be used as ultra-violet sources, for example.

With specific reference to the form of the invention illustrated in the drawing, the numeral 10 indicates generally a fluorescent lamp comprising a tubular envelope 12 having mounts 14 sealed into either end thereof, the envelope terminating in base caps 16 to facilitate lamp support and electrical connection, as is customary. Each mount 14 carries lead conductors 18 extending into the envelope. Coiled tungsten or other suitable refractory metal electrodes 20 carrying an electron-emitting alkaline-earth oxide are supported at the ends of the envelope 12 and are carried between the inwardly extending extremities of the lead conductors 18. As a specific example, the alkaline-earth oxide may consist of 60% BaO, 30% CaO, and 10% SrO by weight. The electron-emitting coating, however, may consist solely of barium oxide or of mixtures of barium oxide and strontium oxide or barium oxide and calcium oxide. Such emission material mixtures are well known in the art and in the usual lamp, the primary constituent of the mixture will be barium oxide.

The lead conductors 18 which extend into the lamp envelope to support the coils 20 are electrically connected by welding or otherwise fastening to glass-sealing conductors 22 which are sealed through the ends of the envelope and which are generally fabricated of Dumet wire. As is well known, Dumet wire consists of a copper sheath on a nickel or iron core and such wire is particularly designed for sealing hermetically through glass. This Dumet wire is electrically connected by copper leads, for example, to the base pins 24, as is customary. In the case of a fluorescent lamp, the envelope carries on its interior surface a phosphor material 26 such as zinc silicate activated by manganese, for example, in order to convert the ultraviolet radiations emanated by the positive-column discharge of the lamp into visible radiations. Such phosphor materials are well known and a multitude of these materials have been employed in lamps. If the lamp is to be used as a U.V. source, the phosphor coating may be omitted. In addition, the envelope contains a small charge of inert, ionizable gas, such as argon at a pressure of 4 mm. mercury, for example, in order to facilitate starting and a small charge of mercury 28 is also contained within the envelope. Many other inert, ionizable gases at various pressures have been used as starting gases, as is well known in the fluorescent lamp art.

Fluorescent lamps are normally adapted to be operated on alternating current and in such operation, the coils 20 carrying the electron-emitting material serve as a cathode on each half-cycle. While the coil at one end of the lamp is serving as a cathode to emit electrons, the lead wires 18 and coil 20 at the opposite end of the lamp both serve as the anode. In the usual lamp operation, those portions of the lead wires 18, which are proximate to the respective coils 20 which they carry, serve as the anode. These anode-serving lead wire portions tend to become quite hot during operation of the lamp due to I²R loss through the wire, positive-ion bombardment, and conducted heat from the hot cathode. This tends to make the lead-wire sections which are proximate to the coils operate at a relatively high temperature, and temperatures as high as 880° C. and hotter have been noted.

The mechanism by which barium is transferred from the coils 20 to the envelope 12 of the lamp in the form of spots is not understood. Previous to the teachings of this invention, it was thought that there was either some

direct transfer from the coils to the envelope or perhaps some intermediate transfer via the lead conductors. Previous experiments to eliminate end spots have primarily been directed to improving the emission mixture with regard to stability. It has been found, however, that by modifying the lead conductors, or at least those portions of the lead conductors which serve as anodes during lamp operation, the formation of end spotting can be substantially inhibited. This has been accomplished by providing the exterior surfaces of at least those lead-conductor portions which serve as anodes when the lamp is operated with a dull-dark color and a roughened surface in order to increase the thermal emissivity for at least these anode portions. Normally under production practices the entire portion of the lead conductor 18 which extends within the envelope 12 will have such a dull-dark and roughened surface.

In explanation of the term "thermal emissivity," this refers to a heat loss by radiation and this emissivity is measured by the ability of a material to absorb radiant heat as compared to the ability of a theoretical "black body" to absorb all radiant heat. It should be noted that the ability of a body to absorb or radiate heat are the same, and if a body is a good absorber it is an equally good radiator. Some materials such as lamp black mixed in water glass have an emissivity of approximately 95% of a perfect black body while a commercially polished copper or an ordinary shiny aluminum surface have an emissivity less than 5% of the perfect "black body." The most important factor in thermal emissivity is the state of the surface which should be of an etched or roughened nature. The color is also important, but is secondary. In the instant case, it has been found that the lead wires, or at least those portions which serve as anodes during the operation of the lamp, should be provided with a roughened surface and a dull-dark color. The improvements of this invention, as hereinafter elaborated upon, have been achieved by using lead wires which were dull gray in color with a roughened surface as well as lead wires which were dull black in color with a roughened surface. Other colors of lead wires would work equally well as long as these colors were of a dull and dark nature. It should be noted that normally any surface which has an etched or roughened nature will have a dull appearance due to the lack of spectral effect.

In the operation of the lamps which are provided with lead wires having the dull-dark and roughened surfaces, some of the heat which is radiated by the hot cathode will be absorbed by the lead wires and an equal amount of this heat will be radiated as hereinbefore explained. However, much of the heat which is passed to the lead wires by conduction from the hot cathode, by I²R losses and by positive ion bombardment, as heretofore explained, is radiated from the lead wires in order to cause them to operate considerably cooler than the lead wires of the prior art which normally consisted of nickel or nickel-plated iron which had a relatively light color and, what is more important, a shiny surface. Measurements have indicated that the improved lead-wire constructions of this invention operate about 100° cooler than the lead-wire constructions of the prior art.

Immediately upon incorporation of the improved lead wires of this invention into the fluorescent lamps, a drastic decrease in the appearance of end spots was noted. In view of this, a better explanation of the mechanism of the formation of these spots can be offered. Apparently the barium is sublimed or otherwise passed from the coils to the lead wires during operation of the lamp. From these lead wires the barium is then transmitted to the lamp envelopes where it collects mercury and is manifested as black spots. By causing the lead wires to operate considerably cooler, apparently either the primary reaction where the barium is deposited on the lead wires or the secondary reaction, wherein the barium is deposited from the lead wires onto the envelope, is inhibited, thus

inhibiting the formation of the end spots. It should be understood that this is only a theoretical approach to the problem as based upon actual observed phenomenon, but it is clear that where the lead wires are provided with a surface as indicated, the formation of the end spots is inhibited drastically.

As an additional requirement for the leads of this invention, the dull-dark and roughened surface should also be physically and chemically stable and adherent to the lead under the normal operating conditions of the lamp. In tests conducted, it has been found that these surface coatings may be subjected to temperatures as high as 750° C. and higher and, of course, the interior of the lamp operates under partial vacuum conditions.

The use of thermally-emissive coatings for elements in electronic tubes has been known. In such applications, however, the emissive coatings have been used to make the elements of the tube operate cooler in order to decrease what is known as back electron emission since lead conductor materials very often become electron emitting in nature when heated to very high temperatures. The instant improvement, as relating to fluorescent lamps, is to be distinguished from this electronic tube application for in the instant application the lead conductors are rendered thermally emissive in order to interrupt what apparently is a two-stage cycle of operations whereby barium is bombarded or sublimed from the cathode to the lead conductors and thereafter deposited in some way from the lead conductors onto the envelope wall. It is this interruption of the barium deposition which has been achieved. It should be noted that it is not clear whether the barium is prevented from depositing on the lead conductors or whether it is prevented from depositing off the lead conductors onto the envelope for the amounts of lead-wire barium deposition at any one time are very negligible. It is only clear that the barium deposition on the wall of the fluorescent tube is greatly inhibited.

The preferred dull-dark and roughened surface for the lead conductors is a black plating of a chromium and vanadium complex and comprises from 100 to 9.5 parts by weight of total chromium per part by weight of vanadium. The vanadium is plated essentially as V₂O₃, which is a black material. The chromium as plated is partially oxidized with the ratio of total chromium atoms to total oxygen atoms combined with chromium being from 2:1 to 100:1. This dull-black plating may be applied to a wire base metal of iron or nickel, for example, having a diameter of 20 mils, for example. The coating thickness is not particularly critical as long as the exterior surface is as indicated, but the thickness may be about 0.05 mil, for example, and such a coating is illustrated in Fig. 2.

In Fig. 3 is shown an apparatus for plating this black chrome-vanadium on wire for use in fluorescent lamps in accordance with this invention. The wire to be plated is drawn from an unwind reel 30, around two idler pulleys 32, over the contact roller 34, into the alkaline cleaning solution which partially fills the tank 36. The wire is held under the solution surface by passing around the depressor rollers 38 and 40, after which the wire is anodically cleaned in this solution at a current density of approximately 350 amps. per square foot of wire surface. Electrical contact with the wire is made by means of contact rollers 34 and 42. From the alkaline cleaning solution the wire passes over the contact roller 42, through the water spray 44, and over the contact roller 46, into the acid cleaning solution in tank 48. Just before and after passing through the water spray 44 the wire rubs over rubber squeegee blades fastened on the drain tray 50 in order to remove any excess liquid from the surface of the wire.

In tank 48 the wire is held under the solution surface by passing around depressor rollers 51 and 52. The wire is anodically cleaned in this solution at a current

5

density of approximately 350 to 500 amps. per square foot and electrical contact with the wire is made by means of contact rollers 46 and 54. From the acid cleaning solution the wire passes over contact roller 54 through the water spray 56 and over the contact roller 58, into the black chrome vanadium plating solution in tank 60. Just before and after passing through the water spray 56, the wire rubs over additional rubber squeegee blades mounted on the drain tray 62 in order to remove excess liquid from the surface of the wire.

In tank 60 the wire is held under the solution surface by passing around the depressor roller 63 and 64. It also slides under the contact bar 66. The wire is coated with an adherent deposit of black-chrome vanadium by electrolysis at a current density of 750 to 1200 amps. per square foot of wire surface, electrical contact with the moving wire being made by means of contact roller 58 and contact bar 66. From the electroplating machine the wire passes over an idler roller 68 and along the surface of a washing sponge 70 which is supported on the drain tray 72. Water is projected from the jets 74 onto the surfaces of the wire and the sponge to wash away the chemicals. The washed wire then passes under the heat lamps 76 which dries the wire, after which it is rewound.

The solution used in the alkaline cleaning tank 36 is preferably an aqueous solution of an alkaline cleaner such as 5 ozs. of sodium hydroxide per gallon of water and alternatively, a commercial alkaline cleaner may be used and this cleaning solution may be kept at a temperature of about 60-65° C.

The solution used in the acid cleaning tank 48 is preferably a 50% aqueous solution of concentrated sulfuric acid and in operation this solution may be kept at room temperature.

The black-chrome vanadium plating bath may contain the following aqueous solution: chromium trioxide—200 grams per liter; ammonium metavanadate—20 grams per liter; glacial acetic acid—6.5 cc. per liter. This plating bath may be operated at about room temperature although cooling of this solution may be required if the operation is continued over an extended period.

The chromium and vanadium salts concentration in the electrolyte are preferably maintained in an approximate ratio of about 12 parts chromium to one part vanadium although this ratio may vary from 100 to 1 to 9.5 to 1. Other organic acids such as formic or citric acid may be used in place of the acetic acid and the organic acid content of the bath may vary from 3 to 20 milliliters per liter.

The black chrome-vanadium wire coating under a magnification of 2000× shows a very fine crystalline structure with a plurality of very fine incipient cracks which gives it a very rough surface and the chromium and the vanadium compounds are not distinguishable under the microscope as separate crystals, but rather appear to be a black mass of homogeneous-type crystals. Analysis indicates that the black coating on the lead conductors will have about the same percentage composition with regard to vanadium and chromium as the percentage of these elements which were present in the electrolyte from which the coatings were formed. The black chrome-vanadium coatings as described herein are broadly disclosed in co-pending application of M. F. Quaely, S.N. 339,469, filed February 27, 1953, now Patent No. 2,824,829, and owned by assignee of the present invention.

After plating, the wire is cut to lead conductor length and electrically connected to the Dumet wire by well-known techniques such as welding, before fabricating the lamp mount. The mount and lamp are then fabricated by standard manufacturing techniques.

While the heretofore described black chrome-vanadium coating is preferred, very good results have also been obtained with an iron lead wire coated with a compound of aluminum and iron. In fabricating such wire, pow-

6

dered aluminum may be wiped over the iron wire and the aluminum-wiped iron wire may then be heated to 800° C., for example, in hydrogen or a nonoxidizing atmosphere. Other techniques for first applying the aluminum, such as cladding, plating, etc. may be used. This produces an iron-aluminum alloy on the surface which has a dull gray appearance and a roughened surface effect and the emissivity is approximately 85% that of a black body. The aluminum-iron alloy thickness may be between about 0.001" and 0.0005", for example.

Other types of dull-dark and roughened coatings have also been utilized such as carbonized nickel and while this coating gives some improvement over the relatively poor emissive-type coatings of the prior art, improvements have not been as great as those realized with the preferred black chrome-vanadium or iron-aluminum alloy type coatings. It is felt that the carbonized nickel primarily presents an adherence problem and that this can readily be overcome with some experimentation.

Other types of coatings which will present a dull-dark and roughened surface may also be used in accordance with the teachings of this invention and these coatings may be produced by vacuum evaporation of aluminum on iron or reacting an iron wire with a small amount of molybdenum at its surface to produce a similar dull-dark and roughened surface of high emissivity.

In Fig. 4 is shown an alternative embodiment of the lamp as illustrated in Fig. 1. In this embodiment, the lead conductors are extended beyond the point where they are secured to the coil 20 and are then bent longitudinally with respect to the coil so that they are parallel thereto and axially displaced therefrom. Preferably the anodes 78 which are thus formed by the extension of the lead conductors 18 and the coil 20 generally lie in a plane which is perpendicular to the axis of the lamp envelope 12 in order that the mercury discharge paths of the operating lamp are not altered. In such an embodiment, at least these anode sections 78 will carry the dull-dark and roughened surface in accordance with the teachings of this invention.

In testing the improved lamps of this invention, life test data was taken over a very large number of lamps and the points at which end discoloration for these lamps was first noted was recorded. Following is a table, designated Table I, tabulating these results for 500 hours, 1000 hours, and 1500 hours:

Table I

Lead Type	Hours Operation (clean lamps)		
	500 hrs.	1,000 hrs.	1,500 hrs.
Lamps having lead conductors with dull dark and roughened surface.....	Percent 95	Percent 85-92	Percent 73-85
Control lamps—lead conductors of standard nickel-plated iron.....	77	50	38

It will be recognized that the objects of this invention have been achieved by providing a positive-column low-pressure mercury-discharge lamp preferably of the fluorescent type, wherein end discoloration is inhibited. In addition, there has been provided a method for preventing this end discoloration, as well as specific coatings for lead conductors for effecting this inhibition of end discoloration.

While in accordance with the patent statutes, one best-known embodiment of the invention has been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

We claim:

1. A low-pressure positive-column mercury-discharge lamp comprising, a sealed double-ended light-transmitting envelope, a charge of mercury and a small amount of inert ionizable gas contained within said envelope, glass-sealing electrical conductors sealed through the ends of

said envelope, lead conductors electrically connected to said glass-sealing conductors and projecting within said envelope, operatively disposed refractory metal coils electrically connected to and supported by said lead conductors at either end of said envelope, alkaline-earth-oxide electron-emitting material comprising at least barium oxide carried by said electrode coils, said electrode coils serving primarily as cathodes when said lamp is operated, portions of said lead conductors serving as anodes when said lamp is operated, the exterior surfaces of at least said lead conductor portions which serve as anodes when said lamp is operated having a dull-dark color and a roughened surface, and said dark and roughened lead conductor surfaces being stable and adherent under the normal operating conditions of said lamp.

2. A low-pressure positive-column fluorescent lamp comprising, a sealed double-ended light-transmitting envelope, a phosphor material carried on the internal surface of said envelope, a charge of mercury and a small amount of inert ionizable gas contained within said envelope, glass-sealing electrical conductors sealed through the ends of said envelope, lead conductors electrically connected to said glass-sealing conductors and projecting within said envelope, operatively disposed refractory metal coils electrically connected to and supported by said lead conductors at either end of said envelope, alkaline-earth-oxide electron-emitting material comprising at least barium oxide carried by said electrode coils, said electrode coils serving primarily as cathodes when said lamp is operated, portions of said lead conductors serving as anodes when said lamp is operated, the exterior surfaces of at least said lead conductor portions which serve as anodes when said lamp is operated having a dull-dark color and a roughened surface, and said dark and roughened lead conductor surfaces being stable and adherent under the normal operating conditions of said lamp.

3. A low-pressure positive-column fluorescent lamp comprising, a sealed double-ended light-transmitting envelope, a phosphor material carried on the internal surface of said envelope, a charge of mercury and a small amount of inert ionizable gas contained within said envelope, glass-sealing electrical conductors sealed through the ends of said envelope, lead conductors electrically connected to said glass-sealing conductors and projecting within said envelope, operatively disposed refractory metal coils electrically connected to and supported by said lead conductors at either end of said envelope, alkaline-earth-oxide electron-emitting material comprising at least barium oxide carried by said electrode coils, said electrode coils serving primarily as cathodes when said lamp is operated, portions of said lead conductors serving as anodes when said lamp is operated, the exterior surfaces of at least said lead conductor portions which serve as anodes when said lamp is operated having a dull-dark color and a roughened surface, and said dark and roughened lead conductor surfaces being stable and adherent under partial vacuum conditions at temperatures of at least approximately 750° C.

4. A low-pressure positive-column fluorescent lamp comprising, a sealed double-ended light-transmitting envelope, a phosphor material carried on the internal surface

of said envelope, a charge of mercury and a small amount of inert ionizable gas contained within said envelope, glass-sealing electrical conductors sealed through the ends of said envelope, lead conductors electrically connected to said glass-sealing conductors and projecting within said envelope, operatively disposed refractory metal coils electrically connected to and supported by said lead conductors at either end of said envelope, alkaline-earth-oxide electron-emitting material comprising at least barium oxide carried by said electrode coils, said electrode coils serving primarily as cathodes when said lamp is operated, portions of said lead conductors serving as anodes when said lamp is operated, a black chromium-vanadium plating on the exterior surfaces of at least said lead conductor portions which serve as anodes when said lamp is operated, said plating principally comprising from 100 to 9.5 parts by weight of total chromium per part by weight of vanadium, the vanadium in said plating essentially compounded as V_2O_3 , and the chromium in said plating partially oxidized with the ratio of total chromium atoms to total oxygen atoms combined with chromium in said plating being from 2:1 to 100:1.

5. A low-pressure positive-column mercury-discharge fluorescent lamp comprising, a sealed double-ended light-transmitting envelope, a phosphor material carried on the internal surface of said envelope, a charge of mercury and a small amount of inert ionizable gas contained within said envelope, glass-sealing electrical conductors sealed through the ends of said envelope, lead conductors electrically connected to said glass-sealing conductors and projecting within said envelope, operatively disposed refractory metal coils electrically connected to and supported by said lead conductors at either end of said envelope, alkaline-earth-oxide electron-emitting material comprising at least barium oxide carried by said electrode coils, said electrode coils serving primarily as cathodes when said lamp is operated, said coils being connected to said lead conductors at a point intermediate the ends thereof, the portions of said lead conductors which are located inwardly from the point of coil connection being bent longitudinally with respect to said coils so that they are substantially parallel thereto and so that said bent lead-conductor portions and said coils generally describe a plane which is perpendicular to the axis of said envelope, said bent lead-conductor portions serving as anodes when said lamp is operated, the exterior surfaces of at least said lead conductor portions which serve as anodes when said lamp is operated having a dull-dark color and a roughened surface and said dark and roughened lead conductor surfaces being stable and adherent under the normal operating conditions of said lamp.

References Cited in the file of this patent

UNITED STATES PATENTS

1,527,703	Prince	Feb. 24, 1925
1,902,185	Rothe	Mar. 21, 1933
1,925,075	Miller	Aug. 29, 1933
2,233,917	De Boer et al.	Mar. 4, 1941
2,417,460	Eitel et al.	Mar. 18, 1947
2,576,129	Levin	Nov. 27, 1951
2,714,681	Keiffer et al.	Aug. 2, 1955
2,769,112	Heine et al.	Oct. 30, 1956