

W. A. DARRAH.

ARC LAMP.

APPLICATION FILED JUNE 11, 1915.

Patented June 29, 1920.

4 SHEETS—SHEET 1.

1,344,757.

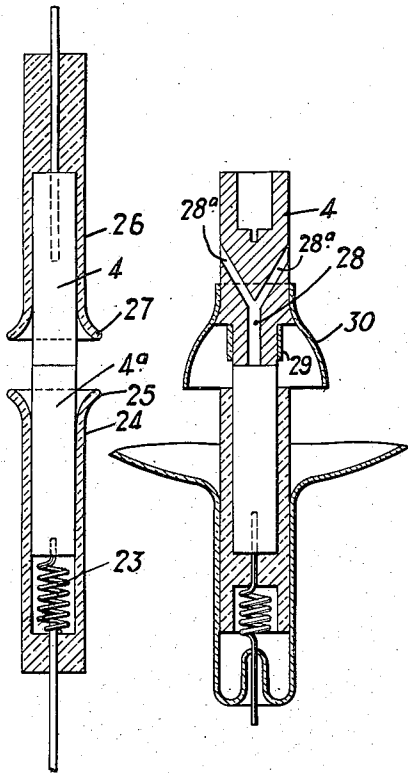


Fig. 2

Fig. 3

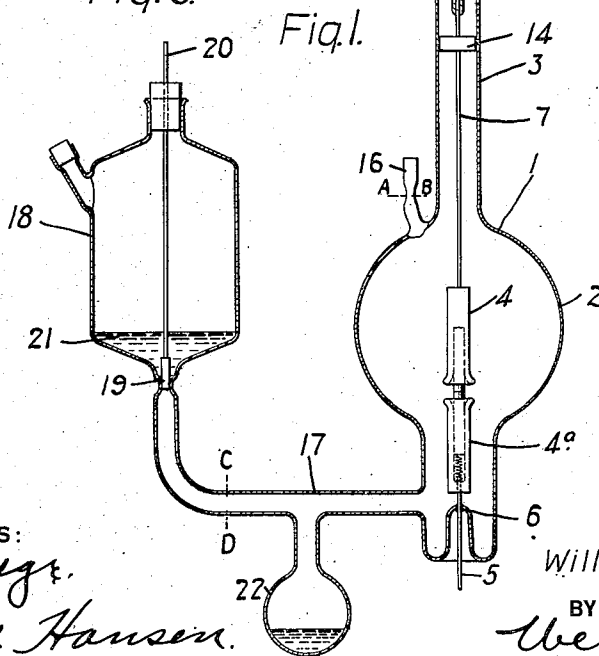


Fig. 1

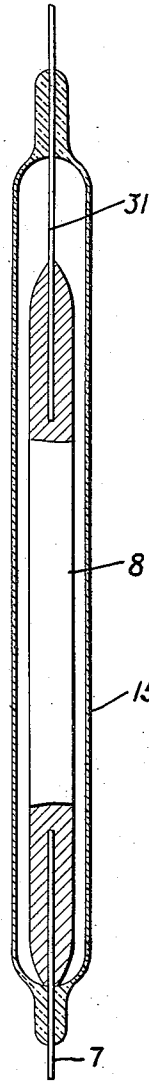


Fig. 4

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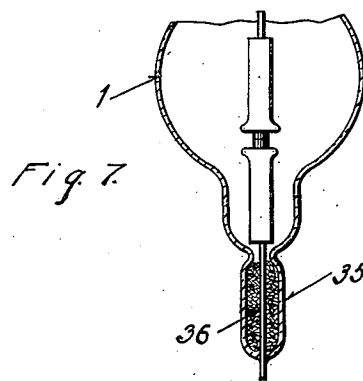
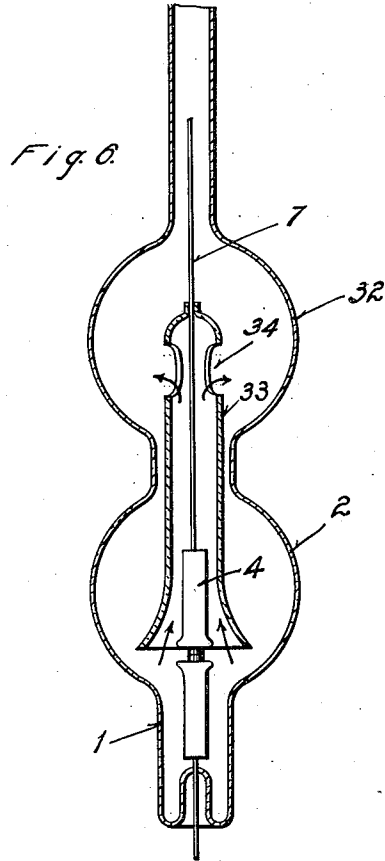
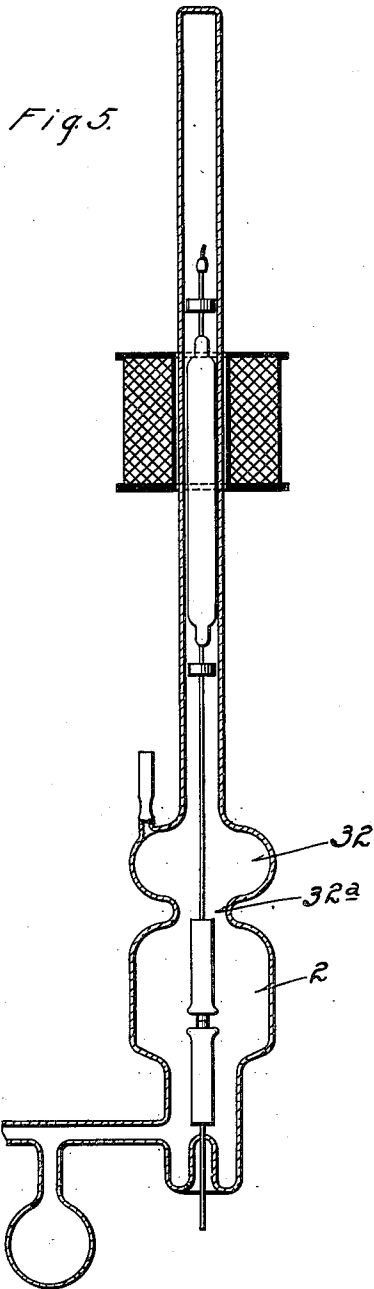
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4 SHEETS—SHEET 3.

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Fig. 8.

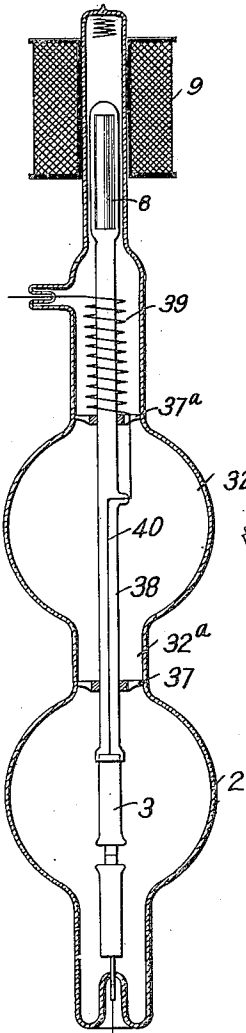


Fig. 9.

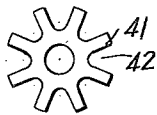
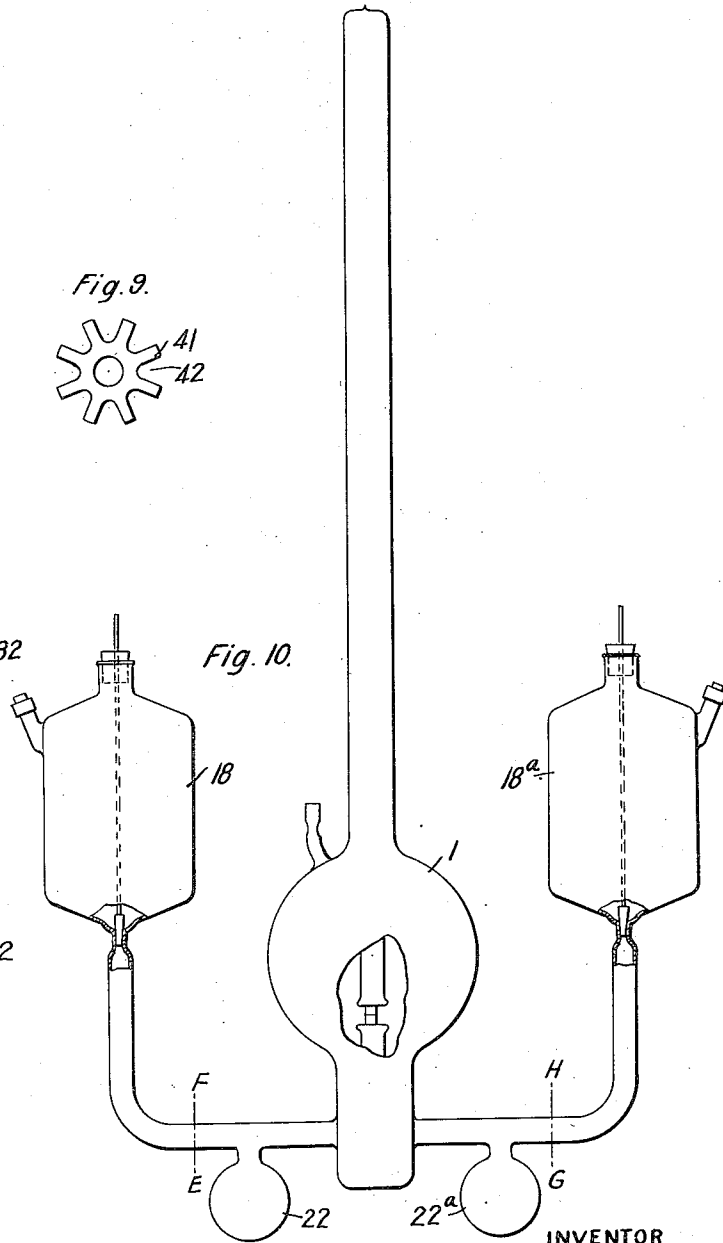


Fig. 10.



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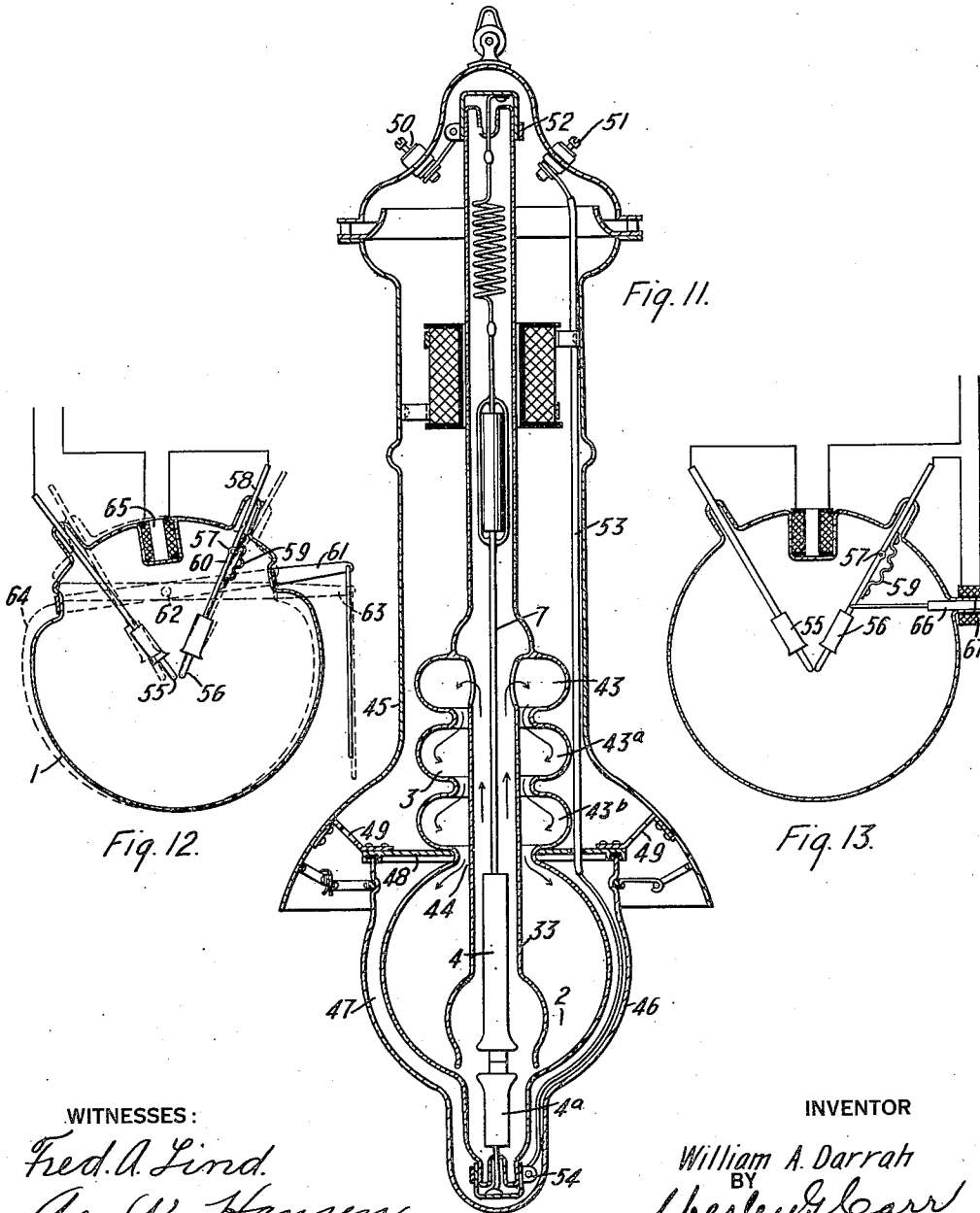
ARC LAMP.

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4 SHEETS—SHEET 4.

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UNITED STATES PATENT OFFICE.

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ARC-LAMP.

1,344,757.

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To all whom it may concern:

Be it known that I, WILLIAM A. DARRAH, a citizen of the United States, and a resident of Wilksburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Arc-Lamps, of which the following is a specification.

My invention relates to electric lighting, and it has special reference to that class of electric lamps in which the light-giving media are vapors or gases.

More particularly, my invention relates to electric arc lamps which comprise confined bodies of vapors or gases of light-giving materials that may be continuously introduced to the arc without appreciably affecting their light-giving properties.

Electric glow lamps have heretofore been constructed which comprise a confined body of a rare gas or vapor, such as neon or nitrogen. In these lamps, however, the initial electrical discharges between the spaced electrodes are occasioned by applying relatively high voltages thereto. The intrinsic brilliancy of lamps of this character is relatively low, inasmuch as the gases contained therein glow only and no definite arcs appear to exist such as obtain in ordinary arc lamps. Consequently, it is necessary to employ very large tubes filled with these rare gases in order to generate sufficient candle power for illuminating purposes.

Another type of electric lamp employing a body of gas or vapor, as the light-giving medium, comprises an electrode of a vaporizable material, such as mercury. However, unless the mercury is properly ionized, it is ineffective as a light-producing material. In these lamps, the mercury vapor, after having served as a conductor for electric current, is usually recondensed and subsequently fed into the arc. A modified form of this type of arc lamp comprises two electrodes between which the initial discharge occurs. The heat generated by the arc vaporizes a body of mercury in conjunction with other light-producing materials so that the arc is bridged by the vapors of a combined character. It will be noted that, in these instances, the light-giving materials either comprise electrodes which are vaporized when an initial electrical discharge is established, or bodies of vaporizable material which are in proximity to the electrodes

in order that they may be vaporized by reason of the heat generated on the occurrence of the initial discharge.

I have found that, if an arc is established in a hermetically sealed chamber from which air, moisture and active gases are excluded but which contains certain vapors or gases of a character to be hereinafter disclosed, the light derived therefrom is of high intensity, of a very satisfactory quality and of such abundance as to warrant the use of such a lamp for extensive commercial applications.

The electric lamp of the present invention is, in a sense, closely related to the flame carbon arc lamp, inasmuch as the arc is of high intrinsic brilliancy and is maintained in an atmosphere of various light-giving materials. However, the electrodes in my present type of arc lamp are substantially non-consumable in the arc, and the light-giving materials are introduced to the arc in the form of vapors which always surround the arc. These vapors are produced from easily volatilized compounds of light-giving materials and they are maintained, while in the lamp, in a vaporous condition under all circumstances. Moreover, the arc is continuously fed by these light-producing vapors of high luminous efficiency, because they are continuously reformed, after having been introduced to the arc, to assume substantially their initial state without affecting their light-giving properties.

An object of this invention is to provide an electric lamp in which the light may be produced with a very high degree of efficiency. Again, it is unnecessary to renew the electrodes, inasmuch as they are substantially non-consumable in the arc. The light-giving vapors or gases are introduced into the arc chamber and are used continuously without appreciable deterioration of their light-producing qualities. The operating mechanism embodied in the lamp structure is very simple in construction and operation, and will require very little attention on the part of users or attendants. Lamps constructed in accordance with my invention may be made of almost any desired size and capacity, and the light derived therefrom may be of any desired color or quality.

For a better understanding of the nature

and scope of my invention, reference may be had to the following description and the accompanying drawings in which Figure 1 is a view, partially in elevation and partially in section, of an arc lamp embodying a form of my invention; Fig. 2 is an enlarged view, partially in elevation and partially in section, showing the construction of the electrodes embodied in the lamp of Fig. 1; Fig. 3 is a sectional view, showing a modified form of the structure of Fig. 2; Fig. 4 is a detailed sectional view of the plunger magnet embodied in the arc lamp of Fig. 1; Figs. 5, 6, 7 and 8 are views, partially in elevation and partially in section, of modified forms of my arc lamp; Fig. 9 is a plan view of the guiding means for the upper electrode embodied in the arc lamp of Fig. 8; Fig. 10 is a view, partially in elevation and partially in section, of a portion of an arc lamp embodying my invention and illustrating a method that may be employed in generating and confining the light-giving gases or vapors, and Figs. 11, 12 and 13 are views, partially in elevation and partially in section, of modified forms of my arc lamp.

It is a well known fact that, when certain materials, such as salts of titanium, cerium, tungsten and other compounds of a similar character, are introduced into an arc, the efficiency thereof is very greatly increased. While there are several theories which partially account for the high light-producing efficiency thus obtained, it is probable that it results from the selective radiation which materials of the aforementioned character exhibit at high temperatures, such as obtain in an electric arc. High illuminating efficiency also may arise from the fact that these materials ordinarily form compounds which are not readily volatile in the arc, and that the high temperatures reached in the formation and dissociation of these materials render them highly incandescent, thereby causing them to generate large amounts of light at a high efficiency. Of course, it will be understood that the above-mentioned theories for light production are, as yet, not firmly established, and I do not desire to commit myself as to their correctness.

However, as it is not sufficient merely to introduce vapors or liquids of light-giving materials into an arc for the reason that arcs thus produced are frequently very unstable, I propose to add some other material which lends stability to the arc. Again, in order to continuously maintain an arc in a confined body of vapors or gases, it is essential to have such vapors or gases so constituted that they may be recurrently introduced into the arc without undergoing deterioration of their light-giving properties. At the same time, it is important that

the interior walls of the light-transmitting material providing the arc chamber be kept substantially clean in order that the amount of light absorbed thereby shall be as small as possible. Ordinarily, deposits will form upon the walls of the glass container, and it is necessary, therefore, to prevent the accumulation or occurrence of decomposition products. To this end, the confined body of gases or vapor should be so constituted that the decomposition products of the arc recombine to preclude the formation of deposits on the walls of the arc chamber and to permit the light-producing materials to be repeatedly introduced to the arc without substantially affecting the light-giving properties which they initially possess.

To conform to the above-mentioned qualifications, it is desirable that the confined body of gases or vapors be so constituted (1) that an arc of high luminous efficiency may be produced which results from introducing into the arc that class of materials which may be called the illuminants; (2) that a stable arc may be produced which results from introducing materials which may be called stabilizers, and (3) that the decomposition products of the arc may recombine as a result of introducing that class of materials which may be called the catalyzers or catalytic agents. The stabilizers which I have found most satisfactory usually produce arcs which give out a comparatively small amount of light but which have great stability.

I have found that the most desirable illuminants for use in my arc lamp are the volatile compounds of such light-giving materials as titanium, cerium, calcium, tungsten, molybdenum, chromium, thorium, lanthanum and other substances of a similar nature which have been found to be peculiarly suitable for use as light-giving materials in flame carbon electrodes, lamp-glowers, Welsbach mantles, and for similar service. In order to feed these materials into the arc continuously, I employ the volatile compounds thereof which, at the temperatures and pressures obtaining within the arc chamber, are in the form of a gas or vapor. For example, those volatile compounds which I have found most suitable are titanium tetrachlorid, tungsten tetrachlorid, boron trichlorid, etc., these materials being liquids at ordinary temperatures and at atmospheric pressure and being readily volatilizable at pressures slightly below atmospheric pressure. They are, therefore, well adapted for use in arc lamps which are designed to operate at temperatures not greatly above room temperatures. Other light-producing materials which may be satisfactorily used in my arc lamp are cerium chlorid, calcium chlorid, zirconium chlorid, ytterbium chlorid, thorium chlorid,

etc., these materials being solids at ordinary temperatures and pressures but being readily volatilized at temperatures approximating a red heat. These last-named materials, therefore, are best adapted for use in an arc lamp of the quartz-tube type in which the container is designed to be operated at relatively high temperatures. In this case, it may be desirable to apply heat in any well known manner to the supply of light-giving materials. While the materials mentioned above and chosen for illustration are largely chlorids, it should, of course, be understood that bromids and iodids are frequently entirely satisfactory, the materials mentioned being chosen because of their rather low melting or volatilization points.

Moreover, it appears to be most desirable to use compounds of these light-giving materials which comprise halogen elements for the reason that these compounds are comparatively simple in their chemical structure. As previously mentioned, these light-giving materials are to be continuously introduced to the arc and, consequently, their chemical construction should be of such a character that their dissociation in the arc, if such occurs, may be readily halted in order that their dissociation products may recombine to assume their original state, so far as their light-giving properties are concerned. For example, sulfates, nitrates, silicates, phosphates and other compounds of complex acid radicals will usually break down in the arc into elements or compounds from which the original material cannot be readily reformed. For a similar reason, compounds, such as nitrids, sulfids and phosphids, are not usually satisfactory, because they are frequently dissociated in the arc into materials which are comparatively inert and do not readily recombine to form the original material.

As hereinbefore mentioned, stabilizing materials may be employed in order to lend stability to the arc, and I have found that antimony penta-chlorid, stannic tetrachlorid, phosphorous trichlorid, arsenic trichlorid, free bromin, free chlorin and other similar materials may be thus utilized. The stabilizing properties of these materials may possibly be explained by the fact that their dissociation products in the arc are either gases or solids which are very readily volatilized, and that, as a result of these materials being fed into the arc, the amount of heated vapor is considerably increased, thereby reducing the resistance of the arc. The increase in amount of heated vapor, of course, tends to produce a corresponding increase in the free ions in the arc, thereby greatly increasing the conductivity of the arc. It will, of course, be understood that this theory for explaining the stabilizing properties of materials is not yet fully sub-

stantiated, and I, therefore, do not desire to commit myself as to its correctness. While the above-mentioned stabilizers are adequate to impart stability to the arc, I prefer to use halogen elements or compounds, inasmuch as I have found them to be very satisfactory.

My experience has demonstrated that an arc lamp which contains certain illuminants and stabilizers causes considerable deposits to form upon the walls of the arc-inclosing chambers.

Since the electrodes which I embody in my lamp structure remain practically intact, it appears that these deposits result from the dissociation of the materials which are continuously introduced into the arc. For all operating purposes, it is, therefore, desirable to preclude the formation of these deposits, and, to this end, I introduce catalyzers for the purposes above mentioned. I have found that free chlorin and free bromin are especially effective as catalytic agents. When bromin is used, its action is apparently to effect recombination of the dissociated products of the titanium tetrachlorid, in the event that titanium tetrachlorid is used as the illuminant. Titanium tetrachlorid is probably dissociated in the arc to form non-volatile titanium bichlorid and trichlorid which, in turn, combine with the bromin to form titanium bromochlorid. Titanium bromochlorid is readily volatilized at the temperatures obtaining in the arc lamp, and it will be evident, therefore, that any deposit formed under these conditions will be readily volatilized and thereby pass into the arc, thus keeping the walls of the arc chamber substantially clean. When chlorin is used in conjunction with titanium and tungsten compounds, products may be formed which are also readily volatilized at the temperatures obtaining within the lamp.

While the structure of my arc lamp will be explained more in detail, I have found that a most satisfactory lamp may be made which comprises a glass container filled with a vapor or gas which comprises approximately 50% of titanium tetrachlorid vapor and 50% of free bromin vapor and having tungsten or hard coke electrodes disposed therein. If the pressure within the glass container is regulated to approximately 10 centimeters of mercury, it is possible to secure a very steady arc of high intrinsic brilliancy and of approximately four inches in length, when a direct current at 220 volts is impressed upon the coöperating electrodes. The light generated by this lamp is white and contains luminous bands in all parts of the spectrum. A lamp of this character operates satisfactorily with currents of from 4 to 15 amperes, the quantity of emitted light, of course, being very greatly increased as the current is increased. While, in this particu-

lar lamp, I employ titanium tetrachlorid, it is possible to substitute various tungsten chlorids therefor. I have also obtained very satisfactory results by adding small quantities of free chlorin to the vaporous mixture contained in the arc chamber.

Another lamp which operates very satisfactorily, consists of a transparent quartz container in which two solid electrodes are disposed, one of them containing a small amount of fused cerium chlorid. A little free bromin and free chlorin may be contained in the quartz container which enhances the light-giving properties of the lamp. In operating a lamp of this character, it is necessary, because of the high volatilization point of the cerium chlorid, to maintain the temperature of the container at approximately 900 to 1,000 degrees centigrade. Under these circumstances, an extremely stable arc of several inches in length may be established between the cooperating electrodes when direct-current at 110 volts is applied thereto. It is desirable, in this case, to employ currents ranging from 10 to 20 amperes, although lamps may be constructed which may employ currents of lower values than those above mentioned. In order to insure the ready volatilization of the cerium chlorid, heat may be applied to the cerium chlorid independently of the arc established between the electrodes.

Under all circumstances, it is highly desirable, in lamps of the aforementioned characters, to exclude air, moisture, and active, as well as inert, gases from the hermetically sealed container in which the arc is established. The active gases have a tendency to cause the electrodes to consume in the arc and also to effect rapid decomposition of the light-giving gases and vapors contained in the lamp. Inert gases increase the pressure within the arc chamber, thereby effecting an increase in the resistance of the arc and a consequent increase in the energy consumption of the lamp without a corresponding increase in the volume of light generated.

Referring to a specific embodiment constructed in accordance with my invention, such as is shown in Fig. 1, a containing globe 1, which may be made of any transparent or translucent material, such as glass, quartz, etc., is provided with an expanded portion 2 which constitutes the arc chamber of my lamp. A tubular extension 3 is an integral part of the expanded portion 2 and receives the operating mechanism which is associated with an upper electrode 4. The upper electrode 4 cooperates with a lower electrode 4^a to establish the arc, the latter electrode being mounted as shown, and connected to a conductor 5 which is sealed into the container 1 by means of a hermetical seal 6. The upper electrode 4 is rigidly connected to a rod 7 which, in

turn, is connected to a core member or plunger 8 of an electromagnet 9. Current is led to the upper electrode 4 by means of a conductor 10 which is sealed at 11 in the upper end of the tubular extension 3. A flexible conductor 12 is inserted between the lead 10 and the plunger 8 which, in this instance, constitutes a part of the electrical circuit of the lamp. Guide members 13 and 14 are mounted above and below the plunger magnet 8, respectively, in order to maintain the upper electrode 4 in a central position, irrespective of its position relative to the lower electrode 4^a. Inasmuch as the heat developed in the lamp and the gases contained in the container 2 may attack the plunger magnet 8, I provide the plunger with a shell 15 of some inert or refractory material.

In order to fill the lamp with the desired light-giving vapors, I provide a tubulature 16 which is adapted to be connected to an air pump for exhausting air from the air chamber. Moreover, the lower portion of the container 1 is connected, through a tubular extension 17, to a filling bottle 18 which is provided, at its lower portion, with a valve 19 that is manually operated by means of an accessible extension 20. Material 21 which, as previously mentioned, may comprise any suitable material, such as titanium tetrachlorid, is contained in the filling bottle 18. When an exhaust pump is connected to the tubulature 16, the valve 19 is opened in order to permit the material 21 to flow into a bulb 22 which is formed integrally with the tubular extension 17. After a certain amount of material has been received in the bulb 22, the valve 19 may be closed. As the pressure within the container 1 decreases, the material contained in the bulb 22 will vaporize because of the decreased pressure obtaining within said container. The exhausting process is continued until it is insured that no gases or vapors will be contained within the container 1 excepting that which evolves from the material contained in the bulb 22. When the proper amount of gases or vapors is confined within the container 1, the tubulature 16 is sealed off in any suitable manner along the line A—B, and the tube 17 is likewise sealed off along the line C—D. It may be desirable to retain the bulb 22 in order that the material contained therein may act as a reserve supply for subsequently evolving gases or vapors to fill the container 1.

In the manner described above, the container 1 is hermetically sealed, and is also filled with vapors or gases of easily volatilizable compounds of light-giving materials. While the most desirable pressure obtaining within the container 1, depends upon the special gases or vapors employed,

I have found that a pressure of approximately 1 to 1½ inches of mercury absolute, is satisfactory when the material 21 comprises a mixture of titanium tetrachloride and bromine. After the lamp has been properly charged, it may be connected in an electrical circuit, the winding of the electromagnet 9 being preferably connected in series relationship with the electrodes 4 and 4^a. On connecting the lamp in circuit, the coil 9 is energized, thereby actuating the core 8 which, in turn, separates the electrodes 4 and 4^a and thus initially establishes the arc. When the electrodes are separated and the arc is drawn, it is maintained by the confined body of light-producing gases or vapors contained within the container 1. Inasmuch as the light-producing materials are introduced to the arc, it becomes intensely luminous. The characteristics of the arc, such as color, luminosity, stability, shape and size may be controlled largely by the character of the vaporous materials contained in the arc chamber and by the pressure obtaining therein. Gases and vapors, being introduced into the arc to add luminosity thereto, are heated to a high temperature and are carried upwardly. Other gases are continuously introduced to the arc, thus insuring the production of a steady light. The heated gases, on leaving the arc, become cooled and, if dissociated, recombine to maintain their initial light-giving properties intact. This cycle of operation for the light-giving gases and vapors is substantially continuous. While a lamp of this character may be operated either on direct-current or alternating-current circuits, I have secured the best results when operating the lamp upon a direct-current circuit.

By referring to Figs. 2 and 3, it will be noted that the lower electrode 4^a, which may be made of tungsten, hard coke, or other suitable material, is mounted upon a resilient member or spring 23 and is embraced by a refractory tube 24 which is preferably made of quartz. The upper end of the tube 24 is flared at 25 in order to expose a sufficient portion of the electrode 4^a to the arc. Inasmuch as the lower electrode 4^a is supported by the glass container 1, mechanical shocks imparted thereto by reason of impacts from the upper electrode 4 are absorbed by the spring element 23. The upper electrode 4 is likewise embraced by a refractory tube 26 which is flared at 27. The tubes 24 and 26 prevent the arc from creeping along the sides of the electrodes. In Fig. 3, the upper electrode 4 is provided with a central opening 28 that communicates with other openings 28^a that extend transversely of the body of the electrode, substantially as shown. I have found this arrangement of openings to be very satis-

factory, because the drafts occasioned thereby lend stability to the arc. The arcing end of the electrode 4 is provided with a refractory tubular member 29 that closely embraces it, and a second refractory flared member 30 which assists in properly directing the drafts through the openings 28 and 28^a. The upper electrode 4, in this instance, is preferably made of hard coke which I have found to be very satisfactory, inasmuch as it is substantially non-consumable in the arc.

In Fig. 4, I have shown a means for protecting the core member 8 of the electromagnet 9. In this instance, the core member 8 comprises an iron member having electrical conductors 31 and 7 sealed in its ends. A tube 15 of refractory or non-corrodible material is hermetically sealed around the member 8, thereby preventing it from being attacked by reason of any chemical or heat action occurring in the lamp. It is essential that the outer diameter of the tube 15 be sufficiently small to permit the core member 8 to slidably engage the tubular extension 3 of the glass container 1.

When an arc lamp operates for any appreciable length of time, small amounts of deposits may form upon the inner walls of the arc-inclosing globe 2 unless provision is made for causing the condensation products to deposit upon other portions of the arc-lamp container. To this end, I provide the container 1 with a condensing chamber 32, as shown in Fig. 5. The condensing chamber is above the arc-inclosing chamber 2, and communicates therewith through an opening 32^a which is formed by a constriction in the glass container. The condensing chamber 32 of my arc lamp acts in a manner similar to condensing chambers provided in inclosed flaming carbon arc lamps, which are well known in the art. The heated gases, after passing through the arc, rise and pass into the condensing chamber 32 where they are cooled. As a result, the gases condense and deposit their suspended particles upon the walls of the condensing chamber 32. After having been relieved of their suspended matter, the gases pass into the arc chamber 2 where they are again utilized to impart luminosity to the arc.

In Fig. 6, the shape of the condensing chamber 32 conforms to that of the arc chamber 2. A draft tube 33, which is firmly attached, in any suitable manner, to the rod 7, surrounds the upper electrode 4. The upper portion of the draft tube 33 is provided with openings 34 which afford direct communication between the draft tube and the condensing chamber 32. The heated gases being evolved from the arc, pass upwardly through the draft tube 33 and through the openings 34 into the condensing chamber 32 where they are relieved of their suspended particles. In this manner, a de-

finer circulating path is provided for the light-giving gases or vapors contained in the glass container 1. It will be noted that the draft tube 33 occupies a fixed position relative to the electrode 4, irrespective of the position of the electrode. Its length is so regulated that, under all circumstances, communication is afforded between the arc chamber 2 and the condensing chamber 32 through the draft tube. I have found this means very effective in keeping the inner walls of the arc chamber 2 substantially free from deposits.

Under certain circumstances, it may be necessary to provide a reserve supply of the light-giving gases or vapors, and, to this end, I have provided a reservoir 35 which freely communicates with the arc chamber 2 and is filled with porous material 36 such, for instance, as charcoal. The porous material 36 absorbs the liquids or gases which may be contained in the glass container 1 and emits gas or vapor as the pressure within the lamp decreases and re-absorbs gas or vapor as the pressure within the lamp increases. In the latter instance, increases in pressure may be occasioned by the rise in temperature of the lamp and, consequently, the absorbent material 36 absorbs the excess gas or vapor, in this manner acting somewhat as a pressure regulator.

In Fig. 8 is shown an arc lamp provided with a condensing chamber 32 which is similar to the condensing chamber shown in the structure of Fig. 6. Communication between the arc chamber 2 and the condensing chamber 32 is afforded by means of the elongated passageway 32^a in which is disposed a member 37 to guide the movement of the upper electrode 4. In this instance, the upper electrode 4 is secured to the lower end of a tubular member 38 in the upper end of which is disposed the magnetizable core member 8 of the electromagnet 9. Electrical connection is made to the upper electrode 4 by means of a flexible lead 39 and a conductor 40 which is sealed in the tubular member 38, substantially as shown in the drawing. A second guide member 37^a, similar to the guide member 37, likewise embraces the tubular member 38 which slidably engages therewith. In order to afford unobstructed communication between the arc chamber 2 and the condensing chamber 32, each of the guide members 37 and 37^a is made in the form of a star having radially-extending arms 41 which are spaced from one another to provide alternately-disposed openings 42 through which the arc gases may pass between the two chambers provided in the glass container 1.

It may frequently be desired to supply a mixture of gases or vapors to the glass container 1 in order that color-modifying sub-

stances may be added to the arc, or that other materials suitable for the operation of the arc may be introduced thereto. To this end, I may employ the structure shown in Fig. 10 in which two reservoirs 18 and 18^a are provided, each being similar, in all respects, to the reservoir 18 of Fig. 1. The various materials are disposed in these reservoirs and may be admitted into the bulbs 22 and 22^a in any suitable manner. The use of two or more such reservoirs may be desirable in cases where the volatilizable liquids, which are utilized to charge the lamp, are of different specific gravities and, consequently, will not satisfactorily mix in their liquid state. In this case, the reservoirs 22 and 22^a may be filled with different materials and, after the same have volatilized to fill the glass container 1, the container may be sealed at E—F and G—H.

In Fig. 11, I have shown an arc lamp constructed in accordance with my invention. In this instance, however, the condensing chamber 3 comprises a series of superposed chambers 43, 43^a and 43^b, all being similarly formed and communicating with one another and with the arc chamber 2 by means of constricted openings 44. The draft tube 33, which embraces the upper electrode 4 is so designed that, in operating condition, communication is afforded thereby between the arc chamber 2 and the upper condenser 43. The heated gases or vapors evolved from the arc will flow upwardly through the draft tube 33 and into the condensing chamber 43 where they may expand and condense. From the chamber 43, the cooled gases or vapors descend into the chamber 43^a, and, as they pass through constricted opening 44, they are compressed, and, on passing into the chamber 43^a, are permitted to expand again. In this manner, the gases or vapors are repeatedly compressed and expanded, in each instance depositing further quantities of suspended material. As a result, the gases are substantially free from all suspended material before they re-enter the arc chamber 2 where they are subsequently introduced to the arc. In the particular arrangement shown, the condensing chambers 43, 43^a and 43^b are contained in a tubular casing 45 which affords protection for the super-structure of the glass container 1. It will be noted that the draft tube 33 extends downwardly to embrace the upper portion of the lower electrode 4^a so that, when the arc is drawn, it is surrounded by the draft tube throughout its entire length. This insures a strong draft to convey the evolved gases to the condensing chamber and also a steady arc.

The arc chamber 2 is inclosed by a globe 46 which provides a dead air space 47 which, in turn, substantially surrounds the arc-in-

closing globe 2. In order to provide means for retaining the condensing chambers 43, 43^a and 43^b as cool as possible, I provide an imperforate member 48 which separates the lower portion of the glass container 1 from its upper portion. Openings 49 are provided to secure circulation of air currents through the tubular member 45. As the air currents sweep past the condensers 43, 43^a and 43^b, the latter are maintained cool and, consequently, are in an effective state to relieve the heated vapors and gases of their suspended material. Terminals 50 and 51 are provided at the upper portion of the containing case 45, the former being connected to a clip terminal 52 which, in turn, is connected to the upper electrode 4, and the latter being connected, by means of an insulated conductor 53, to a clip terminal 54, which, in turn, is connected to the lower electrode 4^a.

In Fig. 12 is shown a modified form of lamp in which converging electrodes are employed. In this instance, the arc is contained in the inclosing globe 1 and extends between converging electrodes 55 and 56. The electrode 56 is pivotally secured at 57 to a terminal member 58 and is engaged by a resilient member 59, which is attached to the terminal member 58 and to a rod 60 that supports the electrode 56. A mechanism 61 is provided in order to initially draw the arc. To start the arc, the mechanism 61 is rotated about a pivot 62 to occupy a horizontal position, as indicated by dotted lines 63. At the same time, the globe 1 occupies a position indicated by dotted lines 64. Simultaneously therewith, the electrode 56 is withdrawn from its cooperating electrode 55, thereby initially establishing an arc. The resilient member 59 limits the movement of the electrode 56 and thus insures an arc of constant length. A blow magnet 65 is so disposed as to retain the arc in its proper operating position.

In Fig. 13, the electrode 56 is separated from its cooperating electrode 55 by means of a magnetizable core member 66 which is influenced by an electromagnet 67. When the lamp is not energized, the electrodes 55 and 56 are maintained in close mechanical contact by reason of the resilient member 59. In order to initially establish the arc, the lamp is connected in circuit with the supply mains, thereby energizing the winding of the electromagnet 67. At the same time, the core member 66 is so actuated as to separate the electrodes 55 and 56 from each other. In this manner, the arc is initially established, and the regulating functions thereof are performed by the electromagnet 67.

While I have shown and described several embodiments of my invention, it will be apparent to those skilled in the art that many

modifications may be made therein without departing from the spirit and scope of the appended claims.

I claim as my invention:

1. An electric arc lamp comprising an inclosure containing materials which vaporize at the pressure obtaining within said inclosure, the resulting vapors being capable of producing light only when in the path of an electric discharge, cooperating non-vaporizable electrodes disposed therein, and means for establishing an electric discharge between the electrodes, said vapors imparting the luminosity to the resulting arc and being capable of successive dissociation and recombination, whereby they may be introduced repeatedly to the arc without undergoing substantial deterioration of their light-giving properties.

2. An electric arc lamp comprising a hermetically-sealed envelop for the arc, substantially non-consumable and non-vaporizable electrodes disposed therein, means for establishing an electric discharge between said electrodes, and vapors that become light producing only when in the path of said discharge and contained in said envelop for continuous introduction to the established light producing arc, said vapors being capable of successive dissociation and recombination, whereby they may repeatedly attain their initial light-producing properties after recurrently passing through the arc.

3. An electric arc lamp comprising a confined body of vapors that become light producing only when in the path of an electric discharge, and substantially non-consumable and non-vaporizable electrodes for establishing an electric discharge, said vapors being capable of successive dissociation and recombination whereby they may continuously impart a high intrinsic brilliancy to the said electrical discharge without undergoing substantial deterioration in their light-giving properties.

4. The combination with two cooperating electrodes for producing an electric arc, of means for continuously furnishing titanium tetrachlorid to the arc.

5. The combination with two cooperating electrodes for producing an electric arc, of means for continuously furnishing titanium tetrachlorid vapor to the arc.

6. The combination with two cooperating electrodes for producing an electric arc, of means for continuously furnishing to the arc titanium tetrachlorid and a halogen.

7. The combination with two cooperating electrodes for producing an electric arc, of means for continuously furnishing vapors comprising titanium tetrachlorid and an element of the halogen group to the arc.

8. The combination with two cooperating electrodes for producing an electric arc, of

means for continuously furnishing vapors comprising titanium tetrachlorid and bromin to the arc.

9. The combination with two cooperating electrodes for producing an electric arc, of means for continuously furnishing titanium tetrachlorid to the arc, and means for effecting recombination of the decomposition products of the arc, whereby the titanium tetrachlorid may be recurrently introduced to the arc without undergoing substantial deterioration of its light-giving properties.

10. An arc lamp comprising a sealed container providing an arc chamber and a superposed condensing chamber, a stationary electrode disposed in the arc chamber, a cooperating movable electrode extending therein, a draft tube surrounding said movable electrode and furnishing an annular opening exterior of said draft tube and between the arc and condensing chambers, and means for effecting separation of said electrodes.

11. An arc lamp comprising a globe providing an arc chamber and having a plurality of superposed condensing chambers, cooperating electrodes and a draft tube surrounding the upper electrode, said draft tube furnishing direct communication therethrough between the arc chamber and the uppermost condensing chamber only.

12. An arc lamp comprising a container providing an arc chamber and a plurality of condensing chambers superposed upon said arc chamber and arranged in series relationship, an electrode, and a draft tube surrounding said electrode and furnishing direct communication therethrough between the arc chamber and the uppermost condensing chamber only.

13. An arc lamp comprising a container providing an arc chamber and a plurality of expanded portions superposed upon said arc chamber and communicating with one another in series relationship through constricted openings, an electrode and a draft tube surrounding said electrode and furnishing direct communication therethrough between the arc chamber and the uppermost one only of said expanded portions.

14. An arc lamp comprising a container providing an arc chamber and a superposed condensing chamber, a pair of cooperating and aligned electrodes, and a light transmitting draft tube embracing the upper electrode for furnishing direct communication between the arc chamber and said condensing chamber, said draft tube serving to completely surround the arc formed between said electrodes.

15. The combination with two cooperating non-consumable and non-vaporizable electrodes for producing an electric discharge, of means for continuously furnishing

a cyclically dissociable and recombinable vapor to said discharge, which vapor imparts light giving property thereto whereby a defined arc of high intrinsic brilliancy may be generated.

16. The combination with a hermetically-sealed chamber, cooperating electrodes therein between which an electric arc may be maintained, and means for continuously furnishing vapors of a titanium halid to the arc.

17. The combination with a hermetically-sealed chamber, cooperating electrodes therein between which an electric arc may be maintained, means for continuously furnishing vapors of a titanium halid to the arc, and an auxiliary chemical substance that serves to stabilize said arc.

18. The combination with a hermetically-sealed chamber, cooperating electrodes therein between which an electric arc may be maintained, and means for continuously furnishing vapors of a titanium tetrahalid to the arc.

19. The combination with a hermetically-sealed chamber, cooperating tungsten electrodes therein between which an electric arc may be maintained, and means for continuously furnishing vapors of a titanium tetrahalid to the arc.

20. The combination with a hermetically-sealed chamber, cooperating, non-consumable and non-vaporizable electrodes therein between which an electric arc may be maintained, and means for continuously furnishing vapors of a light-giving halid to said arc, the said vapors being derived externally with respect to the said electrodes.

21. The combination with a hermetically-sealed chamber, cooperating, non-consumable and non-vaporizable electrodes therein comprising tungsten between which an electric arc may be maintained, and means for continuously furnishing vapors of a light-giving halid to said arc, the said vapors being derived externally with respect to the said electrodes.

22. The combination with a hermetically-sealed chamber, cooperating non-consumable and non-vaporizable electrodes therein between which an electric arc may be maintained, means for continuously furnishing vapors of a light-giving halid to said arc, and an associate chemical substance for stabilizing said arc.

23. The combination with a hermetically-sealed chamber, cooperating, non-consumable and non-vaporizable electrodes therein comprising tungsten between which an electric arc may be maintained, means for continuously furnishing vapors of a light-giving halid to said arc, and an associate chemical substance for stabilizing said arc.

24. An electric arc lamp comprising a

light-transmitting container constantly
filled with vapors of a halid having high
luminous capacity, coöperating and non-
vaporizable electrodes disposed therein, and
5 means for establishing an electric discharge
between said electrodes whereby the por-
tion of said vapors in the path of said dis-

charge only becomes luminous to impart a
high intrinsic brilliancy to the resulting arc.

In testimony whereof, I have hereunto 10
subscribed my name this 28th day of May,
1915.

WILLIAM A. DARRAH.