S. O. HOFFMAN.

INCANDESCENT LAMP.

APPLICATION FILED MAR. 19, 1912.

1,083,326.

Patented Jan. 6, 1914.

2 SHEETS—SHEET 1.

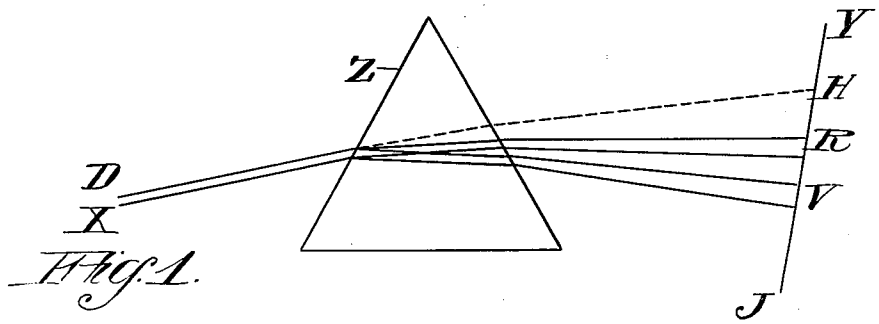


Fig. 1.

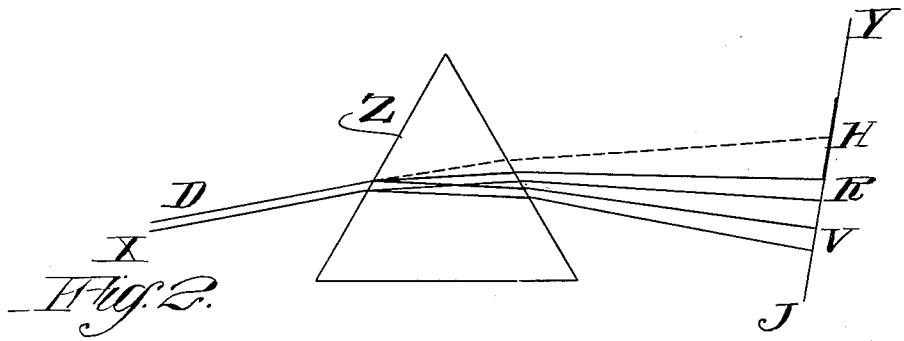


Fig. 2.

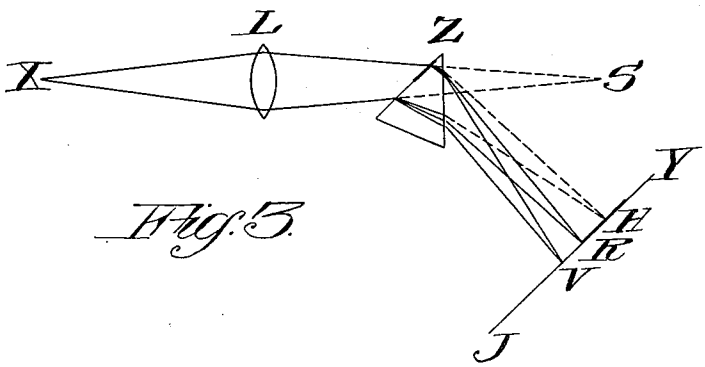


Fig. 3.

Witnesses.
Thos. Lastberg.
R. S. Berry.

Inventor.
Samuel O. Hoffman.
by G. H. Strong.
his Atty.

S. O. HOFFMAN.

INCANDESCENT LAMP.

APPLICATION FILED MAR. 19, 1912.

1,083,326.

Patented Jan. 6, 1914.

2 SHEETS—SHEET 2.

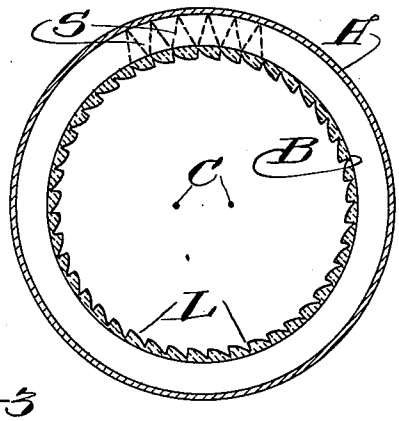


Fig. 5.

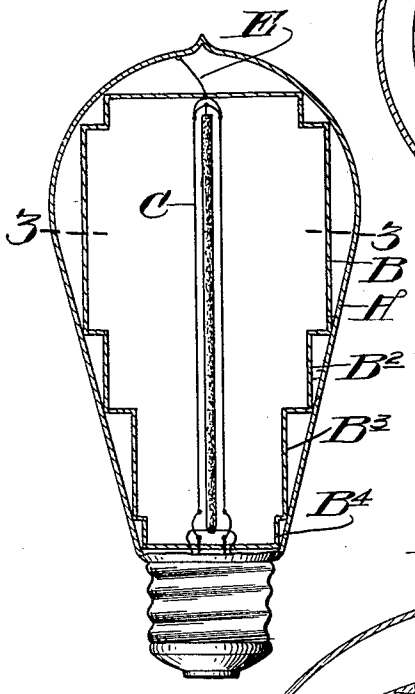


Fig. 7.

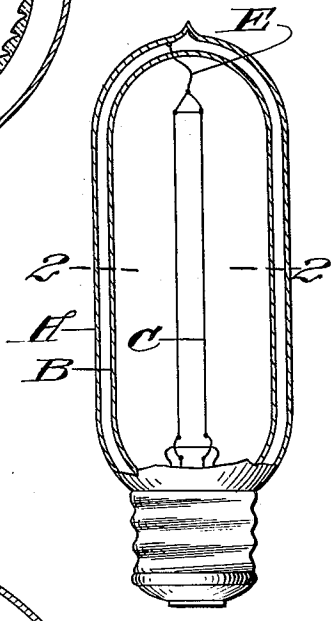


Fig. 4.

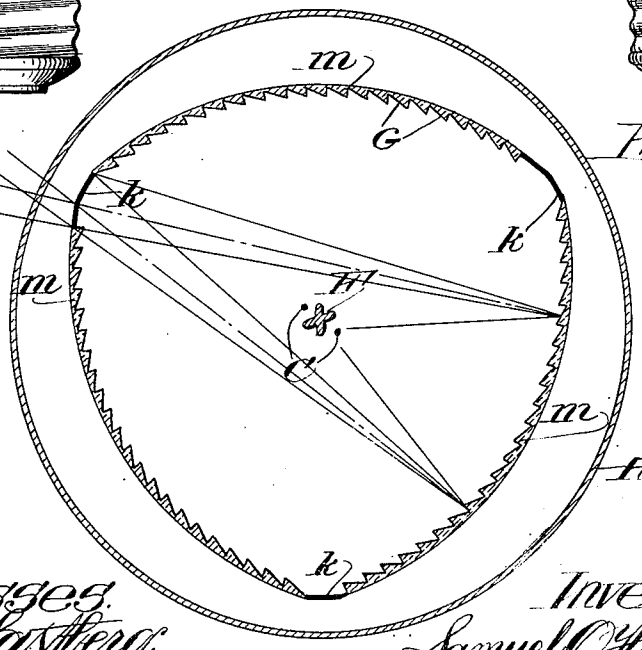


Fig. 6.

Witnesses.
Thos. Castberg.
R. S. Burns.

Inventor.
Samuel O. Hoffman.
by S. H. Strong.
his Atty.

UNITED STATES PATENT OFFICE.

SAMUEL O. HOFFMAN, OF SAN FRANCISCO, CALIFORNIA.

INCANDESCENT LAMP.

1,083,326. Specification of Letters Patent. Patented Jan. 6, 1914.

Original application filed November 3, 1911, Serial No. 658,359. Divided and this application filed March 19, 1912. Serial No. 684,750.

To all whom it may concern:

Be it known that I, SAMUEL O. HOFFMAN, a citizen of the United States, residing in the city and county of San Francisco and State of California, have invented new and useful Improvements in Incandescent Lamps, of which the following is a specification.

This invention relates to the production of light, and pertains more especially to improvements and developments in the method and means indicated in my co-pending application Serial No. 638,911. While this present invention is in the nature of an improvement on the subject-matter of said prior application, it is not to be considered thereby as limited in its nature and scope, since in some respects it proceeds along distinctly original lines.

The invention consists of the parts and the construction and combination of parts as hereinafter more fully described and claimed, having reference to the accompanying drawings, in which—

Figures 1, 2 and 3 illustrate the application of the laws of optics, underlying the invention. Figs. 4 and 6 represent different forms of the invention embodying the same principle. Figs. 5 and 7 are sectional views taken respectively on enlarged lines 2—2, Fig. 4 and 3—3 Fig. 6.

In my prior application referred to, I disclose a method for separating the radiation from an incandescent source into its luminous and non-luminous portions, allowing the luminous portions to radiate freely and directing the non-luminous back to the source, using it over and over again regeneratively without loss.

In the present invention I employ the principle of a spectrum; the invention consisting generally in forming a spectrum, or series of spectra of the radiation from the source directing the non-luminous portion of the spectrum or spectra back to the source, and allowing the luminous portion to pass freely; also to produce radiation of a desired wave length by forming a spectrum or spectra of the total radiation from the source allowing the portion of the spectrum of the desired wave length to pass, and directing the remainder of the spectrum back to the source and using it regeneratively.

The radiation from an incandescent source, such as a lamp filament, consists of waves of all lengths, a small portion (ranging from red to violet) being luminous (or so-called white light) but by far the larger part of the energy being radiated as invisible infra-red waves. It is this production of non-luminous radiation that causes all the present forms of incandescent lamps to have such a low efficiency. In this invention a spectrum is formed of the radiation from the source, the luminous portion of the spectrum being allowed to pass freely, and the non-luminous infra-red radiation, carrying most of the energy, being directed back to the source and used regeneratively; the consumption of energy thus being equivalent only to the light produced, and there is no production of useless infra-red radiation.

Fig. 1 represents diagrammatically the usual method of producing a spectrum. A narrow beam of white light D, coming from source X, enters the prism Z, and is refracted toward the base. White light consists of waves of all lengths between the red and violet, and each wave length is refracted to an extent depending upon its length, the violet being refracted most and the red least. Therefore, the beam of white light D upon passing through the prism is split up into its constituent wave lengths (indicated by colors) producing a spectrum RV on the screen YJ. Now suppose D is a beam from an incandescent source X containing radiation of all wave lengths, luminous and non-luminous. The beam will be refracted as before and a spectrum formed on screen YJ, the luminous portion extending from V to R and infra-red R to H. It might be remarked that aside from the physiological fact of being luminous, the optical behavior of the infra-red radiation is no more different from the luminous radiation than that of red light is from violet light.

Fig. 2 is exactly the same as Fig. 1 except that a sheet of glass is used in place of the screen YJ. That portion of the glass where the infra-red radiation strikes RH is silvered; RV being left clear. It is apparent then that all the infra-red radiation in the beam D will be intercepted by this silvered glass and reflected back toward the source, the luminous radiation radiating freely through the clear glass RV. If now the total radiation from the source should be passed through a structure similar to Fig.

2, all the non-luminous radiation would be reflected back toward the source and only luminous radiation would be produced.

In Figs. 1 and 2, the waves of different lengths would overlap to a certain extent on YJ producing an impure spectrum. Fig. 3 shows the usual arrangement to overcome this. The radiation from the source X is intercepted by lens L and without the prism would produce a sharp image of the source at S, but if a prism Z is interposed, the light will diviate toward the base of the prism and a spectrum will be formed on YJ. This spectrum will readily consist of a series of images of the source in radiation of each wave-length, producing a spectrum with very little overlapping. It is apparent that the function of the lens L and prism Z could be combined into a prism with curved faces, as shown in the prisms L in Fig. 5.

These general principles are incorporated in the lamps shown in Figs. 4 to 7.

In Fig. 4 is represented an incandescent electric lamp, similar to the ordinary form except as explained below. A is the outer bulb; B an inner bulb so constructed as to produce on the inner surface of bulb A a series of spectrum images of the filament C. E is a spring support for the filament to keep it in proper position. The bulb A is silvered where the infra-red portions of the spectra strike, and clear where the luminous portions are formed; the infra-red radiations thus being reflected back to the filament and used regeneratively, while the luminous waves radiate freely. There is thus no loss due to non-luminous radiation.

Fig. 5 is an enlarged cross section of Fig. 4. The inner bulb has formed on it prisms L, (here shown exaggerated) which form spectra S on the bulb A; the portion of the bulb A where the infra-red waves strike being silvered, as explained. The faces of the prisms L are curved or lenticular in order to produce sharp spectrum images of the filament; the return of the infra-red radiation to the source being accomplished by the reflector provided by the silvered portion of the bulb in conjunction with the prisms.

Fig. 6 shows another form of the lamp lettered to correspond. The inner bulb B (shown in scetion in Fig. 7) is so made as to produce a series of spectra at certain points on its inner surface, which is silvered where the non-luminous portions of the spectrum strikes, and clear where the luminous are formed; the result being the same as in the lamp shown in Fig. 4. The inner bulb B is constructed, (Fig. 7) of a number of parabolic silvered totally reflecting surfaces *m*, *m*, *m*, which in conjunction with the prisms G (shown exaggerated) produce sharp spectrum images at points *k*, *k*, *k*, where the bulb is silvered as described as illustrated in Figs. 2 and 3. In this form of the lamp (Fig. 7) it appears in operation to have three filaments at the points *k*, *k*, *k*. F is a thin X-shaped strip of carbon placed between the two limbs of the filament, where it absorbs some of the reflected infra-red radiation and acts as a secondary source. Its size is so proportioned that it will attain the same temperature as the filament. It is not necessary to connect it in the circuit in any way.

It is to be noted that with the combination of prisms and reflectors shown, the spectrum image will always be formed at the same point (depending upon the curvature of the reflector), and independent of the refractive index of the glass used. The inner bulb B is made in portions of gradually increasing diameter as shown at B_4, B_3, B_2, in order to get the greatest possible amount of surface exposed to the radiation of the filament, as the life of an incandescent varies directly with the inner surface (due to blackening). In this lamp the outer bulb A has no function other than a mechanical inclosure.

The bulb B in Fig. 6 is preferably made as shown with a series of steps or conjoint sections with the lengthwise portions of these sections all parallel with the filament, in order to obtain the greatest amount of possible surface in a pear-shaped bulb, to which latter we are limited by the commercial practice of to-day.

It is understood that any suitable method of manufacturing may be employed in constructing these lamps, one very simple method being the making of the bulbs in sections, applying or forming the necessary prismatic surfaces on the inner bulbs and then assembling the sections.

A convenient way for forming the reflectors with prismatic surfaces is to draw the necessary forms on an enlarged scale, then reduce and transfer the same photographically to the interior of a polished cast iron mold. The mold is then engraved with the aid of templets and in casting the glass in the mold as easily fusible glass is preferably employed while the mold itself is kept at a temperature but slightly below that of the solidifying point of the glass, so as to prevent chilling. In the casting operation air is exhausted from the molds and the fluid glass is forced into all the fine lines by atmospheric pressure.

A convenient method of forming the reflecting surfaces in proper position for reflecting only those portions of the radiation which are non-luminous is to silver the entire reflecting and transparent portion of the surface of the bulb after the parts have been assembled, then coating the silvered surface with a film of bichromatized gelatin. A radiation source similar in shape and po-

sition to the filament is then placed in the bulb and a filter interposed between the source of radiation and the reflector, which filter is so constructed as to absorb the luminous rays while allowing the infra-red rays to pass through freely. A suitable filter is formed of a solution of iodin in carbon disulfid. Since all the luminous radiation is absorbed by the filter the spectra formed will consist only of the infra-red rays, and as the bichromatized gelatin is rendered insoluble when acted upon by such infra-red rays, those portions which are to constitute the reflecting surfaces will be protected by an insoluble coating of gelatin. After this treatment the bulb is put into hot water, thereby dissolving the soluble portions of the gelatin or those portions not acted upon by the infra-red rays, and corresponding in position to the position of the luminous rays on the glass. The silvering so exposed is then dissolved off, leaving these portions of the glass transparent and finally the insoluble gelatin is removed, leaving the reflecting surfaces perfect on those positions where the infra-red rays will strike the same. The insoluble gelatin may be removed by simply rubbing when softened by boiling water, if the silver film is thick enough to stand it, otherwise, by heating in contact with an oxidizing agent such as potassium nitrate, when the gelatin is destroyed. (This insoluble film is transparent.) In the above process the gelatin can be made more sensitive to the infra-red radiation by the use of dyes in the well known manner.

This application is a division of my original application filed November 3, 1911, Serial No. 658,359.

While the theory under which the invention appears to work has been expressed to the best of my ability, I wish to say that independent of any theory I have as a practical demonstrated fact, taken an incandescent body emitting a definite amount of luminous radiation; surrounded said incandescent body with a suitable selectively reflecting envelop, as already explained, and found that the amount of energy required to cause said incandescent body to continue to emit the same definite amount of luminous radiation was very greatly reduced from that amount of energy necessary when said body was radiating freely without the selective envelop. In addition to this, I have actually used the secondary source referred to and found that in certain instances even a still higher efficiency resulted.

Having thus described my invention, what I claim and desire to secure by Letters Patent is—

1. In a lamp, the combination of a source of radiation, a selectively reflecting structure so constructed as to produce a spectrum of total radiation from the source, one portion of the spectrum, representing one class of radiation, being intercepted by the reflector and returned to the source; the other portion of the spectrum, representing the balance of radiation being allowed to radiate freely.

2. A lamp comprising in combination an initial source of radiation, a secondary source, means for forming a spectrum of the radiation, and means whereby the luminous radiation is allowed to radiate freely and the infra-red radiation is directed back to the secondary source to be converted into luminous radiation.

3. A lamp comprising in combination an initial source of radiation, a secondary source, an arrangement of prisms and reflectors to produce sharp spectrum images of the source, and means whereby the luminous radiation is allowed to radiate freely and the infra-red radiation is directed back to the secondary source to be converted into luminous radiation.

4. A lamp comprising in combination an initial source of radiation, an arrangement of lenticular prisms to produce spectrum images of the source, and means whereby the luminous radiation is allowed to radiate freely, and the infra-red radiation is directed back to the source to be converted into luminous radiation.

5. A lamp embodying a source of radiation of waves of various length, a selective reflector for preventing the escape of non-luminous waves, and a radiator, independent of the initial source of radiation, interposed in the path of the reflected waves.

6. A lamp embodying an initial source of radiation of waves of various length, a selective reflector for preventing the escape of the non-luminous waves and embodying refracting surfaces for separating the waves of different length, and reflecting surfaces for the non-luminous waves, and a radiator independent of the initial source of radiation interposed in the path of the reflected waves.

7. A lamp embodying a source of radiation of waves of various lengths, and a reflector for returning the non-luminous waves embodying prisms for separating the waves of various length thereby forming spectra and reflecting surfaces interposed only in the path of the separated non-luminous waves and arranged to direct said waves to a source of radiation, whereby luminous waves only are allowed to escape and the non-luminous waves are utilized regeneratively.

8. A lamp embodying a source of radiation of waves of various lengths, a selective reflector around said source and embodying curved reflecting surfaces, prisms interposed between the source and reflecting surfaces,

whereby spectra of the waves are projected by said surfaces, and a secondary reflector interposed in the path of the projected non-luminous waves, whereby the luminous waves only are allowed to escape.

9. A lamp embodying a source of radiation of waves of various lengths, a parabolic reflector with prismatic faces whereby the projected waves are separated in accordance with their length, a second reflector interposed in the path of the non-luminous waves and means for converting the reflected non-luminous waves into luminous waves.

10. A lamp embodying a source of radiation of waves of various lengths, a curved reflector having a prismatic face whereby spectra of the waves are projected, and a means interposed in the path of the non-luminous waves, for converting them into luminous waves.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

SAMUEL O. HOFFMAN.

Witnesses:
JAMES MASON,
M. V. COLLINS.