UNITED STATES PATENT OFFICE.

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METHOD OF EXHAUSTING INCANDESCENT LAMPS.

1,273,629. Specification of Letters Patent. Patented July 23, 1918.

No Drawing. Application filed December 5, 1914. Serial No. 875,725.

To all whom it may concern:

Be it known that I, IRVING LANGMUIR, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Methods of Exhausting Incandescent Lamps, of which the following is a specification.

My invention relates to the treatment of glass receptacles, such, for example, as bulbs for incandescent lamps, to remove from the glass water vapor or other gases which would tend to shorten the life or lower the efficiency of the lamp or other device for which the receptacle is used.

It is well known that ordinary glass such as is used for incandescent lamp bulbs contains considerable amounts of absorbed or occluded water vapor and other gases. Portions of these gases are liberated as the bulb is heated, and when liberated within the bulb lower the vacuum and at the same time attack the filament and cause it to disintegrate. This action is especially noticeable in an incandescent lamp having a tungsten filament. In this case the water vapor apparently attacks the tungsten, forming tungsten oxid and liberating hydrogen. The tungsten oxid is deposited on the glass and the free atomic hydrogen reduces it, forming more water vapor and leaving a deposit of pure tungsten on the glass, the water vapor thus formed again attacking the filament. Thus the filament is disintegrated and at the same time a black deposit is formed on the bulb which absorbs a large portion of the light.

It is customary to heat the lamp bulbs or other receptacles while connected to the exhaust pump and thus drive off from the glass the greater portion of the water vapor or other gaseous matter which would be given off during the normal operation of the lamp or other device. If the lamp is a vacuum lamp the bulb does not usually, in operation, attain a temperature above 50° C. and by heating during exhaust to a temperature of 350° to 400° C. satisfactory results may be obtained. If, however, the apparatus is so designed that the glass receptacle will attain in the course of normal operation a much higher temperature than 50° C. difficulty is experienced in removing the water vapor or other gases to such an extent that the operation of the lamp or other device will not be impaired or the useful life shortened by water vapor or other gases which may be given off during normal operation.

The object of my invention is to provide a method for treating glass receptacles which will remove the water vapor or other gases to such an extent that it will be possible to operate them at a higher temperature than is possible with the previously used methods without the liberation of sufficient quantities of gas to affect the operation or life of the device for which the receptacle is employed.

There are many cases in which it is desired to operate glass receptacles at higher temperatures than those which have previously been employed. In the manufacture of incandescent lamps, and especially those which are filled with an inert gas, the size of bulb required to allow of operation at a comparatively low temperature may be much larger than would be required by other considerations or which it would be desirable to use. If, for example, the lamp is filled with mercury vapor it becomes necessary to make the bulb small enough so that it will operate at the high temperature necessary to produce the desired pressure of mercury vapor. With other devices than incandescent lamps, such as mercury vapor lamps, rectifiers, Röntgen ray tubes, vacuum discharge apparatus, etc., it may be desirable to employ smaller receptacles than heretofore, or it may be possible to improve the operation by better methods of treating the receptacle than have previously been used. In all such cases my improved method of treating the receptacle may be used to advantage.

The temperature at which the exhaust may be carried on will depend largely upon the nature of the glass which is used. With ordinary lead glass if an attempt is made to exhaust at temperatures above 400° the glass begins to soften. By employing a vacuum oven so arranged that the pressure outside of the bulb may be maintained practically the same as that inside the temperature may be carried as high as 500° C. In the construction of lamps which are so designed that the bulb will operate at high temperatures I consider it preferable, however, to employ a glass having a higher melting point than ordinary lead glass. I

have found that a sodium-magnesium boro-silicate glass known as low expansion glass gives very good results. If with such a glass the exhaust is carried on at a temperature of 400° to 500° C. fairly satisfactory results may be obtained. If, however, the temperature is carried much higher, say, from 550° to 600° C. it is found that the results obtained are much less satisfactory than when a temperature of less than 500° C. is used. It would seem from this result that higher temperatures than 500° C. should be avoided altogether. I have discovered, however, that if the bulb is exhausted first at a temperature of from 550° to 600° C. and later at a temperature of about 400° to 500° C. much better results may be obtained than by treating at either temperature alone. If the process is reversed and treatment at a high temperature follows the treatment at the lower temperature the results obtained are no better than if the treatment at the higher temperature alone is employed. In some cases the exhaust may be carried out in more than two steps, the temperature successively decreasing with each step in the operation.

As an indication of the improvement which may be obtained in this way I will give an example of results which have been secured in actual practice. Three lots of lamps were made with the same structural details and operating characteristics, the first lot was exhausted at approximately 450° C., the second lot at 550° C. and the third lot at 550° C. at first and then at 400° C. The average life of the first lot was approximately 575 hours, of the second lot 300 hours, and of the third lot over 900 hours, the conditions of operation with all three lots being the same.

Just why such a marked improvement may be obtained by my method of exhaust perhaps cannot be stated with certainty. Apparently, however, the treatment at 400° to 500° C. liberates the water vapor only from a comparatively thin surface layer of the glass. When the temperature is increased the water vapor is apparently drawn out from a much deeper layer of the glass and possibly is drawn outward at a greater rate than it can be liberated at the surface. If this is true, when the exhaust is stopped at 550° to 600° C. there will be considerable amounts of water vapor left in the surface layer of the glass. If, however, the exhaust is continued at 400° to 500° C. no more water vapor will be drawn out of the deeper layers and that which remains in the surface layer will be liberated.

The length of time ordinarily required to liberate the water vapor will vary, but in general it has been found that after treating a glass having a high melting point, such as the one I have mentioned, for half an hour at a given temperature below 500° C. the liberation of water vapor will practically stop. At higher temperatures, however, this apparently is not true, but water vapor will continue to be liberated no matter how long the treatment is continued. Possibly this is due to the fact that there is a diffusion through the glass at the higher temperatures. Careful experiments have shown that no matter how long the treatment is continued at temperatures above 550° C. if the bulb is not subjected to further treatment at a lower temperature sufficient quantities of water vapor may be liberated during the normal operation of the lamp to greatly shorten its life and lower its efficiency.

The length of time necessary to carry on the exhaustion according to my method to secure the desired results will vary with different glasses and different temperatures employed. With the boro-silicate glass mentioned I have found that little is to be gained by treating longer than one-half hour at each temperature, and in some cases treatment for a much shorter time may be sufficient.

While I have described my invention with special reference to a gas filled lamp, it will be apparent that its utility is not confined to such a device but that it may be advantageous in any case in which a glass receptacle is operated at such a high temperature that injurious gases are liberated therefrom which are not removed by the previous known methods of exhaust. Although water vapor is believed to be the only gas which is greatly injurious in an incandescent lamp, it is possible that there are other gases given off by the glass the presence of which tend to shorten the life or lower the efficiency of the lamp and that my method of treatment is effective in removing these gases as well as in removing water vapor.

It will be understood that the temperature values I have given are somewhat general with the exception of the particular temperatures mentioned with regard to the boro-silicate glass. In general, however, it may be said that for the highest temperature the best results will be obtained when the exhaust is carried on at a temperature only slightly below that at which the glass becomes so soft that there is danger of the bulb being deformed even in a vacuum oven. The utility of my invention, however, is not limited to treatment in a vacuum, but may be employed to advantage with temperatures which may be safely attained with atmospheric pressure outside of the bulb. The second step of the process should be carried on at a temperature which may be 100 or more degrees lower than the higher temperature.

The temperature at which the operation should be carried on will also depend somewhat upon the temperature at which the lamp or other device is to operate normally. The maximum temperature should be at least 200° above the normal operating temperature and the lower temperature should be at least 100° above the normal operating temperature and at least 100° below the highest temperature.

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

1. The method of freeing a glass receptacle from occluded or absorbed gases which consists in maintaining it during exhaustion for a time at such a temperature that gas will be continuously liberated from the walls in appreciable quantities irrespective of the length of time the treatment is continued and continuing the exhaustion at a definite lower temperature which is so chosen that the liberation of gas practically ceases after treatment at the lower temperature for a period of not over one-half hour, the lower temperature being at least 100° C. above the normal temperature at which the receptacle is to be operated.

2. The method of freeing a glass vessel from occluded or absorbed gases which consists in maintaining the vessel while being exhausted at a temperature of at least 550° C. for a time and afterward maintaining it at a definite temperature of less than 500° C. as long as gas continues to be liberated from the glass while continuing the exhaustion.

In witness whereof, I have hereunto set my hand this fourth day of December 1914.

IRVING LANGMUIR.

Witnesses :

WILLIAM C. WHITE,

HELEN ORFORD.