

UNITED STATES PATENT OFFICE.

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METHOD OF TREATING FILAMENTS FOR INCANDESCENT ELECTRIC LAMPS.

No Drawing.

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To all whom it may concern:

Be it known that I, JOHN H. RAMAGE, a citizen of the United States, and a resident of Norfolk, in the county of Norfolk and State of Virginia, have invented a new and useful Improvement in the Method of Treating Filaments for Incandescent Electric Lamps, of which the following is a specification.

My invention relates to the manufacture of metallic filaments for incandescent electric lamps, and it has for its object to provide a method of treating filaments of tungsten and other equivalent refractory metals for the purpose of imparting to such filaments an internal structure which resists alteration during burning and which, therefore, adds materially to the operating life of the filaments.

The life of a metal incandescent-electric lamp filament is limited by the alterations which take place in the filament during burning, such alterations comprising mainly the bodily discharge or evaporation of particles of metal from the filament and rearrangements and crystalline growth within the filament. Such internal changes render the filament brittle and cause it to become deformed or break after a limited period of service, particularly if the filament is of the small diameter required in the smaller types of lamps. One such internal change manifests itself in a displacement in sections of a filament with respect to its longitudinal axis and it is usually designated by the term "off-setting".

I have discovered that, if a definite internal crystalline structure is imparted to a metallic lamp filament before the lamp is placed in service, further internal alteration is restrained and the life of the filament is materially increased. I produce such internal structure by subjecting the filament, after it is placed in the lamp bulb, to a form of heat treatment, which, I have discovered has the above indicated beneficial effect upon the filament. This heat treatment may conveniently be combined with the usual flashing operation or if desired it may be carried out in a separate operation. In either case the object of the invention may be achieved which, more specifically stated, is to impart to a finished filament, adapted to function as the incandescent ele-

ment of an electric lamp, a definite and advantageous crystalline structure in which the number of the grains or crystals lie within certain limits and the size thereof is maintained uniform

In practicing the treatment contemplated by my invention, it is possible to control the crystalline structure and therefore the burning life of metallic filamentary materials, such as tungsten and similar highly refractory metals, which are in the fibrous state before the process is applied. The term fibrous state as here and hereinafter used is intended to mean a metallic structure responsive to a treatment capable of producing an equiaxed crystalline condition.

In metals, the grain structure of which has been deformed by mechanical working there is a certain temperature known as the critical or equiaxing temperature at which the metal assumes an unstressed or natural cell-like structure, known as the equiaxed condition. Immediately above this equiaxing temperature there is a temperature zone in which the enlarging or growth of the grains composing the metal structure is extremely rapid, which for the purpose of this application will be termed the rapid grain growth range. Beyond the extreme limit of this range there is another range in which grain growth takes place much more slowly and which extends up to the fusion point of the metal. To avoid rapid grain growth and to retain the desirable structure imparted to the filament, it is deemed essential that the zone of rapid grain growth be passed through rapidly, i. e., the heat-treatment is not prolonged for any appreciable period of time in the rapid grain growth range, thus avoiding detrimental crystal growth.

I have found that, in the case of a swaged tungsten rod or ingot of .170" diameter, the equiaxing temperature is approximately 1800° C. It is to be understood that there are several factors which influence the critical and germinative temperatures of a filament such as the kind and purity of the material comprising the same, size thereof, operating efficiency, etc., but generally speaking, these temperatures cover a range from 1800° C. to 2100° C. for tungsten filaments containing a small percentage of an offset-resisting material such as thoria. As here-

inafter more fully set forth, the germinative range is not a fixed temperature range for all metals, but nevertheless may be regarded as substantially fixed for given conditions as to kind, quality, and mass of the substance composing the filament. For the purpose of this application, the germinative range of temperatures shall be considered as that range including the critical temperature and the range of rapid grain growth and excluding the range in which slow grain growth takes place.

I have found that there is a direct relation between the life of the filament and its initial grain structure. By initial grain structure is meant that structure the filament has when it begins its commercial useful life. My invention is directed to influencing the grain structure when the fibrous structure is changed to crystalline. This latter conversion has always occurred in the manufacture of tungsten lamp filaments when the latter have been heated for the first time by a flashing process, which consisted in increasing the applied voltage at a uniform and comparatively slow rate from a fractional part of the normal voltage to a value somewhat in excess of the normal; the structure resulting from such heating, however, has resulted in the formation of a filament having an initial grain structure non-uniform in size. My invention, therefore, is directed to a properly controlled method of converting the fibrous structure of the drawn wire to the optimum crystalline condition and the process is therefore begun when the filament is in the fibrous condition. Furthermore, by practicing my method, a filament is produced having an initial grain structure that is uniform.

I have also discovered that the grain structure of the lamp filament changes during the life of the lamp and that, after a certain time, which is in the filament's early life, the grain growth takes place very rapidly and that the formation of uneven and coarse grains effects a subsequent deterioration of the filament, recognized in the phenomenon known as offsetting.

Controlling the crystalline structure and thus increasing the life of lamps now commonly used is one of the purposes of this invention.

In practicing my invention, the metal may be raised to just below the critical temperature thereof and then by a subsequent heat-treatment the germinative range or zone may be passed through very rapidly to a relatively high temperature, i. e., a temperature which is higher than the extreme limit of the germinative range, which temperature should be less than the fusion point of the metal. The high temperature may be maintained for a predetermined

period, care being exercised not to reach the fusion point. This treatment contemplates two stages. However, the treatment may be practiced in one stage by raising the temperature in one step to the high temperature.

In passing rapidly through the critical point to a relatively high temperature, the intermediate germinative range is necessarily also passed rapidly. In maintaining the filamentary body at the relatively high temperature above the germinative range, the duration of time in which it is so maintained is dependent on the grain size which it is desired to produce.

By this process I obtain a structure in which all the grains are substantially of the same size. This uniformity of grain size is one of the features of my invention, as grains of the same size are not readily absorbed into each other and therefore no substantial amount of grain growth occurs to result in the objectionable non-uniform sized grains which results in off-setting.

The previous method of initially heating the filament which comprised passing slowly and uniformly through the critical point and the rapid grain growth range, produced an irregular grain structure, i. e., a structure consisting of large and small grains. This difference in grain size resulted in the absorption of the small grains by the large grains; in other words, there was a grain growth resulting in non-uniform sized grains which offset and are therefore deleterious to the life of the filament.

Following these general principles, a heat-treating schedule may be determined which will produce a given grain structure for any size filament. A proper heat-treating schedule may be devised for a filament of given size by applying the proper voltage for the proper period of time. This temperature control permits the regulating or governing of the initial grain structure of a lamp filament, and upon the initial grain structure depends the life of the filament. In other words, a given grain formation depends upon the use of a certain heat-treating schedule, and the life of the lamp is dependent upon a given grain formation. I have found that a heat-treating schedule which will produce a grain size or formation of between say, 12000 to 18000 grains per sq. mm. results in a tungsten filament destined for a considerably longer life than one in which no attempt has been made to control the grain growth.

As an example of how the foregoing data may be applied in predetermining the grain structure of a given filamentary body, I submit the following schedules which produced very satisfactory results where standard 40 watt 110 volt Mazda B type lamps, i. e., vacuum lamps were used. I found that the

filament of this type lamp if heat-treated for 5 minutes at 80 volts and then the temperature is rapidly increased by raising the voltage in one step to 130 volts and maintaining the same for about 5 minutes would be given a crystalline structure of approximately 12,000 grains per square mm. These stages may follow each other or the first may be performed and the latter take place when the lamp is initially burned in commerce. The filament temperature of such a designed lamp, when operated at 80 volts is about 1775° C. and, when burned at 130 volts, is substantially 2200° C. Since the germinative range for tungsten filaments is from 1800° C. to 2100° C., depending upon whether the tungsten is substantially pure or contains additive materials such as thoria, etc., it will thus be observed that the filament was first raised to a temperature bordering upon its critical temperature, and then this temperature was suddenly increased to a temperature in excess of that at which grain growth takes place rapidly. It must be borne in mind that the fundamental idea underlying my invention is that of passing through the rapid range growth very rapidly. Therefore, it is to be appreciated that instead of conducting the heat-treatment in two distinct stages, the desired result may be secured by raising the temperature of the filament in one step to a point above the rapid grain growth range. In the illustration given, the first step could be omitted and only the second step applied. By further variation in the heating schedule, following the general principles outlined, practically any desired grain size for a given filamentary material may be developed. When lamps treated according to the schedule mentioned were life-tested, they did not burn out for substantially 1400 hours. Since the average life of a lamp not subjected to my heat seasoning schedule is approximately 1100 to 1200 hours, it is evident that a lamp treated as contemplated by this invention has an increased life efficiency of at least 10%.

From the above remarks, it will be seen that heat-treatment causes the grain growth to start, and that the proper control of the heat-treatment determines whether the grain structure shall be regular or irregular, i. e., uniform or non-uniform, and also determines the fineness of the grain at the beginning of the life of the lamp. Also, it would appear that the life of the lamp is dependent on the rate of grain growth, and any means which will have a tendency to retard grain growth during the service of the lamp will increase its efficiency by prolonged life.

According to my discovery, if the filament is given a predetermined initial crystalline structure, future rapid grain growth

is retarded, especially if the lamp is operated at its designed rating, and this retardation of rapid grain growth is found to be beneficial in prolonging the useful life of the lamp.

While I have herein particularly described a preferred method of effectuating my invention, I do not wish to be limited to the precise details set forth as changes may readily be made without departing from the spirit of the invention.

What is claimed is:

1. A filament of tungsten or equivalent refractory metal consisting of grains substantially uniform in size.

2. An offset-resisting filament consisting essentially of crystallized tungsten only, said tungsten having crystals substantially uniform in size.

3. A metallic filament of tungsten or equivalent refractory material having a crystalline structure in which the grains are of uniform size and within a range of 12,000 to 18,000 grains per square millimeter.

4. A crystallized filament formed from tungsten having initially a fibrous structure, said filament consisting of grains which number 12,000 to 18,000 per square millimeter.

5. In the process of treating incandescent lamp tungsten filaments having a fibrous structure, the step which consists in elevating the temperature thereof rapidly through the critical temperature and the range of rapid grain growth.

6. In the process of treating tungsten having a fibrous structure, the step which consists in elevating the temperature thereof rapidly through the critical temperature and the range of rapid grain growth.

7. The method of producing an offset-resisting filament which consists in initially heating fibrous tungsten to just below its critical temperature, passing rapidly through the germinative range to a relatively high temperature and maintaining the latter temperature for a predetermined period.

8. The method of producing an offset-resisting filament which consists in initially heating drawn tungsten to just below its critical temperature, passing rapidly through said critical temperature and the range of rapid grain growth and maintaining a temperature for a predetermined period above said range.

9. In the method of retarding grain growth in an incandescent lamp filament of tungsten having initially a fibrous structure the step which consists in producing crystals in said filament substantially uniform in size by heating the filament rapidly to a temperature above the range of rapid grain growth.

10. The method of imparting a definite crystalline structure to tungsten or equivalent refractory material, which consists in raising the material to just below its critical temperature, passing through the germinative range rapidly, and maintaining a high temperature above said range for a predetermined period, being careful not to reach the fusion point.
11. In the method of imparting a definite crystalline structure to a tungsten filament, the step which comprises rapidly raising the temperature of the filament to a degree above the germinative range but below the fusion point of the metal.
12. The method of imparting a definite crystalline structure to a tungsten filament, which comprises rapidly raising the temperature of the filament to a degree above the germinative range but below the fusion point of the metal and maintaining said temperature for a predetermined interval.
13. The step in the method of imparting a definite crystalline structure to a tungsten or equivalent metal filament mounted in an incandescent lamp, which consists in rapidly raising the temperature of the filament to a degree above the germinative range but below the fusion point of the metal.
14. The method of imparting a definite crystalline structure to a tungsten or equivalent metal filament mounted in an incandescent lamp, which comprises rapidly raising the temperature of the filament to a degree above the germinative range but below the fusion point of the metal and maintaining such temperature for a predetermined interval.
15. In an electric incandescent lamp, a filament composed mainly of tungsten and possessing, after having its temperature rapidly raised above the germinative range, grains substantially uniform in size.
16. In an electric incandescent lamp, a filament consisting essentially of crystallized tungsten only and possessing, after having its temperature rapidly raised above the germinative range, crystals substantially uniform in size.
- In testimony whereof, I have hereunto subscribed my name this 24th day of Sept. 1917.

JOHN H. RAMAGE.