Oct. 5, 1965 J. J. MASON 3,210,589

ELECTRIC INCANDESCENT LAMP HAVING FILAMENT OF PARTIALLY RECRYSTALIZED FIBROUS STRUCTURE

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FIG. 1.

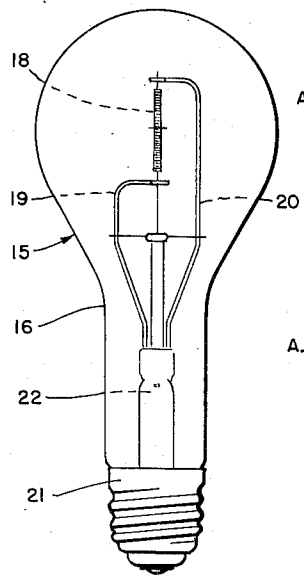


FIG. 2.

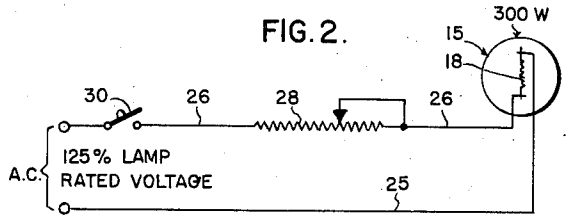


FIG. 3.

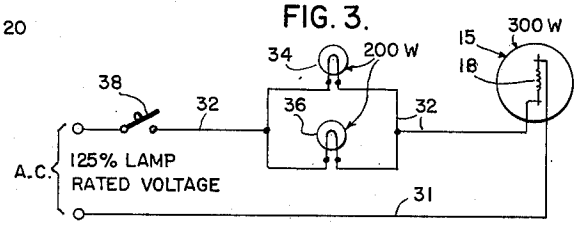


FIG. 4.

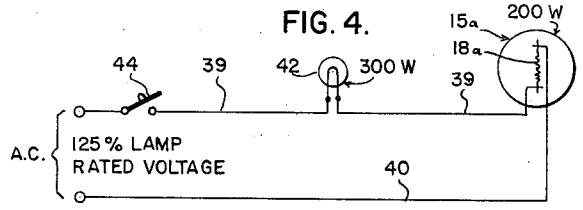


FIG. 6.

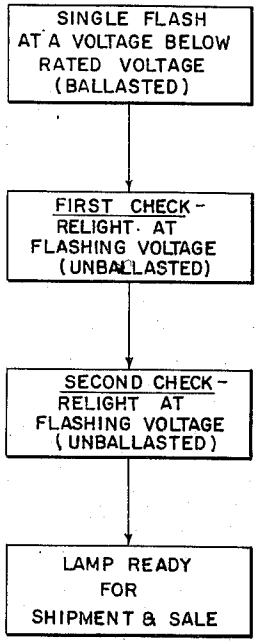
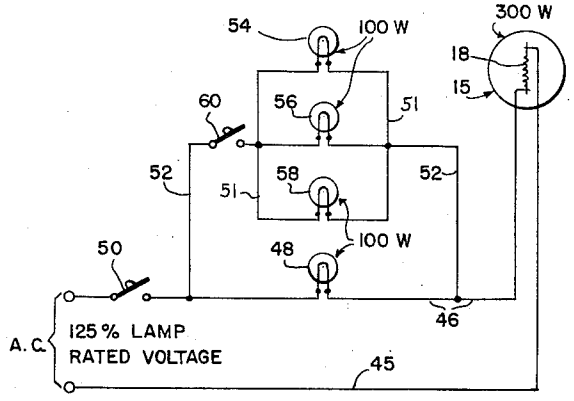


FIG. 5.



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FIG. 7.

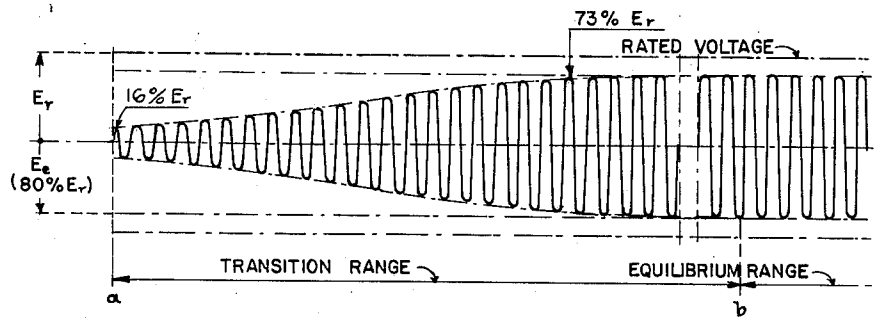


FIG. 8.

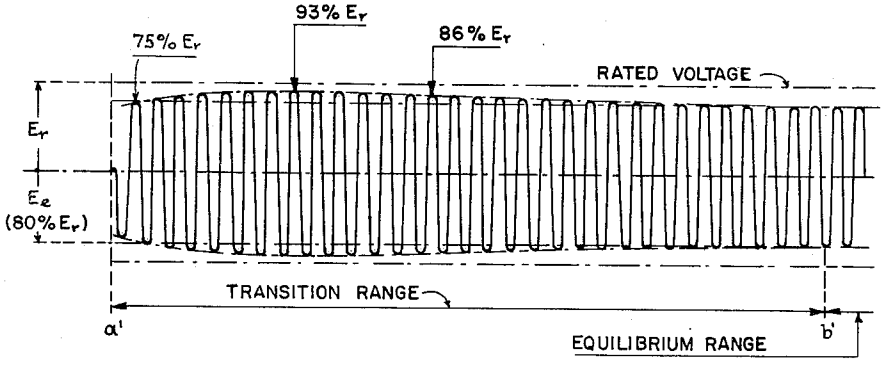
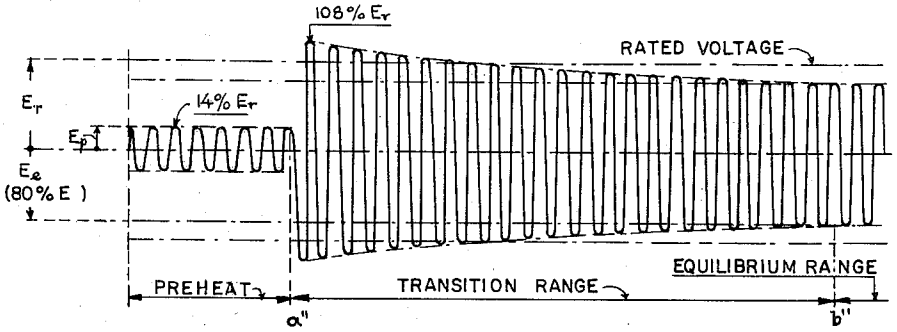


FIG. 9.



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FIG. 10.

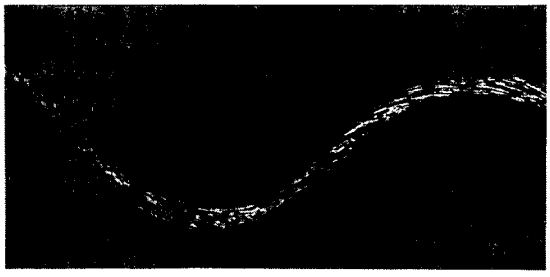


FIG. 11.

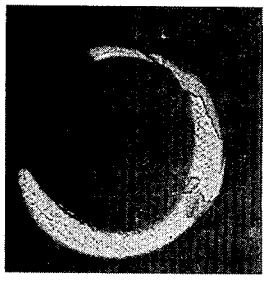


FIG. 13.

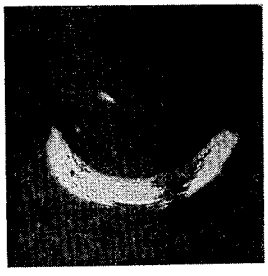


FIG. 12.

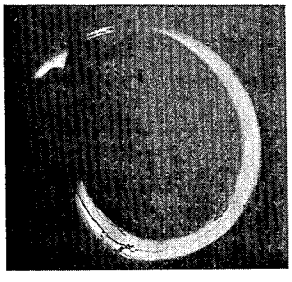
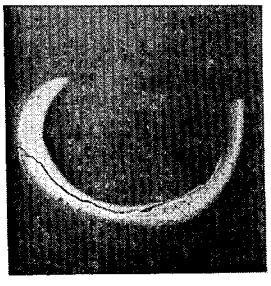


FIG. 14.



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6 Claims. (Cl. 313—315)

This invention relates to electric lamps and, more particularly, to incandescent lamps having filaments with improved shock resistance.

After incandescent lamps have been exhausted and sealed they are customarily lighted up or "flashed" a number of time at progressively higher voltages. The purpose of this so-called flashing schedule is to heat the filament to a sufficiently high temperature at vaporize impurities such as oxides or other foreign matter that may be present on the surface of the wire and to convert such wire from its worked or fibrous microstructure to a crystalline microstructure that is conducive to good life performance. In lower wattage lamps where getter is applied to the filament to facilitate the cleaning up of gaseous impurities in the lamp, the aforesaid flashing also serves to vaporize such getter.

Flashing is most commonly accomplished on the basing machine and a typical schedule for gas filled lamps having coiled-coil filaments consisting of a step-wise increase of applied voltages from about 50% to 105% of the rated lamp voltage in, perhaps, five or more index positions or stations of the basing machine. The flashing circuit at each of the aforesaid stations includes a suitable ballast (except in the case of low voltage lamps) to limit the current and thus prevent the impurities vaporized from the filament from causing an arc and ruining the lamp. A final light-up at 100% of the lamp rated voltage or higher is provided at an unballasted position for the purpose of detecting and destroying lamps having internal shorts.

As is well known, lamp filaments are fabricated from refractory metal such as tungsten that is produced by powder metallurgy techniques, drawn into wire and then wound into either a single coil or coiled-coil helix of the proper diameter and length. Thus, the filamentary wire before flashing has a worked or fibrous microstructure throughout and is, accordingly, sufficiently ductile to withstand the coiling operation. During flashing, the wire is heated to its recrystallization temperature and its fibrous microstructure thus converted to a crystalline microstructure with resultant setting or hardening of the filament. However, before the filament reaches its recrystallization temperature and is set and rendered sag-resistant, it reaches a temperature at which it becomes plastic enough to sag under its own weight.

When the unflashed filament is slowly heated to its recrystallization temperature, as by flashing the lamp at progressively higher voltages in a plurality of steps in accordance with conventional flashing schedules, the filament remains plastic for a sufficiently long period of time to develop an appreciable amount of sag. While the degree of sag which occurs during multiple-step flashing may not be serious in lamps having filaments that are disposed transverse to the lamp axis, as for example in the so-called C9 or CC6 type filament, it constitutes a serious problem in the vertically mounted coiled-coil or CC8 filaments now being employed in that when such lamps are flashed in a vertical position it causes the spacing between the secondary turns at the lower end of the coil to decrease and the spacing between turns at the upper end of the coil to increase. The resultant non-uniform temperature distribution along the length of the filament produces

"hot-spots" which shorten the life of the lamp and cause undesirable variations in its rating. As a solution to this problem it has been proposed that lamps having CC8 filaments be flashed in a horizontal rather than a vertical position. However, this is not only inconvenient from a manufacturing standpoint but produces an appearance defect in lamps with clear bulbs since the coil sag is asymmetrical to the lamp axis rather than symmetrical as in the case of C9 and CC6 filaments.

In addition to the aforesaid sag problem, the prior art practice of completely recrystallizing the filament during flashing makes it brittle and very fragile. As a result, the filament frequently breaks while the finished lamp is being packed or shipped thus posing a problem that has plagued the lamp industry from its very inception and, in some cases, necessitates the use of very costly packaging.

It is accordingly the general object of this invention to provide a flashed incandescent lamp that has a long useful life and a filament with a minimum amount of sag.

It is a further object to provide an electric incandescent lamp that contains a flashed filament having a microstructure which improves the shock resistance of the filament and reduces the incidence of filament breakage during handling and shipment of the finished lamp.

The foregoing objects, and other which will become apparent as the description proceeds, are achieved by flashing the lamp in a single step or operation instead of in several stages as heretofore. A voltage of such character is applied to the lamp that the filament is readily heated to its recrystallization temperature and set. Thus, the filament is in a plastic condition for a shorter period of time than in the case of the prior art mode of flashing and, accordingly, experiences less sag.

According to the second aspect of this invention, the incidence of filament breakage during shipment of the finished lamps is reduced by employing a flashing voltage that has an equilibrium value below that at which complete recrystallization of the filament would occur within the flashing period. The flashed filament is, accordingly, only partly recrystallized or "underflashed" and has unrecrystallized fibrous regions therein which render the flashed filament more resilient and better able to withstand the vibration and shock it experiences during the packing and shipping of the finished lamp. Preferably, the two concepts, namely, "underflashing" and "one-step" flashing, are combined to provide a means for controlling both the degree of filament sag and brittleness or fragility which occur during flashing.

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

FIG. 1 is an elevational view of a 300 watt PS30 incandescent lamp incorporating a coiled-coil CC8 filament processed in accordance with this invention;

FIG. 2 is a schematic diagram of one type of flashing circuit that can be employed in accordance with the invention;

FIGS. 3 to 5 are schematic representations of other and preferred types of flashing circuits wherein one or several incandescent lamps are employed as the ballast means;

FIG. 6 is a block diagram illustrating a preferred sequence of steps according to the invention for completing the fabrication of an incandescent lamp and inspecting it prior to shipment;

FIGS. 7, 8 and 9 are graphic representations of the flashing voltages obtained from the circuits illustrated in FIGS. 2, 3 and 5, respectively;

FIG. 10 is a photomicrograph of a stretched segment of a 300 watt coiled-coil filament, before flashing, illustrating the fibrous microstructure typical of tungsten wire that has been worked but not recrystallized;

FIGS. 11 and 12 are photomicrographs of portions of

a primary turn of filaments from the same coil lot after flashing in accordance with the conventional multiple-step schedule and after seasoning, respectively; and

FIGS. 13 and 14 are photomicrographs of similar portions of other filaments from the same lot after flashing in accordance with the principles of this invention and after seasoning, respectively.

While the present invention can be advantageously employed in the manufacture of various types of incandescent lamps, it is particularly adapted for use in conjunction with incandescent lamps having vertically mounted coiled-coil filaments and has accordingly been so illustrated and will be so described.

With specific reference to the form of the invention illustrated in the drawings, in FIG. 1 there is shown a 300 watt CC8 incandescent lamp **15** which generally comprises a pear-shaped envelope **16** having a coiled-coil filament **18** sealed therein and supported in substantially coaxial relationship therewith by a pair of lead-in conductors **19** and **20** and the usual support and tie wire arrangement. The aforesaid conductors are sealed through a conventional re-entrant glass stem **22** that is fused to the end of the envelope neck and protrudes inwardly therefrom. Electrical connection with the lead wires and filament is effected in the usual manner by means of a base **21** attached to the sealed end of the envelope. The lamp **15** contains a filling of suitable inert gas such as a mixture of 90% argon and 10% nitrogen, for example, at a pressure of 600 millimeters of mercury.

The filament **18** is fabricated from a suitable refractory metal wire such as wire consisting essentially of tungsten, for example, that has been prepared in accordance with standard powder metallurgy techniques. As a specific example, tungstic acid or tungstic oxide is first prepared from tungsten ore and has added thereto predetermined amounts of so-called "doping" compounds, such as silicon dioxide, alumina, and potassium chloride, for example, to form a slurry that is then chemically reduced to metallic tungsten powder. The powder is then compacted and sintered to form an ingot that is mechanically worked, as by swaging or drawing, into a filamentary wire of the desired diameter. The wire at this stage is ductile and has the characteristic fibrous or stringy microstructure of worked unrecrystallized wire as shown in FIG. 10, which is a 100× photomicrograph of a stretched segment of an unflashed 300 watt coiled-coil filament from a lamp such as that shown in FIG. 1. The aforesaid photomicrograph (and those shown in FIGS. 11 to 14) was prepared in the usual manner by first polishing the filament segment to obtain a longitudinal cross-section of the wire and then etching the polished surface to bring out the structural features thereof. Thus, the view presented in FIG. 10 is actually a view of the particular segment of the coil as it would appear if sliced longitudinally along a plane and viewed through a microscope, and as such, clearly indicates that the filamentary wire initially (that is, prior to flashing) is of fibrous microstructure throughout.

In the "Metals and Alloys Dictionary," by M. Merlub-Sobel, Chemical Publishing Company, Inc., N.Y., 1944, the word "fiber" is defined as the "direction in which metals have been caused to flow, as by rolling, with microscopic evidence in the form of fibrous appearance in the direction of flow," and the expression "fibrous structure" defined in terms of a "fibrous fracture" having a surface "of long stringy nature." The word "fibrous" as herein used accordingly refers to a stringy pattern or structure in the wire as distinguished from a granular or crystalline structure. "Fibrous regions" as used herein accordingly denote unrecrystallized regions in the filamentary wire which remain ductile and tough.

In accordance with the "one-step" flashing concept of the present invention, after the lamp **15** is sealed the filament **18** is heated in one continuous operation or step to its recrystallization temperature. While this may be accomplished by various means, as by high frequency induction heating for example, it is preferably achieved by applying a predetermined voltage to the filament. It has been found that for the 300 watt CC8 lamp **15** here shown, the critical temperature range in which filament sag occurs during flashing corresponds to a voltage between about 40% and 75% of the lamp rated voltage (E_r), or approximately 2000–2500° K. The unflashed lamp is, accordingly, energized with a voltage of such magnitude that that filament is rapidly and continuously heated through the aforesaid temperature range to the desired equilibrium temperature.

In accordance with the second aspect of this invention, it has been found that the strength of the filament can also be improved by maintaining the equilibrium value (E_e) of the applied flashing voltage between about 75% and 90% E_r. Voltages of this order will heat the filament sufficiently to set it with a minimum of sag without completely recrystallizing it within the flashing period. Good results have been obtained in the case of the 300 watt CC8 lamp here illustrated by maintaining the equilibrium value (E_e) of the applied voltage at approximately 80% E_r, which corresponds to a filament temperature of about 2600° K. for this particular type lamp. Of course, where improved filament strength alone is desired the lamp can be flashed at still lower voltages, as for example 50% E_r.

Thus, by controlling both the rate of rise of temperature of the filament and its ultimate or steady state temperature, the filament can be set with a minimum amount of sag without causing the complete recrystallization and embrittlement thereof. The aforesaid voltages and ranges are merely illustrative and will vary depending upon the particular type of lamp and filament involved.

Various types of flashing circuits for heat treating unflashed filaments in accordance with the foregoing will now be described.

In FIG. 2 there is shown a resistor-ballasted flashing circuit according to the invention wherein a current-limited voltage of predetermined magnitude is applied to a lamp **15** by means of a pair of conductors **25** and **26** that connect the lamp to an A.C. voltage source through a variable resistor **28** and a switch **30** that are connected in series with each other and the lamp filament **18**. The magnitude of the supply voltage exceeds the lamp rated voltage (E_r) by a predetermined amount, as for example 125% E_r as in the case of a 300 watt CC8 120 volt lamp here shown. By properly adjusting the resistor **28** the equilibrium value of the voltage (E_e) which appears across the filament **18** during flashing is set at a predetermined value high enough to heat the filament to its recrystallization temperature and set it, but low enough to prevent the complete recrystallization thereof within the flashing period, as for example 80% E_r as mentioned above.

Under these conditions, when the switch **30** is closed and an unflashed 300 watt CC8 lamp **15** is in the circuit, a voltage in the order of 16% E_r will be immediately applied to the filament **18** which voltage rises to 73% E_r in about twenty cycles. The resulting wave form of the flashing voltage applied to the lamp is shown in FIG. 7. As will be noted, the transient portion of the flashing voltage (that is, the region *a–b* in FIG. 7) is such that the voltage across the filament rises fairly rapidly from its initial relatively low value to its equilibrium value E_e, or 80% E_r. Thus, the filament temperature is continuously increased and traverses the critical sag temperature range in a much shorter time than in the case of a conventional multiple-step flashing schedule.

The actual rate at which the filament heats up will, of course, vary considerably depending upon the particular type of lamp, wire size, coil design, fill gas, etc. involved. However, in order to effectively limit the amount of sag during flashing with most coiled filaments, the filament should reach a temperature of about 2500° K. within three seconds after the voltage is applied. It

would, of course, be preferred if the filament were heated to this temperature in a shorter time interval since this would reduce filament sag still further.

A circuit capable of achieving both underflashing and accelerated heating of the filament is shown in FIG. 3 and, as there shown, employs a pair of incandescent lamps **34** and **36** arranged in parallel as the ballast means. As shown, the lamps **34** and **36** are connected between one end of the unflashed filament **18** and one side of the voltage supply by means of a conductor **32** and a switch **38**. The other end of the unflashed filament is connected to the other side of the supply line by another conductor **31** as before. In order to enable the unflashed filament **18** to heat up faster than the filaments of the ballast lamps **34** and **36**, it is necessary that the combined wattage of the ballast lamps be greater than that of the unflashed lamp and that the proper balance of impedance be provided. In the particular case of an unflashed 300 watt CC8 lamp **15** here shown, both of these requirements are met by using a pair of 200 watt lamps as the ballasting means.

If the A.C. supply voltage is 125% E_r as indicated in FIG. 3, then the voltage applied across the unflashed filament **18** by this particular circuit will have a wave form of the character shown in FIG. 8. As there shown, upon closure of the switch **38** the initial voltage applied to the unflashed filament **18** is about 75% E_r. The voltage rises to approximately 93% E_r in about seven cycles, and then gradually decreases to 86% E_r in thirteen cycles and finally to its equilibrium value E_e or 80% E_r. It should be noted that in this case the transient (that is, the region *a'* to *b'* in FIG. 8) by virtue of the non-linear resistance of the ballast lamps is such that the voltage applied to the unflashed filament first exceeds and then decreases to its preselected equilibrium value E_e. Thus, the unflashed filament is heated to its recrystallization temperature at a faster rate than with the resistor-ballasted circuit described above and is thus set with a minimum of sag.

In FIG. 4 there is shown essentially the same type of circuit as illustrated in FIG. 3 except that a single lamp **42** is used as the ballasting means. This type of circuit is of particular use where the wattage of the lamp **15***a* is such that the impedance balance necessary to achieve accelerated heating of the unflashed filament **18***a* to the desired temperature can be obtained by using a ballast lamp of a standard and hence readily obtainable wattage. In the example here shown, the unflashed lamp **15***a* is a 200 watt CC8 lamp and the ballast lamp **42** has a 300 watt rating. As before, the ballast lamp **42** is connected in series with one end of the unflashed filament **18***a* and one side of the voltage supply through a conductor **39** and switch **44**, and the other end of the unflashed filament is connected to the voltage source by means of another conductor **40**. For the particular combination of lamps and supply voltage here shown, the wave form of the voltage appearing across the unflashed lamp **15***a* would be similar to that shown in FIG. 8, except that because of the less massive filament being treated the applied voltage would reach its equilibrium value in a shorter time.

Heating of the unflashed filament can be achieved at an even faster rate by preheating it to a temperature below its recrystallization and sag temperature before flashing in order to increase its initial resistance. A circuit of this character is shown in FIG. 5 wherein a 300 watt CC8 120 volt lamp **15** is connected to the supply voltage by means of a preheating circuit consisting of conductors **45** and **46**, a switch **50**, and a 100 watt ballast lamp **48** which is connected in series with the unflashed filament **18** and one side of the line. When the switch **50** is closed and the unflashed lamp **15** is connected to an A.C. supply voltage of 125% E_r as here shown, the ballast lamp **48** limits the current through the unflashed lamp to a value such that a voltage drop E_p (see FIG. 9) of about 17 volts or 14% E_r appears thereacross. This is sufficient to substantially increase the resistance of the filament **18** but is well below the critical range of 40 to 75% E_r in which filament sag occurs.

After the unflashed filament **18** has been preheated, three additional 100 watt ballast lamps **54**, **56** and **58** are connected in parallel with the first ballast lamp **48** by means of conductors **51** and **52** and a second switch **60**. Thus, the ballast lamp **48** is first utilized to limit the current in the preheat circuit and is then used as part of the multiple-lamp-ballasted flashing circuit formed when the aforesaid preheating circuit is connected to the network of parallel-connected ballast lamps **54**, **56**, and **58**. As will be noted in FIG. 9, the voltage is at a maximum initially and then decrease to an equilibrium value of about 80% E_r. The peak initial voltage in the case of the 120 volt 300 watt lamp **15** shown is in the order of 130 volts. Thus, upon closure of the switch **60** (represented in time by the ordinate *a''* in FIG. 9) the voltage immediately increases from the low preheating voltage E_p to a value higher than E_r (in this particular case about 108% E_r), and then drops in the transition range *a''* to *b''* to the aforesaid equilibrium voltage E_e.

In FIG. 6 there is shown a preferred series of steps for flashing and inspecting incandescent lamps preparatory to shipment in accordance with the invention. As shown, the lamps are first flashed in a single step or operation at a ballasted position and at a preselected voltage below the lamp rated voltage to set but not fully recrystallize the filaments. Preferably, the flashing voltage is about 80% of the lamp rated voltage and is applied for a period of about 2 to 3 seconds. After flashing the lamps are relighted twice at unballasted positions for about the same length of time and at a voltage no greater than that at which they were flashed, and preferably at the same voltage. In this manner lamps having arc-initiating defects are detected and destroyed before shipment without substantially increasing the degree of recrystallization of the filaments of the good lamps. The lamps which pass inspection are then packed and shipped. Completion of the recrystallization process within the filament is achieved when the lamp is subsequently lighted at its rated voltage in the customer's socket.

It has been found advantageous in practice to provide two or more separate flashing circuits on the basing machine and to switch from one set to the other. Otherwise, the filaments of the ballast lamps may not have sufficient time to cool while the machine is being indexed and hence may have too high a resistance.

In FIG. 13 is shown a 100× photomicrograph of part of a primary turn of a 300 watt coiled-coil filament from a lamp that was flashed in a single step in accordance with the invention at a voltage having an equilibrium value of about 80% of the lamp rated voltage. It will be seen that this particular segment of the wire is composed of discrete grains of irregular configuration joined by an unrecrystallized fibrous region. As will be understood, this pattern or structure extends throughout the entire length of the wire so that a plurality of discrete fibrous regions and grains intermingled one with another are actually present therein. Both the grains and fibrous regions are elongated in the general direction of the wire axis with the latter substantially filling the crevices in the irregular surfaces of adjacent grains which they join thereby constituting, in effect, a resilient bridge or link therebetween. In an underflashed filament, accordingly, substantial portions of adjacent grains are joined by unrecrystallized fibrous regions thereby eliminating the clearly defined or discrete grain boundaries normally observed in fully recrystallized wire.

In contrast, in FIG. 11 there is shown a photomicrograph of a primary turn of a 300 watt CC8 filament from the same coil lot but which was flashed in accordance with the prior art "multiple-step" type of flashing schedule. In this particular instance the lamp was flashed in five separate steps by lighting it for 2 to 3 seconds at the

following percentages of the lamp rated voltage: 50%, 64%, 80%, 92% and 100%, followed by a final light-up at 105% rated volts at an unballasted position. As will be noted, there is no trace of fibrous or unrecrystallized regions. Instead, the grains are completely formed and have the clearly defined and discrete boundaries therebetween characteristic of fully recrystallized wire.

The marked change in microstructure produced by burning an underflashed lamp at a voltage sufficient to heat the filament to a higher recrystallization temperature than that at which it was originally flashed is illustrated in FIG. 14, which is a 100× photomicrograph of a portion of a filament that was underflashed in the same manner as the filament shown in FIG. 13 and subsequently burned or seasoned for one hour at 115% rated volts. As will be noted in FIG. 14, the fibrous regions between crystals characteristic of underflashing have disappeared and the grain growth and recrystallization process has been completed, as indicated by the discrete and clearly defined grain boundaries.

In FIG. 12 there is shown a photomicrograph of a portion of a filament from an identical lamp that was flashed in accordance with the above-mentioned "multiple-step" schedule and then seasoned in the same manner as the aforesaid underflashed lamp. Again, the absence of stringy fibrous regions between the grains and the presence of discrete and clearly defined grain boundaries characterize the microstructure as one wherein full recrystallization has taken place. Thus, lamps flashed in a plurality of stages at progressively higher temperatures in accordance with conventional practice are fully recrystallized and have the same microstructure after flashing (FIG. 11) as they have after being seasoned (FIG. 12), whereas identical lamps flashed only once at a preselected voltage below their rated voltage in accordance with this invention have a distinctly different microstructure (FIG. 13) that improves the shock resistance of the filament and is totally different from the fully recrystallized structure observed after seasoning (FIG. 14).

In the specific case of the 300 watt CC8 lamp here shown, the filament sag due to flashing has been reduced by approximately 50% when the "one-step" flashing schedule of this invention was employed. In addition, drop tests on comparative lots of conventionally flashed lamps and lamps underflashed in accordance with the principles of this invention have shown that the incidence of coil breakage is reduced by a factor of about 10 to 20, that is, one broken underflashed filament for every ten to twenty regularly-flashed filaments fractured.

As will be apparent from the foregoing, the objects of the invention have been achieved by providing an incandescent lamp that has a flashed filament with a minimum amount of sag and improved shock resistance.

While specific lamp embodiments have been illustrated and described, it will be understood that various modifications and changes in the shape and size of both the lamp and the filament sealed therein can be made without departing from the spirit and scope of the invention.

I claim:

1. In a flashed incandescent lamp ready for use, the

improvement comprising a filament of partly recrystallized refractory metal wire composed of a plurality of discrete grains and unrecrystallized fibrous regions that are intermingled one with another, with portions of said unrecrystallized fibrous regions extending between and joining substantial portions of adjacent ones of said grains.

2. A flashed incandescent lamp as set forth in claim 1 wherein said filament comprises a coil of wire consisting essentially of tungsten.

3. A flashed incandescent lamp as set forth in claim 1 wherein said filament comprises a coil of linear configuration that is unsupported for a substantial portion of its length, and said intermingled grains and unrecrystallized fibrous regions are of elongated configuration and oriented in the general direction of the wire axis.

4. A flashed incandescent lamp as set forth in claim 1 wherein said filament comprises a coiled-coil helix of tungsten wire that extends in substantially the same direction as the lamp axis.

5. In a finished electric incandescent lamp that is ready for shipment and use, the improvement comprising a shock-resistant elongated filament of partly recrystallized drawn tungsten wire that is supported within said lamp by a pair of lead-in conductors and is composed of a plurality of discrete grains that are joined and held together by unrecrystallized fibrous regions that are intermingled with said grains.

6. The improvement set forth in claim 5 wherein the said unrecrystallized fibrous regions constitute portions of the wire that have retained their drawn microstructure and thus effect a resilient juncture of the brittle recrystallized regions.

References Cited by the Examiner

UNITED STATES PATENTS

223,898	1/80	Edison	313—315
244,291	7/81	Perkins	313—315
1,461,140	7/23	Ramage	313—315
1,807,885	6/31	Weingartner	313—278
2,218,345	10/40	Spaeth	313—344 X
2,280,448	4/42	Pfeiffer	316—27
2,371,205	3/45	Zabel	313—344 X
2,753,615	7/56	Claude et al.	29—25.17
2,805,356	9/57	Brown	313—315
2,845,691	8/58	Atherton et al.	29—25.17
2,877,375	3/59	Pearson	313—315
2,943,904	7/60	Bussom et al.	316—27

OTHER REFERENCES

Phillips Technical Review, vol. 19, 1957/58, No. 4, pages 109–144, published October 16, 1957 (pp. 109–110 relied upon especially), "The Function of Additives in Tungsten for Filaments."

Tungsten, by Smithells, TN–799T9.S6, July 12, 1927, pages 47 to 49 and pages 89–90 relied on.

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