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Sulcs et al.

[11] **3,909,660**

[45] **Sept. 30, 1975**

[54] **METAL HALIDE DISCHARGE LAMP STARTING ELECTRODE**

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[73] Assignee: **General Electric Company**, Schenectady, N.Y.

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[52] **U.S. Cl.** **315/60;** 313/25; 313/198; 313/229; 313/318

[51] **Int. Cl.**[2] **H01J 5/50; H01J 61/36;** H01J 61/54; H01J 61/56

[58] **Field of Search** 313/197, 198, 184, 229, 313/225, 25, 318; 315/60

[56] **References Cited**

UNITED STATES PATENTS

2,660,692	11/1953	St. Louis et al.	313/198 X
3,226,597	12/1965	Green	315/60
3,234,421	2/1966	Reiling	313/225 X
3,275,885	9/1966	Pomfrett	313/197 X
3,619,711	11/1971	Freese, Jr.	315/60
3,715,622	2/1973	Page et al.	313/198 X

Primary Examiner—Palmer C. Demeo
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[57] **ABSTRACT**

In metal halide arc lamps utilizing fused silica arc tubes, prevention of electrolysis between the inleads to the main and auxiliary starting electrodes has generally required a shorting thermal switch. Electrolysis can be prevented in a simpler way by using a stub starter, that is an auxiliary electrode having such a short projection into the arc chamber that there is substantially no conduction thereto on either half cycle when the lamp is operating.

8 Claims, 4 Drawing Figures

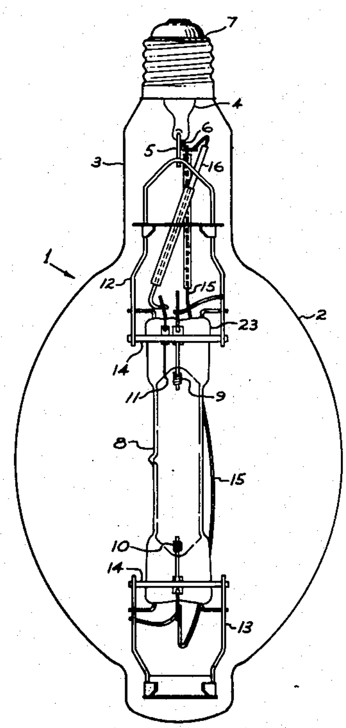

Fig. 1

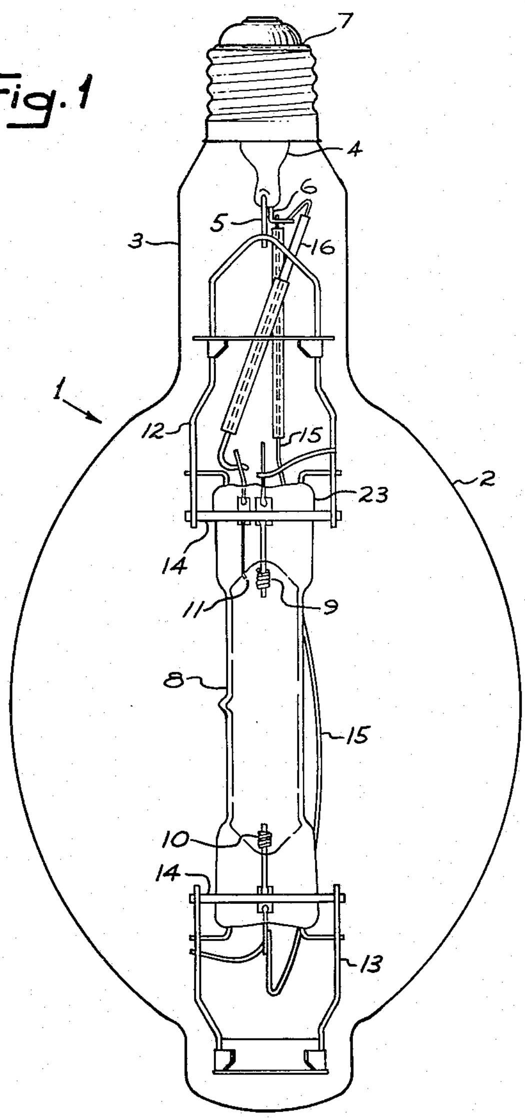
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Fig. 2

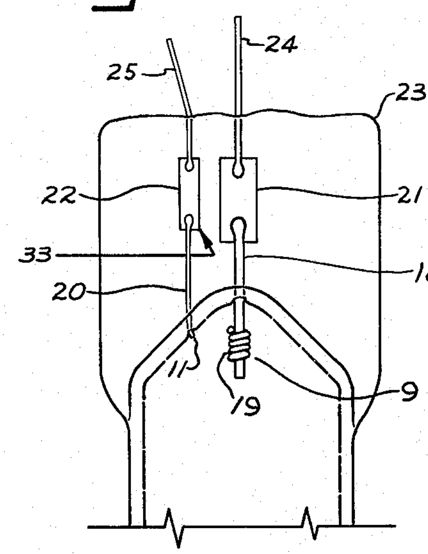
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Fig. 3

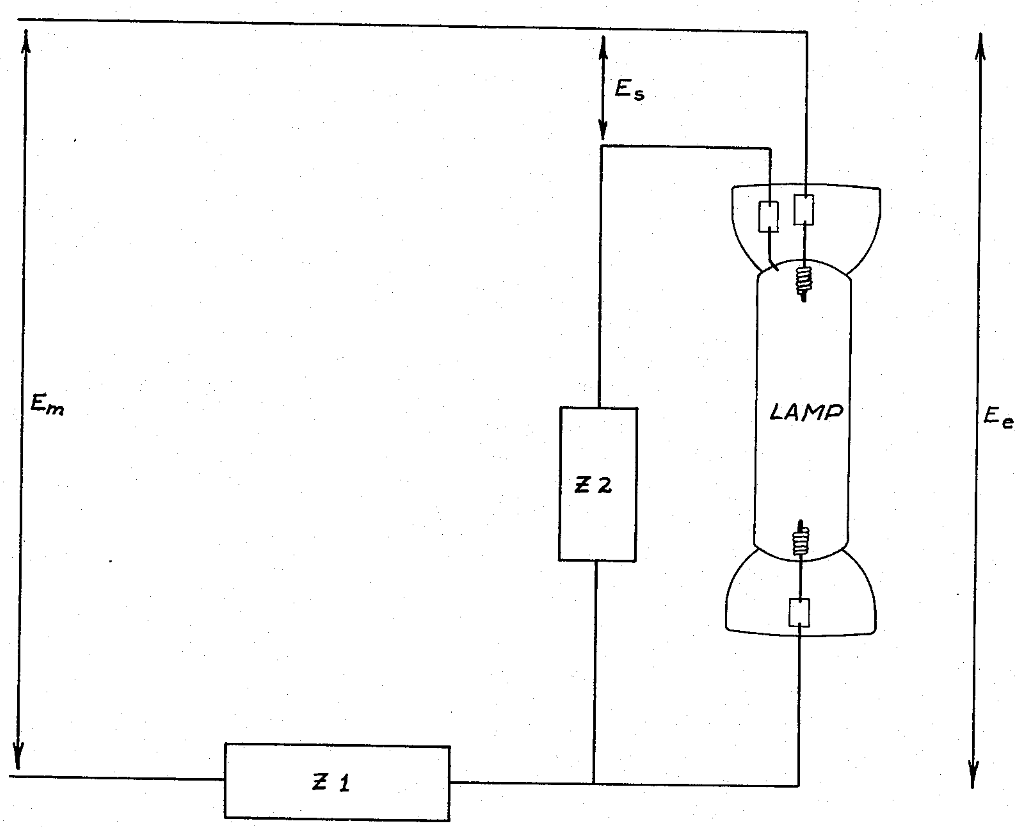
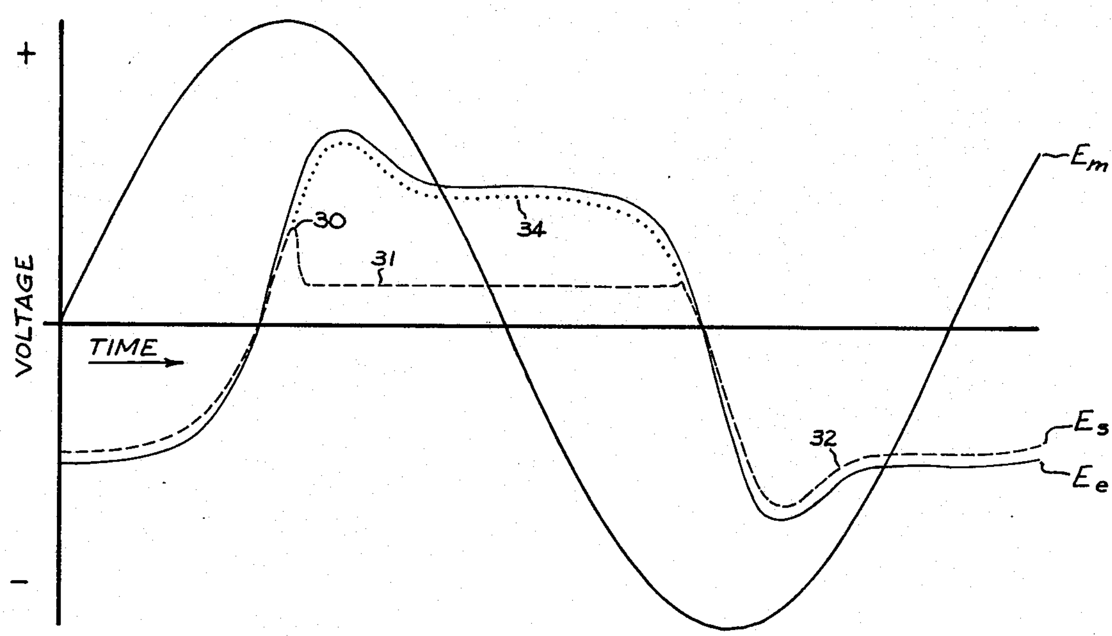


Fig. 4



METAL HALIDE DISCHARGE LAMP STARTING ELECTRODE

BACKGROUND OF THE INVENTION

The invention relates to high pressure arc lamps having a pair of main electrodes, and an auxiliary starting electrode sealed into an envelope of vitreous material such as fused silica, and is more particularly concerned with the auxiliary electrode and problems of electrolysis incident thereto.

The electrodes of metal halide discharge lamps are generally supported by inleads which include a thin molybdenum ribbon section sealed through a press seal at each end of an elongated fused silica tube which serves as the arc chamber. To facilitate starting of the discharge, an auxiliary starting electrode is generally provided adjacent one of the main electrodes. An arc can be ignited between the starter electrode and its adjacent main electrode at a much lower voltage than is required to ignite an arc between the two main electrodes. By this means, the lamp starting voltage requirement may be reduced to a value reasonably close to that required for sustaining the arc in normal lamp operation.

During operation of metal halide lamps containing alkali or alkaline earth metal additives, electrolysis can occur within the press seal between the inleads of the starter and of the adjacent main electrode if an electric potential exists between them. The electrolysis occurs primarily as alkali-ion displacement through the silica, and can always occur, irrespective of lamp fill, because high silica glass or fused silica contains minute quantities of alkali metals as impurities. However it is much greater when an alkali metal, such as sodium in the form of an iodide, is provided as part of the lamp fill, and is greatly aggravated when a net potential difference is allowed to exist between the starter and the adjacent main electrode. Electrolysis causes the silica to devitrify and leads to cracking of the hermetic seal, or alternately it deteriorates the molybdenum ribbon to the point of failure and either event ends the life of the lamp.

Several schemes have been proposed to overcome the electrolysis problem in metal halide lamps containing alkali metal in the fill. The most widely used is that of U.S. Pat. No. 3,226,597 - Green, which provides a thermal switch in the form of a bimetal element to electrically short-circuit the starter electrode to the adjacent main electrode when the lamp reaches normal operating temperature. An alternative proposed by U.S. Pat. No. 3,619,711 — Freese, provides a semiconductor diode connected between the starter and the adjacent main electrode in such polarity that the starter cannot develop a negative potential. These schemes all require the addition of active components that add cost and derogate from reliability. Bimetallic switches are difficult to design for satisfactory operation under all lamp operating conditions. Under prolonged exposure of the switch to the heat emanating from the arc tube, the bimetal may take a "set" in the stressed position resulting in progressively longer time intervals for closure. While the switch is open, electrolysis can occur and in the extreme condition, the switch may fail to close altogether and the lamp will fail within a few hundred hours thereafter. As for semiconductor devices, they are subject to a high rate of failure because the high temperature of the lamp environment both during processing and in subsequent operation are hostile to it.

The object of the invention is to provide a metal halide arc discharge lamp having starting means which substantially eliminates lamp failures due to electrolysis and which does not require the addition of components which are subject to failure such as thermal switches or semiconductor devices.

SUMMARY OF THE INVENTION

In accordance with our invention, we have found that so long as no discharge occurs between the auxiliary starting electrode and the adjacent main electrode on either half cycle during normal lamp operation, there will be no net potential difference between them, that is, there will be no average or D.C. potential extending over more than one full A.C. cycle. Under these conditions, electrolysis is substantially eliminated and no external circuit devices are needed to prevent electrolytic failure. The condition is achieved by using a short starter electrode, sometimes referred to as a stub starter, and by disposing the starter electrode tip as far from the tip of the main electrode as possible within the practical limits of extending the inleads for both electrodes through the same pinch or press seal. We have found that the starter electrode need hardly project out of the silica of the pinch into the arc tube so long as a path is provided whereby the discharge can reach the tip of the starter. The starter electrode should not project into the envelope a distance greater than 10% of the inside diameter of the tubular envelope.

In addition to eliminating the cost of the bimetallic switch, our invention substantially improves lamp reliability. Our starter configuration also works well with the starter end down and is not limited to having the starter at the upper end as is normally the case with lamps using a thermal switch.

DESCRIPTION OF DRAWINGS

In the drawings:

FIG. 1 is a side view of a metal halide lamp provided with a stub starter embodying the invention.

FIG. 2 is an enlarged detail of the upper end of the arc tube showing the stub starter.

FIG. 3 is a typical metal halide lamp schematic circuit showing the electrode connections.

FIG. 4 shows voltage waveforms obtained in the lamp under various operating conditions.

DETAILED DESCRIPTION

A metal halide vapor arc lamp **1** embodying the invention comprises an outer vitreous envelope or jacket **2** having a neck portion **3** closed by a re-entrant stem **4.** Stiff inlead wires **5,6** extending through the stem are connected at their outer ends to the contacts of a screw base **7** and have connections from their inner ends to the inner arc tube **8.** The arc tube is formed of fused silica and has sealed therein at opposite ends main arcing electrodes **9,10** plus an auxiliary starting electrode **11.** The arc tube is supported within the outer envelope by a divided or two-part mount, **12** at the base end and **13** at the dome end. Each part comprises a pair of longitudinally extending support rods bridged by metal straps **14** which clamp about the pinched ends of the arc tube. The base end mount part is welded to inlead **5** and serves as a conductor to main electrode **9.** Main electrode **10** is connected to inlead **6** by curving wire **15.**

Starter electrode **11** is connected to inlead **6** through current limiting resistor **16**. The arc tube contains argon at a pressure of about **25** torr, a quantity of mercury substantially vaporized during operation and exerting a partial pressure of 1 to 15 atmospheres, and sodium iodide, scandium iodide and thorium iodide in excess of the quantity vaporized at the operating temperature. The outer envelope is filled with an inactive gas, suitably nitrogen at about one half atmosphere pressure.

The invention is more particularly concerned with auxiliary electrode **11** at the upper end of the arc tube and its physical relationship to main electrode **9**, both shown to a larger scale in FIG. **2.** The main electrode comprises a core portion which may be a prolongation of wire **18** consisting of suitable electrode metal such as tungsten or molybdenum; the core portion is surrounded by a tungsten or molybdenum wire helix **19.** The tip of electrode **9** is located close to the center of the rounded end of the arc tube. The auxiliary starting electrode **11** comprises the inwardly projecting end or stub of wire **20** which may likewise be of tungsten or molybdenum. The outer ends of wires **18** and **20** are welded to molybdenum ribbon or foil connectors **21,22** which are completely embedded within the pinch or press seal end **23** of arc tube **8.** Relatively short molybdenum wires **24,25** are welded to the ends of the molybdenum ribbon connectors and serve to convey current to electrodes **9** and **11**, respectively.

FIG. **3** illustrates a typical circuit for operating a high pressure metal vapor discharge lamp. The commercial line voltage E_m is sinewave alternating current at a frequency of 60 hz. or alternately 50 hz. and at a voltage from 100 to 600 volts rms. Typically Z1 is a linear inductor having an impedance from 20 to 100 ohms and serving to limit lamp current. Z2 is typically a resistor of 10,000 to 100,000 ohms impedance which serves to limit the starter electrode current and which corresponds to resistor **16** in FIG. **1.** Starting is effected by breakdown of the gap between the starter and adjacent main electrode into a glow discharge. The local ionization greatly reduces the voltage required to break down the gap between the main electrodes.

The common practice up to now has been to locate the tip of the starter electrode as near to the tip of the main electrode as possible while allowing for manufacturing tolerance and the need to avoid contact between them. When such lamps are operated in a circuit such as illustrated in FIG. **3,** a discharge will occur between the main electrode and the starter electrode during normal lamp operation. Breakdown will normally occur on the positive half cycle of lamp voltage when the starter electrode acts as anode. The adjacent main electrode is already acting as cathode and providing thermionic electron emission to support the main discharge. During the negative half cycle when the starter electrode must act as cathode, it is usually too cold to provide thermionic emission. Thus on the negative half cycle a discharge will generally not ignite, and in cases where ignition does occur the current remains low and the burning voltage is quite high.

Referring to FIG. **4,** the applied sinusoidal line voltage is represented by solid line curve E_m. After ignition and during normal operation, the voltage across the main electrodes of the lamp is represented by solid line curve E_e. The voltage between the starter electrode and the adjacent main electrode is represented by dash line E_s. When using the prior art starting electrodes which projected into the envelope close to the tip of the main electrode, on the positive half cycle of the starter electrode, breakdown occurs after the initial peak indicated at **30** and current flow through impedance Z2 maintains the starter electrode voltage low for the remainder of the half cycle as indicated at **31.** On the negative half cycle there is no conduction to the starter electrode and the voltage is high as indicated at **32.** The end result is that a net or average potential difference exists between the main and starter electrode over a full cycle.

A negative net potential at the starter electrode favors displacement of positive sodium ions through the silica from the region of the main electrode inlead to that of the starter electrode inlead. The hermetic seals of the inleads occur at the molybdenum foils and sodium iodide vapor may enter the crevices alongside the wires **18,19** leading up to the foils. The sodium attack on the inleads is generally most severe at the forward corner of starter foil next to the main electrode foil, as indicated by arrow **33.** At the usual operating temperatures of metal halide lamps, electrolysis within the seal area leading to cracking of the seal results in lamp failure in a few hundred hours of operation.

The principle of operation of the thermal switch which has been used up to now to prevent electrolysis has been to eliminate all potential between the starter and adjacent main electrode. Our invention uses a different principle, namely to make the voltage between the starter and the main electrode equal and opposite on successive half cycles. This condition is realized when no discharge occurs between the starter and main electrode on either half cycle. This eliminates any average D.C. potential and substantially eliminates electrolysis without need for external circuit devices. To insure no discharge on either half cycle, a short starter electrode is used and the starter electrode is disposed as far from the tip of the main electrode as possible within the practical limits of extending the inleads for both electrodes through the same pinch or press seal. The starter electrode voltage E_s on the positive half cycle then follows dotted line curve **34** and is symmetrical on positive and negative half cycles.

Referring to FIG. **2,** wire portion **20** of the starter electrode is cut off to a short stube which barely projects into the arc chamber cavity. We have found that the starter electrode need hardly project out of the silica of the pinch and may even be buried within the silica pinch as long as a path is provided whereby the discharge can reach the tip of the starter. In order to maintain congruent starter voltage waveforms on positive and negative half cycles, we have found that the starter should project into the generally rounded end of the envelope a distance no greater than 10% of the arc tube diameter in order to insure the necessary minimum spacing between its tip and the tip of the main electrode. Any greater projection may result in breakdown on the negative half cycle.

As long as no discharge occurs between starter and adjacent main electrode during normal lamp operation, there will be no net potential difference between them and no external circuit devices are needed to prevent electrolytic failure. Our invention not only eliminates the cost of the bimetallic switch, it also substantially improves lamp reliability. Furthermore our starter configuration works well with the starter end of the lamp lowermost, and is not limited to having the starter at the upper end as is normally the case with lamps using a thermal switch. Particularly when using an arc tube having formed end chambers as described and claimed in copending application Ser. No. 374,566, filed June 28, 1973, by Wayne R. Hellman, Klaus Gottschalk and Edward C. DeGeorge, titled "Discharge Lamp Having Blow-Molded Arc Tube Ends" and similarly assigned, the starter works well at either end of the lamp. The reason why blow-molded lamps operate better with a stub-starter may be that the uniformity of the end chambers permits operation at a slightly higher temperature than formerly possible. Thus a blow-molded lamp using the stub-starter of our invention permits a universal burning position lamp design capable of replacing the two lamp types formerly used, namely the baseup and base-down versions.

We have found that the stub-starter configuration of our invention is as effective in reducing lamp voltage starting requirements as was the prior art configuration not only at room temperature but also at low operating temperatures down to minus 20°F. Thus our invention achieves elimination of electrolysis, greater reliability, universal burning position of the lamps, and an appreciable cost reduction by the elimination of external circuit devices.

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

1. An electric discharge arc tube for alternating current operation comprising:
- a tubular envelope of vitreous material subject to electrolysis and deterioration under electrical stress at high temperatures;
- an ionizable radiation-emitting filling within said envelope;
- a pair of main thermionic arc-supporting electrodes mounted on inleads including foil portions extending through seals at the generally rounded ends of said envelope;
- an auxiliary starting electrode adjacent one of said main electrodes mounted on an inlead including a foil portion extending through the seal generally side-by-side with and in close proximity to that of said adjacent main electrode at one end of said envelope;
- a resistance permanently connecting said starting electrode to the opposite main electrode for starting purposes;
- and said starting electrode projecting a short distance only into the envelope and having its tip far enough from that of the adjacent main electrode that substantially no discharge occurs thereto during normal operation, whereby there will be no net potential difference between said starting electrode and the adjacent main electrode and electrolysis in the seal region through which their inleads extend is substantially eliminated.

2. An arc tube as in claim 1 wherein the starting electrode is a wire extending into the rounded end a distance no greater than 10% of the inside diameter of said envelope.

3. An arc tube as in claim 1 wherein the envelope is fused silica.

4. An arc tube as in claim 1 wherein the envelope is fused silica and the ionizable medium includes alkali metal halide.

5. An arc tube as in claim 4 wherein the inleads include molybdenum foils extending through press seals.

6. An alternating current metal halide electric discharge lamp comprising:
- a fused silica arc tube containing an inert gas, mercury and metal halide including a sodium halide;
- a sealed outer envelope enclosing said arc tube but spaced therefrom;
- a pair of main thermionic arc-supporting electrodes mounted on inleads including foil portions extending through seals at the generally rounded ends of said envelope;
- a starting electrode adjacent one of said main electrodes mounted on an inlead including a foil portion extending through the seal generally side-by-side with and in close proximity to that of said adjacent main electrode at one end of said envelope;
- a resistance permanently connected said starting electrode to the opposite main electrode for starting purposes;
- and said starting electrode being a wire projecting a short distance only into the envelope and having its tip far enough from that of the adjacent main electrode that substantially no discharge occurs thereto during normal operation, whereby there will be no net potential difference between said starting electrode and the adjacent main electrode and electrolysis in the seal region through which their inleads extend is substantially eliminated.

7. A lamp as in claim 6 wherein the starting electrode is a short stub extending into the rounded end of the arc tube a distance no greater than 10% of the inside diameter of said arc tube.

8. A lamp as in claim 6 wherein the inleads include molybdenum foils extending through press seal and the starting electrode is a short stub extending into the rounded end of the arc tube a distance no greater than 10% of the inside diameter of said arc tube.

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