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(54) **Discharge tube.**

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"GAS DISCHARGE TUBES", H.L. van der Horst, 1964, Philips Technical Library, pages 150-157.

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Description

This invention relates to a discharge tube as indicated in the precharacterizing part of claim 1.

An ignition system of an automobile engine or the like is adapted to supply a high voltage to an ignition plug to produce a spark. In order to accurately control the ignition timing, an ignition system with a so-called series gap is employed wherein a discharge gap is provided in series to an ignition plug. In order to form such a series gap, a discharge tube is employed wherein inert gas is enclosed in a tube and a pair of electrodes are provided at the opposite ends of the tube. An exemplary one of such discharge tubes is shown in FIG. 4. Referring to FIG. 4, the discharge tube shown includes a glass tube 21 and a pair of metal wire electrodes 22 each covered with a zirconium nitride layer not shown and mounted in an enclosed relationship at the opposite end portions of the glass tube 21. Pressurized mixture gas of nitrogen and hydrogen is filled in the glass tube 21.

Further, the discharge starting voltage of such a discharge tube must necessarily be high to some degree. Accordingly, the discharge tube has a problem that, if the distance between the electrodes is increased to this end, then the discharge maintaining voltage of the discharge tube is also increased and consequently the loss of energy to be supplied to an ignition plug is increased. Also there is another problem that the exhaustion of the electrodes is increased and the life of the discharge tube is reduced accordingly.

The inventors have made an investigation for improvement of making opposing faces of a pair of electrodes less acute or non-acute to raise the discharge voltage and lower the discharge maintaining voltage. Then, it has been found out that improvement in accuracy of the discharge voltage can be attained by the provision of a large number of convex and/or concave portions on a surface at least of the cathode. However, no solution has been found out yet to the problem that the discharge voltage drops as the frequency of discharge rises as described above.

The book "Gas Discharge Tubes," H. L. van der Horst, 1964, Philips Technical Library, pages 150 - 157, describes a discharge tube comprising a hollow tubular casing end a pair of opposing cathode and anode electrodes secured by means of chrome-iron disks to the axial opposite ends of said tubular casing to define in said tubular casing an enclosed hollow spacing in which inert gas is filled, such that a discharge can be started by application of a pulse voltage between said cathode and anode electrodes, each of said electrodes including an electrode base secured to said tubular casing and an electrode member securedly mounted on said electrode member of said cathode electrode, being composed of a layered metal body including a ground layer and a thin surface layer of a cathode formed on a surface of said anode electrode and having a considerably smaller thickness than said ground layer. The electrodes are usually coated with a layer of material with a low work function.

It is the object of the invention to provide a discharge tube which has a stabilized discharge voltage characteristic irrespective of a change of the frequency of discharge.

This object, according to the present invention, is solved by the features as claimed in claim 1. The electrode member of the cathode electrode being composed of a layered metal body including a ground layer and a thin surface layer formed on a surface of the ground layer opposing to the anode electrode and having a considerably smaller thickness than the ground layer.

The electrode member may be of the two-layer structure only including the ground layer and the thin surface layer or of a three- or more-layer structure including an additional layer or layers. The thin surface layer can be formed on the ground layer by plating or the like, and desirably the thickness of the surface layer is within the range from 5 to 20 μm.

Preferably, the electrode member of the cathode electrode has another similar thin surface layer formed on the other surface of the ground layer thereof.

Also, the electrode member of the anode electrode may be composed of a layered metal body including a ground layer and a thin surface layer formed on one or each of the opposite surfaces of the ground layer. The shape of the cathode electrode and/or the anode electrode can be determined suitably such that it may have an optimum characteristic in accordance with an application of the discharge tube.

With the discharge tube of the present invention, even if the frequency of discharge rises, the discharge voltage does not drop very much. Since the change of the discharge voltage with respect to the frequency of ignition is improved in this manner, the discharge tube is advantageous in that it exhibits an excellent effect in maintenance of a stabilized running condition even if a considerable change takes place in the number of revolution of an engine of an automobile or the like in which the discharge tube is incorporated.

The above features and advantages of the invention will become apparent from the following description taken in conjunction with the accompanying drawings.

FIG 1 is a front elevational view, partly in section, showing a discharge tube to which the present invention is applied:

FIG. 2 is a circuit diagram showing an ignition system with a series gap with which a discharge tube is to be tested:

FIG. 3 is a graph showing results of a discharge voltage test of discharge tubes conducted with the ignition system shown in FIG. 2: and

FIG. 4 is a schematic sectional view showing an exemplary one of conventional discharge tubes.

Referring first to FIG. 1, there is shown a discharge tube to which the present invention is applied. The discharge tube shown includes a hollow tubular casing 8 formed from an alumina ceramics, and a cathode electrode 11 and an anode electrode 12 secured to the axial opposite ends of the tubular casing 8 and sealed with a suitable means such as silver solder not shown so as to define a hollow spacing 13 in the casing 8. The cathode electrode 11 includes an electrode base 2 substantially in the form of a disk secured to the tubular casing 8, and an electrode member 1 having a generally semi-spherical shape and fitted on and secured to a hub portion 14 of the electrode base 2 by means of a metal ring 3. The electrode member 1 has a large number of perforations 16 of a suitable size formed at a suitable pitch thereon. Meanwhile. the anode electrode 12 includes an electrode base 6 substantially in the form of a disk secured to the tubular casing 8, and an electrode member 4 having a substantially flat surface and fitted on and secured to a hub portion 15 of the electrode base 6 by means of a metal ring 7. The electrode member 4 also has a large number of perforations 16 of a similar size formed at a similar suitable pitch thereon. A gas conduit 5 extends axially through the center of the electrode base 6. Upon production of the discharge tube, suitable inert gas is introduced into the inner hollow spacing of the discharge tube by way of the gas conduit 5 so as to replace with the air. After such replacement, an outer end of the gas conduit 5 is compressed to seal the conduit 5.

Each of the electrode members 1 and 4 is formed from a layered body in the form of a plate which at least includes, though not shown, a ground layer which is a copper plate having a thickness of about 0. 5 mm, and a thin surface layer formed on each of the opposite surfaces of the ground layer and having a significantly small thickness of 5 to 20 μm, preferably of 10 μm, comparing with the ground layer. The surface layer is formed by electroplating of nickel.

Two different discharge tubes were produced actually in accordance with the present invention, and a performance test of them was conducted.

Example 1

A copper plate of a thickness of 0. 5 mm having a large number of perforations of about 0. 5 mm formed at a pitch of about 1 mm therein was prepared. The perforated copper plate was shaped by press work so as to be rounded at peripheral edge portions thereof, and electroplating of nickel was performed to a thickness of about 10 μm on the opposite inner and outer surfaces of the perforated copper plate. An electrode member 1 obtained in this manner was fitted on and secured to an electrode base 2 by means of a metal ring 3 to form a cathode electrode 11 as shown in FIG. 1.

Another electrode 4 having a substantially flat surface was produced in a similar manner and fitted on and secured to an electrode base 6, which had a gas conduit 5 extending therethrough, by means of another metal ring 7 to form an anode electrode 12.

Then, the cathode electrode 11 and the anode electrode 12 produced in this manner were assembled in an opposing relationship to each other to the opposite ends of a tubular casing 8 of an alumina ceramics and then sealed with silver solder. Then, inert gas was introduced for replacement with air into the internal hollow spacing 13 of the discharge tube by way of the gas conduit 5, and then an outer end of the conduit 5 was compressed for enclosure, thereby obtaining a discharge tube I according to the present invention.

Example 2

Instead of forming the electrodes 1 and 4 from perforated copper plates, they were formed by shaping similar perforated stainless steel plates by press work and then performing electroplating of gold to a thickness of about 10 μm on the opposite inner and outer surfaces of the perforated stainless steel plates. Then, a discharge tube II of the present invention was produced by assembling the electrode plates 1 and 4 to a tubular casing 8 in a similar manner as the example 1 described hereinabove.

Performance Test

A performance test was conducted with such an ignition system with a series gap as shown in FIG. 2. Referring to FIG. 2, the ignition system shown includes an ignition coil T, a pair of discharge gaps G_1 and G_2 provided by a discharge tube and an ignition plug, respectively, and a floating capacitance C provided by a high tension cable, a distributor cap and so forth. An ignition signal is transmitted to the ignition coil T by way of a transistor Tr.

Using the device, discharge voltage characteristics of the discharge tubes I and II of the present invention and a further discharge tube III assembled using electrodes of the same shapes formed from stainless steel plates were tested. Results of such test are shown in FIG. 3. From FIG. 3, it can be seen that the discharge tubes I and II of the present invention present considerably small drops of the discharge voltage with respect an increase of the ignition frequency comparing with the discharge tube III.

Claims

1. A discharge tube, comprising a hollow tubular casing (8), and a pair of opposing cathode and anode electrodes (11,12) secured to the axial opposite ends of said tubular casing (8) to define in said tubular casing an enclosed hollow spacing (13) in which inert gas is filled such that a discharge can he started by application of a pulse voltage between said cathode and anode electrodes (11,12), each of said electrodes including an electrode use (2,6) secured to said tubular casing (8) and an electrode member (1,4) securely mounted on said electrode use (2,6) in said hollow spacing (13), the electrode use (2) of said cathode electrode (11) being substantially in the form of a disk secured to the tubular casing (8), said electrode member (1) of said cathode electrode (11) having a generally semi-spherical shape and said electrode members (1,4) being coated with a layer;
characterized in that
said electrode member (1) of said cathode electrode (11) is fitted on and secured to a hub portion (14) of the electrode base (2) by means of a metal ring (3), has a large number of perforations (16), and is composed of a layered metal body including a ground layer of copper and a thin surface layer of nickel formed on a surface of said ground layer opposing to said anode electrode (12).

2. A discharge tube as claimed in claim 1, wherein the thickness of said thin surface layer of said cathode electrode (11) is within the range from 5 to 20 μm.

3. A discharge tube as claimed in claim 1, wherein said electrode member (1) of said cathode electrode (11) has another similar thin surface layer formed on the other surface of said ground layer thereof.

4. A discharge tube as claimed in claim 1, wherein said electrode member (4) of said anode electrode (12) is composed of a layered metal body including a ground layer and a thin surface layer formed on one or each of the opposite surface of said ground layer.

Patentansprüche

1. Entladungsröhre mit einem hohlen, rohrförmigen Gehäuse (8) und einem Paar von einander gegenüberliegenden Kathode- und Anode-Elektroden (11, 12), die an den axial gegenüberliegenden Enden des rohrförmigen Gehäuses (8) befestigt sind, um in dem rohrförmigen Gehäuse einen eingeschlossenen hohlen Raum (13) zu begrenzen, in den inertes Gas eingefüllt ist, so daß eine Entladung durch Anlegen einer Impulsspannung zwischen den Kathode- und Anode-Elektroden (11, 12) ausgelöst werden kann, wobei jede der Elektroden eine Elektrodenbasis (2, 6), die an dem rohrförmigen Gehäuse (8) befestigt ist, und ein Elektrodenteil (1, 4) umfaßt, das fest an der Elektrodenbasis (2, 6) in dem hohlen Raum (13) angebracht ist, wobei die Elektrodenbasis (2) der Kathoden-Elektrode (11) im wesentlichen die Form einer an dem rohrförmigen Gehäuse (8) befestigten Scheibe hat, das Elektrodenteil (1) der Kathoden-Elektrode (11) eine im wesentlichen halbkugelige Form hat und die Elektrodenteile (1, 4) mit einer Schicht beschichtet sind;
dadurch gekennzeichnet, daß
das Elektrodenteil (1) der Kathoden-Elektrode (11) an einem Nabenteil (14) der Elektrodenbasis (2) aufgepaßt und mit Hilfe eines Metallrings (3) befestigt ist, eine große Anzahl von Perforationen (16) hat und aus einem geschichteten Metallkörper gebildet ist, der eine Grundschicht aus Kupfer und eine dünne Oberflächenschicht aus Nickel umfaßt, die auf einer Oberfläche der Grundschicht gebildet ist, die der Anoden-Elektrode gegenüberliegt.

2. Entladungsröhre nach Anspruch 1, wobei die Dicke der dünnen Oberflächenschicht der Kathoden-Elektrode (11) innerhalb des Bereichs von 5 bis 20 μm liegt.

3. Entladungsröhre nach Anspruch 1, wobei das Elektrodenteil (1) der Kathoden-Elektrode (11) eine weitere ähnliche dünne Oberflächenschicht hat, die auf der anderen Oberfläche ihrer Grundschicht angeordnet ist.

4. Entladungsröhre nach Anspruch 1, wobei das Elektrodenteil (4) der Anoden-Elektrode (12) aus einem geschichteten Metallkörper gebildet ist, die eine Grundschicht und eine dünne

Oberflächenschicht umfaßt, die auf einer oder jeder der gegenüberliegenden Flächen der Grundschicht gebildet ist.

Revendications

1. Un tube à décharge, comprenant une enveloppe tubulaire creuse (8), et une paire d'électrodes cathode et anode (11, 12) se faisant face, fixées aux extrémités axiales opposées de ladite enveloppe tubulaire (8) pour définir dans ladite enveloppe tubulaire un espace creux fermé (13) dans lequel est introduit un gaz inerte de telle sorte qu'une décharge peut être amorcée par l'application d'une tension d'impulsion entre lesdites électrodes cathode. et anode (11, 12), chacune desdites electrodes comprenant une base d'électrode (2, 6) fixée à ladite enveloppe tubulaire (8) et un élément d'électrode (1, 4) monté de façon fixe sur ladite baie d'électrode (2, 6) dans ledit espace creux (13), la base d'électrode (2) de ladite électrode cathode (11) ayant sensiblement la forme d'un disque fixé à l'enveloppe tubulaire (8), ledit élément d'électrode (1) de ladite électrode cathode (11) ayant une forme généralement semi-sphérique et lesdits éléments d'électrode (1, 4) étant enrobés d'une couche :
caractérisé en ce que
ledit élément d'électrode (1) de ladite électrode cathode (11) est monté et fixé sur une partie moyeu (14) de la base d'électrode (2) au moyen d'un anneau métallique (3), comporte un grand nombre de perforations (16), et est composé d'un corps métallique à couches comprenant une couche de base en cuivre et une mince souche de surface en nickel formée sur une surface de ladite couche de base faisant face à ladite électrode anode (12).

2. Un tube à décharge selon la revendication 1, dans lequel ladite mince couche de surface de ladite électrode cathode (11) a une épaisseur comprise entre 5 et 20 µm.

3. Un tube à décharge selon la revendication 1, dans lequel ledit élément d'électrodes (1) de ladite électrode cathode (11) comporte une autre mince couche de surface similaire, formée sur l'autre surface de ladite couche de base de celui-ci.

4. Un tube à décharge selon la revendication 1, dans lequel ledit élément d'électrode (4) de ladite électrode anode (3) est composé d'un corps métallique à couches comprenant une couche de base et une mince couche de surface formée sur l'une ou chacune des surfaces opposées de ladite couche de base.

FIG. 1

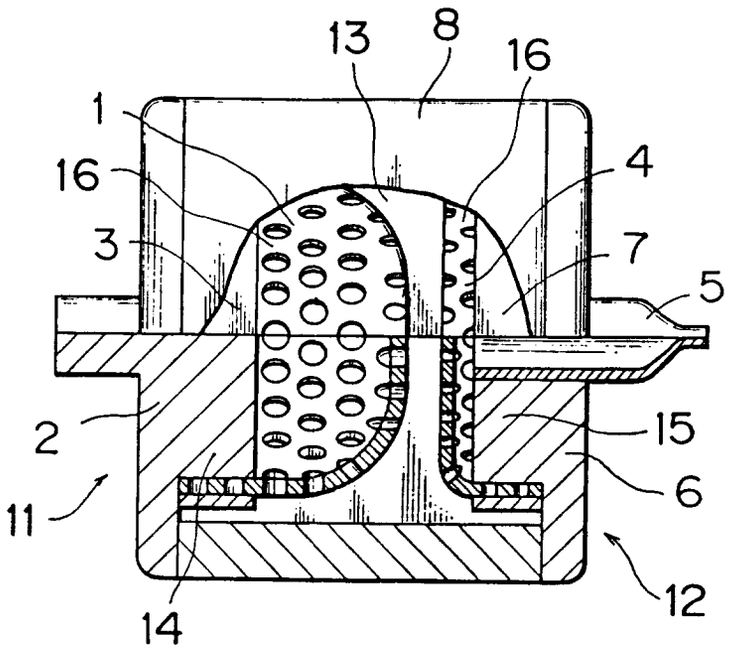
13
8
16
1
16
4
3
7
5
2
15
6
11
12
14

FIG. 2

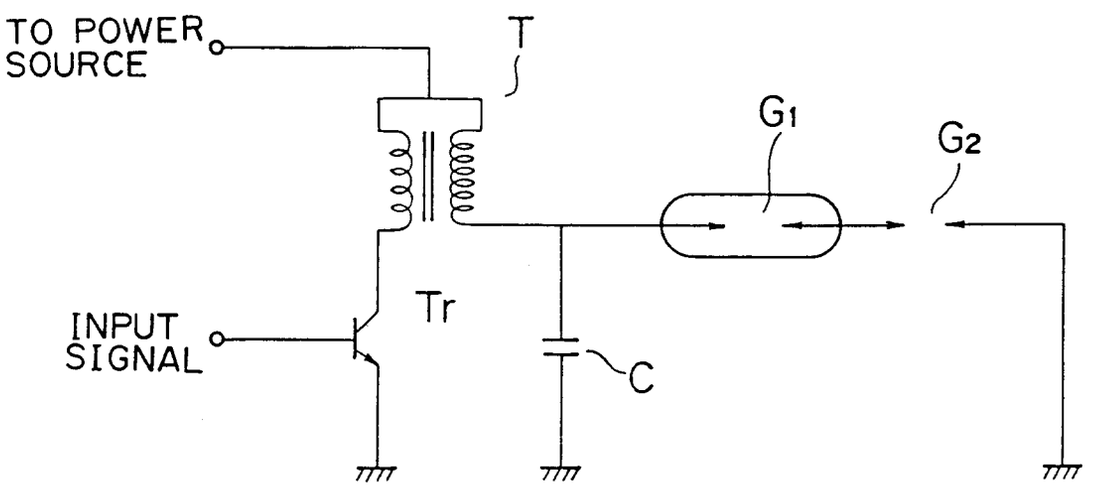
TO POWER SOURCE
T
G1
G2
Tr
INPUT SIGNAL
C

FIG. 3

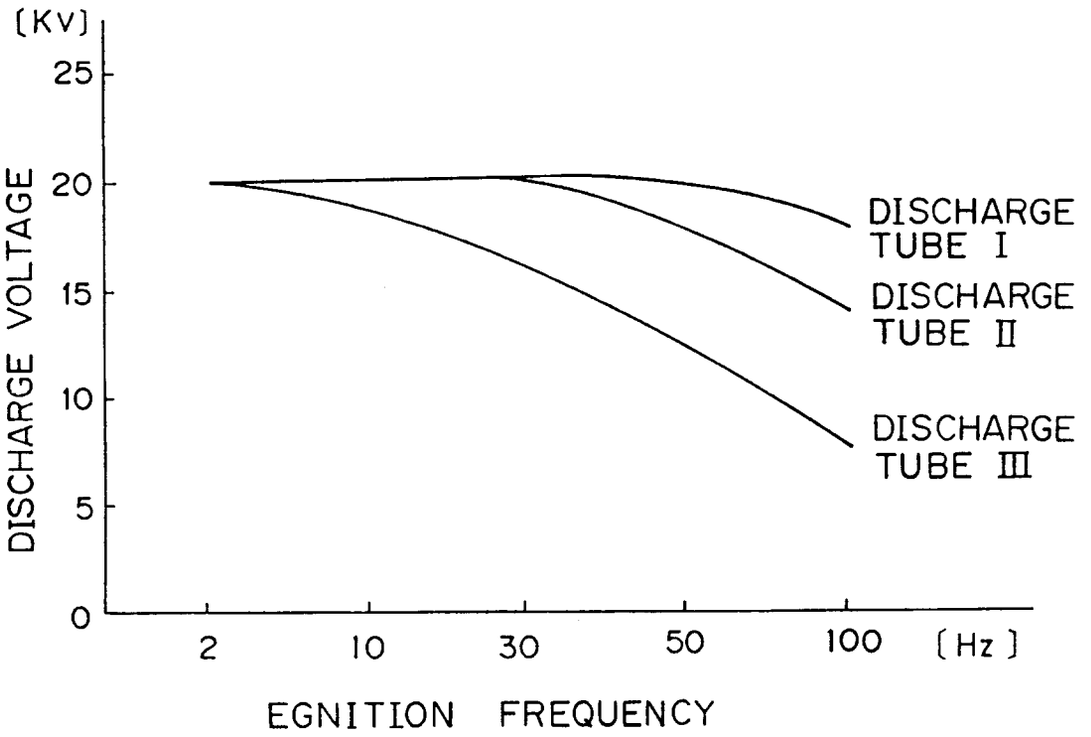

FIG. 4
PRIOR ART