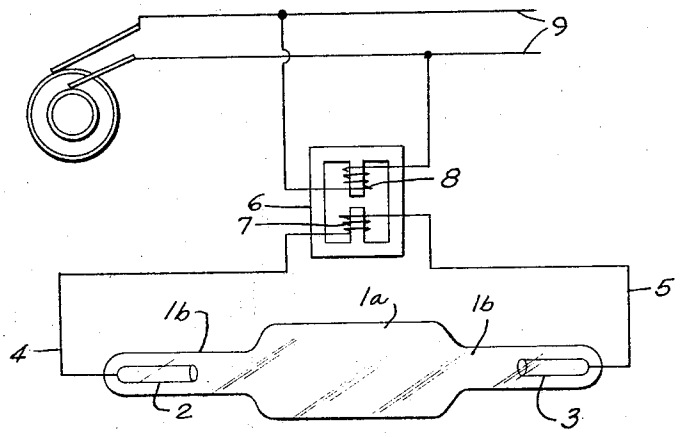
Aug. 23, 1966 A. C. DAURAY 3,268,756

GASEOUS DISCHARGE DEVICE WITH MAGNETIC FLUX CONTROL

Filed June 5, 1963

Fig. 1



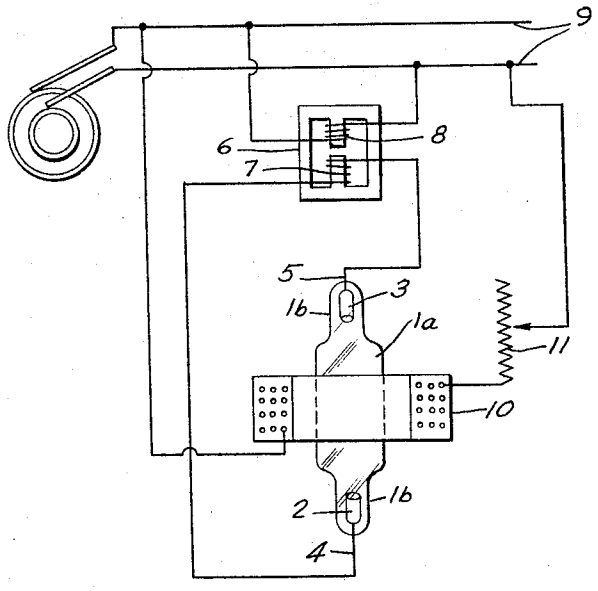


Fig. 2

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GASEOUS DISCHARGE DEVICE WITH MAGNETIC FLUX CONTROL

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1 Claim. (Cl. 313—161)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

The invention relates generally to a device and method for visually observing the behavior of a plasma in a gaseous conductor.

The definition of the word "plasma" as referred to in this specification may be technically defined as the region in a gas discharge which contains very nearly equal numbers of positive ions and electrons, and hence is nearly neutral.

The problem of the stability of a pinched discharge has been studied with great interest during the last decade because of its importance in the field of controlled fusion research. It is generally known from experimental results of those skilled in the art that plasma in a pinched discharge has a pronounced tendency to be unstable. It is further known that a cylindrical column of ionized gas carrying electric current along the axis of same cannot be kept in confinement only by the current's own magnetic field and conducting walls.

In order to understand the nature of the problem, one would like to be able to study the structure of the instabilities of such cylindrical column of ionized gas in great detail. In this respect the experimental physicists doing pinched gas discharge experiments seem to have been handicapped by the great speed with which the instability develops as well as by the light coming from impurities instead of the main body of pinched gas.

Prior to this invention a liquid model of instabilities in a pinched discharge has been tried for the study of the problem of instability with some measure of success, but again this process proved too fast for visual study.

The primary object of this invention is to eliminate the aforementioned difficulties by the use of a novel gas discharge tube or conductor to produce a gaseous conductor in place of a conventional liquid conductor in making a model to study instabilities in a pinched gas discharge.

Further objects of the invention will become more apparent from a consideration of the accompanying drawings, constituting a part hereof, in which like reference characters designate like parts and in which:

FIG. 1 shows diagrammatically a gaseous conductor and circuit embodying the invention; and

FIG. 2 illustrates the apparatus and circuit of FIG. 1 having additionally an externally applied magnetic field means to the gaseous conductor, as shown.

One embodiment of the device comprises a gaseous discharge tube, wherein is produced a cylindrical column of ionized gas carrying electric current along the axis and kept in confinement by the current's own magnetic field for a given electric current and a given gas pressure within the enclosure. The wall of the tube or gas inclosure of this invention appears to play a minor part in keeping the plasma column in a remarkably stable and uniform diameter from one electrode to the other electrode of the gas conductor or inclosure. The plasma column acts like a virtual metallic conductor carrying a current. This invention makes use of the glow discharge stage of operation of a gas discharge tube as opposed to the arcing stage as is commonly used. In this embodiment a magnetic field of any configuration produced by alternating or direct current may be used to probe the interaction of a plasma in an alternating or direct current magnetic field.

Applicant found experimentally that if a U-shaped tube was used instead of a straight tube, the cylindrical column of plasma remained centered along the axis of the tube and was of uniform diameter even when rounding the bend in the tube or gas envelope.

In a further embodiment to produce a gaseous conductor model to study instability in a pinched gas discharge, the tube is placed in the center of a solenoid which is energized by a source of alternating current in phase with the alternating current flowing through the discharge tube. By varying the intensity of the magnetic field of the solenoid the instability of the discharge within the tube can be made to take form step by step. This feature and method is of great importance in studying in detail the true nature of the instability of the plasma.

This invention comprises a gaseous conductor confined in a windowed or transparent sealed gaseous receptacle or envelope which can easily be placed in any position or oriented in any way in a magnetic field. Concerning the character of the gaseous conductor, it consists of a plasma column sealed into a receptacle of such shape as to permit the displacement of the plasma column from the central axis of the receptacle in the presence of a magnetic field. This is accomplished by providing a gaseous discharge tube with a pair of electrodes, a gas capable of giving a glow discharge confined within the tube subjected to a pressure which, at a given low current flow between the electrodes, will produce a discharge glow.

Referring to the drawings, FIG. 1 comprises a gaseous envelope or tube **1** of a U-shaped or other desired shape made of a suitable transparent or windowed material having an intermediate portion **1***a*, and a pair of oppositely extending tubular portions **1***b* usually termed the neck portions of the tube as shown. Within the neck portions of the tube are mounted, in any desired manner electrodes **2** and **3** preferably of the cold cathode type and being hollow tubular iron electrodes or other desired material. Electrodes **2** and **3** are respectively connected to lead wires **4** and **5** of the secondary winding **7** of transformer **6**. The primary winding **8** is connected to an electrical supply **9**. A magnetic field of any configuration produced by alternating or direct current may be used with the tube of FIG. 1 to study the interaction of a plasma in a corresponding alternating or direct current magnetic field.

In FIG. 2, tube **1** is similar to that shown in FIG. 1 and is connected to a suitable source of alternating current as represented by conductors **9**.

FIG. 2 differs from FIG. 1 in that an electro-magnetic coil **10** has been added to the circuit and which may be applied in various forms and shapes to tube **1** to distort and influence the plasma column in a gaseous conductor. Coil **10** may be used to remove any magnetic flux from tube **1**. The zero axis of the external electro-magnetic field of coil **10** may be varied with respect to the zero axis of the electro-magnetic field of tube **1**. Also, the variations of field intensities of these two fields may be in phase or varied with respect to one another as desired. The tendency of the glow discharge to enlarge towards splitting into a plurality of discharges indicates a phase difference increase.

The intermediate section of tube **1** is shown centered along the central axis of the open air core of coil **10**. One end of coil **10** is connected to one of the electrical supply mains **9** in series with a variable resistance **11**. The other end of coil means **10** is respectively connected to the other electrical supply main **9** as shown in FIG. 2.

When mains **9**, FIG. 2, are energized by a source of alternating current, for example, a potential at 110 volts, 60 cycles per second, and 120 milliampere current flow in the primary of high leakage transformer **6**, the secondary winding of transformer **6** being at a high potential of 5,000 volts, a normal glow discharge is initiated from

one electrode of one end of tube **1** to the other distant electrode in tube **1** of FIG. 2. The gaseous discharge is greenish-white in color for other materials such as Xenon, and of such brilliance as to be viewed directly with the eyes without the aid of sunglasses or other protective eye means. The gaseous discharge between electrodes **2** and **3** forms into a uniform column about one-eighth of an inch in diameter and extends along the central axis of the tube at a predetermined gas pressure. Very little, if any, corona discharge or electric glow is visible about electrodes **2** and **3**. The discharge appears as if it were coming out from within the hollow section of the tubular electrodes as a jet stream.

At this stage the variable resistance **11** is connected into the circuit of coil **10** and a negligible current flows through coil **10**. Coil **10**, in this particular specification of the device, is made of approximately 1,000 turns of No. 20 Brown and Sharp gauge magnet wire. The variable resistance **11** has a range of values from zero to 100 ohms.

In operation, if a current is caused to flow from a low magnitude to a larger magnitude through coil **10** by eliminating some of the resistance of resistance **11** in series circuit arrangement with coil **10**, a kink in the plasma column will start to form. If such current flow is further increased in magnitude the radius of the kink will keep on increasing until the current flowing in coil **10** reaches about 3 amperes. At this stage of operation if the current flow is further increased in magnitude the kink changes into a gaseous conductor model of instability in a pinched discharge, which resembles in a remarkable degree the liquid conductor model of instability in a pinched discharge.

The device is very simple to operate and permits detailed study of instabilities of plasma heretofore unobtainable at a fraction of the power required to operate the conventional liquid conductor models. Many of these conventional liquid conductor models may operate on a thousand amperes of current.

Further, it is possible by the instant device to repeat or reproduce for careful study any stage of the formation

of the model of instability which is not possible in the conventional liquid model.

It is to be understood that this invention is not necessarily restricted to the embodiments of FIGS. 1 and 2, as other variations employing different configurations in the shape of the gaseous conductor tube **1**, the means to regulate the flow of current in the magnetic coil **10**, the geometry of the magnetic field of coil **10** may be made by one skilled in the art without departing from the spirit and scope of the invention.

I claim:

Apparatus for observing the behavior of a gas discharge plasma in a magnetic field and for simulating the electromagnetic conditions for controlling the variability of conditions in a fusion plasma comprising: a hermetically sealed elongated transparent enclosure containing a gaseous conductor and having a pair of ends and a pair of electrodes, one of said electrodes located in one of each of said ends, an alternating current source, means for connecting said electrodes across said alternating current source, means for producing a magnetic field acting upon the gaseous conductor in said enclosure, means for varying the intensity of the magnetic field produced by said means for producing a magnetic field and means for connecting said means for producing a magnetic field and said means for varying the intensity to said alternating current source in a predetermined phase relation to said electrodes whereby said gaseous conductor produces a glow discharge the behavior of which is a function of the variations in said magnetic field and whereby any stage in the formation of a plasma created by fusion can be simulated.

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