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STARTING APPARATUS FOR A COLD CATHODE ELECTRON DISCHARGE DEVICE

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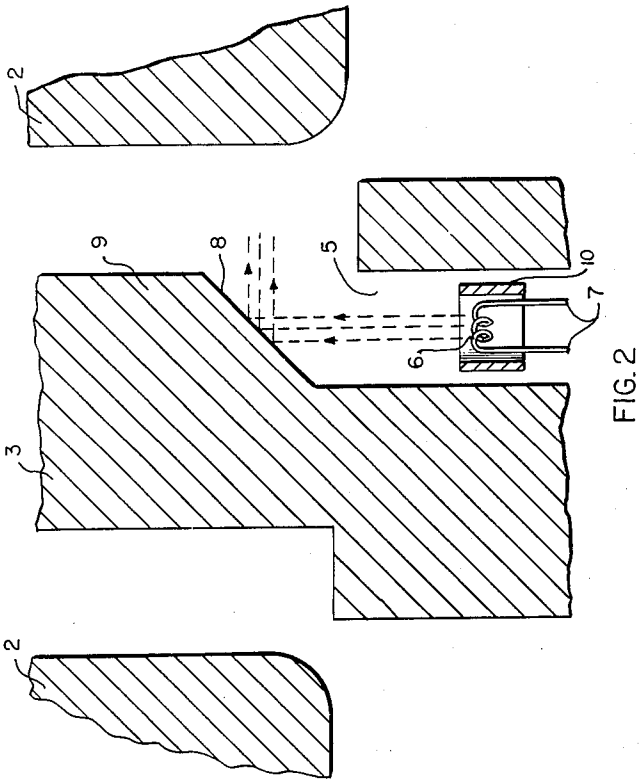


FIG. 2

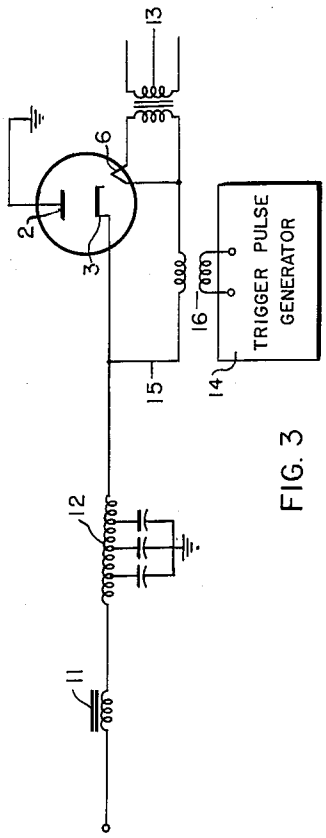


FIG. 3

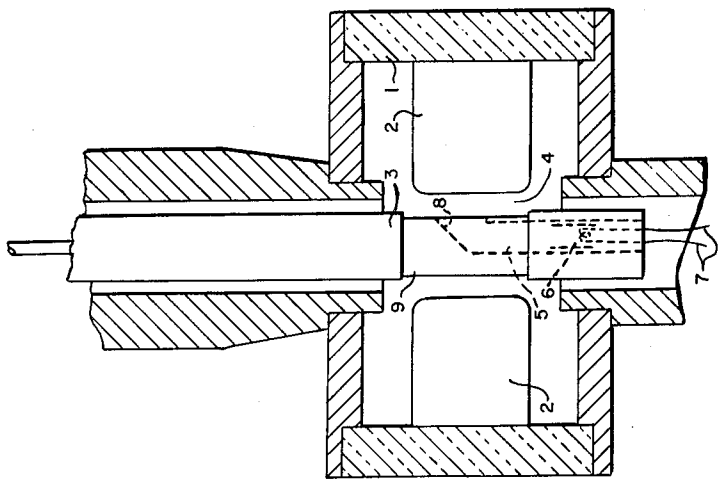


FIG. 1

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STARTING APPARATUS FOR A COLD CATHODE ELECTRON DISCHARGE DEVICE

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This invention relates to means for starting cold cathode discharge devices and is particularly directed to an improved form of cathode for such means.

The principles of the invention are herein presented in connection with magnetrons. The invention may, however, be applied to other forms of discharge devices.

In the construction and operation of cold cathode magnetrons as in other forms of cold cathode devices the problem arises of starting a flow of electrons to support oscillations or discharge within the device. The present invention solves this problem in a manner which makes no compromise upon the like of the tube nor its efficiency of operation.

A source of primary electrons for starting is provided by a small thermionic filament so placed that while it serves as a source of electrons it is itself protected from high velocity electrons during operation of the magnetron.

The source of starting electrons is so arranged that at least a portion of its emission is directed at high velocity to an angularly disposed reflecting surface or target. Relatively slow secondary electrons are thus liberated from the reflecting surface which is so situated that the slow electrons are immediately subjected to the intense field between the anode and cathode of the tube. Here they again acquire high velocity and supply the necessary medium to initiate oscillation of the tube. Once the action has started bombardment of the cold cathode releases sufficient secondary electrons to sustain oscillation in the normal manner.

It should be particularly noted that when the tube has started none of the high velocity electrons traversing the resonator cavities and the interaction spaces of the tube can reach the starter filament because no direct path is provided for them to reach the filament. The electrons that strike the reflecting surface are slowed down to the state where they are again drawn into the high intensity resonator spaces of the tube.

It is therefore a primary object of the present invention to provide a starting means for a cold cathode discharge tube which has a relatively long life.

A further object of the invention is to provide a cold cathode construction having a starting electron source which is situated remotely from the path of high velocity electrons.

A still further object of the invention is to provide a discharge tube in which starting electrons are beamed into the interaction space of the tube from a remote source in such a manner that the electron source cannot be struck by high velocity secondary electrons.

Other objects and features of the invention will more fully appear from the following description and will be particlularly pointed out in the claims.

To present a complete and comprehensive understanding of the invention a particular form thereof will be described and illustrated in the drawings in which:

Fig. 1 is a partial cross-sectional view of a magnetron

embodying the invention; Fig. 2 is an enlarged detail cross-section through portions of the cathode and anode of the magnetron.

Fig. 3 is a circuit diagram illustrating a specific application of the invention.

The invention is shown as applied to a cold cathode type magnetron which has no inherent thermionic emission. The principles of the invention may, however, be applied to any or all discharge devices wherein an auxiliary source of electrons is arranged to cause a small flow of electrons between anode and cathode thus starting oscillation after which the auxiliary flow of electrons may be discontinued.

The starting electrons are introduced in a novel manner as will appear hereinafter. The major elements of the magnetron are substantially of conventional design in which an anode block **1** is provided with a plurality of segments **2** extending radially from a centrally located cathode **3** and having their inner ends terminating a specified distance from the cathode to form an interaction space **4** between the anode and cathode. The anode block may conform to any of the standard types such as the vane or hole and slot type of construction.

The cathode has no direct thermionic emission and may consist of a tungsten rod which functions on the principle of secondary emission to sustain the operation of the magnetron.

In such a device to start from a cold tube there must be a supply of electrons introduced into the interaction space to initiate oscillations. To do this a relatively small channel **5** is formed within the cathode extending axially thereof and within which is received a small filamentary thermionic cathode **6** or any other type of cathode capable of thermionic emission. The filament **6** is insulated from the cathode and has its wires **7** extended outside of the tube and connected to a suitable source of heating current such as an exterior battery not shown. Desirably, this source of power is provided with a switch to control the power reaching the filament.

The channel **5** opens into and is terminated in the region of the interaction space by a flat reflecting surface **8** which forms an electron target which desirably is positioned substantially 45° to the axis of the cathode and the channel **5**. The cathode has an emission zone **9** of sufficient area to embrace all of the interaction space **4**.

Assuming direct current potential has been applied between cathode and anode and a magnetic field is acting along the axis of the cathode oscillation will not take place since the cathode is cold and no source of electrons is available. In the present invention, however, the filament **6** is energized and thus electrons are made available within the channel **5**. Any suitable means may be employed to move the electrons along the channel toward the surface **8**. One desirable means is to make the filament and channel in the form of an electron gun in which case an electron confining tube may be properly placed as in a conventional electron gun with respect to the filament or cathode **6** and energized to focus at least some of the electrons into a beam traveling along the channel **5** to the surface **8**.

The beamed electrons may be accelerated by establishing a potential difference between the filament **6** and the cathode **3** as shown in Fig. 3. Thus the primary electrons from the filament **6** are accelerated toward the target **8**. The fast electrons, thus beamed, will strike the surface **8** and liberate a certain amount of slow secondary electrons. The secondary electrons will be acted upon by the intense electric field in the interaction space and will be accelerated toward the anode **2**. A flow of electrons will thus be established which will sustain oscillation of the magnetron.

When the magnetron starts to operate the emissive area of the cathode will be bombarded to release sufficient electrons for normal operation of the device. In so doing, fast electrons passing from anode to cathode will strike the surface 8 and slow electrons will be released in the direction of the channel 5. These electrons, however, will never reach the filament 6 because they will immediately be drawn into the interaction space because they will be under the influence of strong forces existing at the oscillation areas of the tube.

It will thus be seen that the filament 6 is entirely protected from the destructive action of fast electrons acting at the power generating portion of the tube. Moreover, the life of the filament 6 may be further prolonged by cutting off the heating current flowing thereto during operation of the magnetron.

The life of the magnetron or other device in which this invention is used is thus not limited by the life of the starting device. Heretofore, this has been a limiting factor in cold cathode discharge devices wherein the relatively delicate filament used has been placed in a position where it was bombarded by fast electrons throughout the operation of the tube.

The invention lends itself to many practical applications, as for example, it may be used as a means to start and stop the action of a pulsed magnetron. Such an application is shown diagrammatically in Fig. 3 of the drawings.

In this circuit a cold cathode magnetron is to be pulse operated and the starting capability of the filament 6 is used to initiate each pulse. In the circuit shown direct current power is fed through a charging choke 11 into a pulse forming network 12 which in turn is connected to the cathode 3 of the magnetron, the anode 2 of which is connected to the return or low potential side of the direct current source. The cathode 3 is supplied with an accelerating filament 6 as described above and is supplied with heating current by a transformer 13.

Means are provided to supply a triggered potential between the cathode and the starting filament and in this way start oscillation of the magnetron through the action of the filament 6 as above set forth. To accomplish this any suitable triggering arrangement may be used. As shown a conventional trigger pulse generator 14 is coupled to the filament cathode circuit 15 through a transformer 16 which may have a voltage ratio acting to induce a high voltage in its secondary when a pulse cycle is started by the generator 14 thus applying the voltage between the filament 6 and the cathode thereby starting a flow of electrons to the target 8 which in turn starts oscillation of the magnetron.

Oscillation of the magnetron then continues, receiving its power from the energy stored in the pulse network which in turn has been previously energized from the main direct current power source. The values of capacitance and inductance in the network 12 and the choke 11 are so chosen that at the end of the desired duration of the pulse the cathode potential will have dropped to the point where magnetron oscillation will cease, after which the succeeding pulse cycle will take place as called for by the pulse generator 14. A succession of pulses will thus be generated by the magnetron without the use of a grid triggered supplementary circuit as is common practice in pulsed magnetrons.

I claim:

1. A secondary emission cathode for a discharge device having an electron emissive zone thereon, a channel formed in the cathode extending lengthwise thereof opening laterally into said zone and terminating in an angularly disposed target in line with said channel, a source of primary electrons in said channel remote from said emissive zone whereby primary electrons striking said target liberate secondary electrons into the space adjacent said zone.

2. A secondary emission cathode comprising a supporting structure, an electron emissive zone, an internal channel within said cathode opening at one end laterally into the space surrounding said emissive zone, a source of primary electrons in said channel remote from its lateral opening, an electron target in said channel at the point where it opens laterally into said space, said target being disposed in the path of primary electrons from said primary source whereby the primary electrons striking said target liberate secondary electrons into said space.

3. A secondary emission cathode for use in an evacuated discharge device comprising a non-emissive supporting structure having means for connection to an external power supply, an active emissive zone on the cathode, an elongated channel within said cathode having one end opening laterally into the space surrounding said emissive zone, a source of primary electrons in said channel remote from its lateral opening, an electron target in said channel at its lateral opening and situated in the path of primary electrons from said source and means to accelerate said primary electrons toward said target whereby said primary electrons striking said target liberate secondary electrons into said space.

4. A secondary emission cathode for a discharge device having a rod-like conformation, an electron emissive zone thereon, an inclosed elongated channel formed in said cathode extending lengthwise thereof and opening laterally at one end into the space surrounding said emissive zone, a source of primary electrons in said channel remote from its lateral opening, an electron target angularly disposed in said channel in the path of said primary electrons at the point where the channel opens laterally whereby primary electrons striking said target liberate secondary electrons into said space.

5. A cold cathode discharge device comprising a resonator chamber, an anode and a cathode in said chamber having an interaction space therebetween, a source of primary electrons, a channel opening at one end into said interaction space and containing said source of electrons, said source being located in said channel remote from its open end, said channel acting to protect said primary electron source from bombardment at said interaction space and acting to permit at least some of said primary electrons to move toward the open end of said channel, an electron target at said open end situated in the path of said primary electrons, and means to accelerate said primary electrons toward said target whereby said primary electrons striking said target liberate secondary electrons into said interaction space.

6. A cold cathode discharge device comprising the elements defined in claim 5 and in which said channel is formed within the said cathode.

7. A secondary emission cathode for a discharge device having an electron emissive zone thereon, an enclosed channel formed in said cathode opening laterally at one of its ends into the space surrounding said emissive zone, a thermionic cathode in the other end of said channel remote from its lateral opening, means within said channel acting to accelerate primary electrons from said thermionic cathode toward said lateral opening and an electron target in said channel at its lateral opening and disposed in the path of said primary electrons whereby said primary electrons striking said target release secondary electrons into said space.

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