My invention relates to an electrode and surface therefor, which is capable of liberating secondary electrons at a ratio greater than unity upon electron bombardment at low impact velocities, and is particularly adapted for use in conjunction with electron multipliers and multiplier oscillators such as have been previously described in my prior applications Serial #692,585, filed October 7, 1933, entitled Electron multiplying device issued as Patent 2,071,551 and Serial #733,837, filed July 5, 1934, entitled Oscillation generator, Patent 2,071,516.

The primary object of this invention is to provide an electrode which will give secondary emission at ratios greater than unity when impacted by electrons travelling at low velocities and which will remain operative at relatively high temperatures. Other objects are:

To provide a secondary emitter which is equally efficient over a wide temperature range.

To provide an easily formed secondary emitter.

To provide a means and method of forming electron multiplier cathodes.

And to provide a rugged secondary emission electrode.

My invention possesses numerous other objects and features, some of which, together with the foregoing, will be set forth in the following description of specific apparatus embodying and utilizing my novel method. It is therefore to be understood that my method is applicable to other apparatus, and that I do not limit myself, in any way, to the apparatus of the present application, as I may adopt various other apparatus embodiments, utilizing the method, within the scope of the appended claim.

The figure is a drawing of one form of electron multiplier, together with an operating circuit therefor. This figure is the same as Figure 1 of my prior application, Serial No. 733,837, referred to above.

In the construction of electron multipliers, as previously described by me, I have utilized a surface, against which electrons are repeatedly and cyclically directed, whereby the electron current is augmented by secondary emission at each impact until the required electron multiplication is obtained. Certain surfaces, of course, release secondaries better than others, and it has heretofore been customary to utilize certain photo-electric surfaces such as, for example, caesium deposited on silver oxide. Due to the low melting points involved, however, it is obvious that such cathodes, when used for secondary emitters in tubes which are required to handle high power, will not remain operative over any great temperature range, due to the fact that as the cathode temperature increases the cathode surface will be destroyed and the tube becomes inoperative, and also due to the fact that such surfaces are low temperature thermionic emitters.

My present invention provides a cathode for use as a secondary emitter, which has a uniform secondary emission impact response over a wide range in temperatures and which will remain operative at a temperature above that which would destroy alkali metal cathodes. At the same time, the sensitivity of the material herein described is substantially as good as far as secondary emission is concerned as the surfaces heretofore used. Furthermore, any thermionic emission in an electron multiplier decreases the efficiency of the device, and therefore more power may be abstracted from the cathodes herein described because thermionic emission takes place at a much higher temperature than it does with alkali metal cathodes.

Broadly, my invention comprises an alloy of a base metal, such as, for example, nickel alloyed with an alkaline earth metal, exemplified by barium or strontium, etc. In processing secondary emission electrodes, I treat this material in such a manner that it is highly efficient as a secondary emission electrode without respect to either its photo-electric or thermionic emission.

Referring to the drawing for a specific example of a multiplier tube embodying my present invention, an envelope 1, usually of vitreous material, is provided at each end with secondary emission cathodes 2 and 4. These cathodes are preferably parallel and opposed.

Intermediate the two cathodes is an annular anode 5. Inasmuch as there is no thermionic emission in the tube and no means provided for heating the cathodes 2 and 4, it is necessary, for the operation of the device, that the cathodes 2 and 4 be of such material, or be so treated, that they will be capable of producing secondary electrons at a ratio greater than unity when impacted by an electron traveling at a relatively low velocity. It is with the particular material and treatment of these cathodes that my present invention deals.

I prefer to use, as a specific example illustrating my invention, a barium-nickel alloy containing approximately 1% of barium, in sheets, forming my electrodes to proper shape and mount in the envelope 1. The material may be oxidized heavily before being put into the tube, or may be oxidized after mounting therein by passing a glow dis-
charge between the alloy electrode and the anode, preferably using direct current with the alloy at negative potential. The envelope is then pumped out, with the cathode being gradually heated to remove gas. The heat is then still further increased until barium is distilled out of the cathode and appears on the walls of the tube. A getter may then be flashed in the tube, and this getter may conveniently also be barium, as I find that it is satisfactory. During the heating process a large portion of the oxide is removed from the cathode. The tube is then allowed to cool and is connected in an oscillating circuit, as shown in the drawing, to see whether or not the secondary emission has been fully developed. Inasmuch as this oscillating circuit used for testing the device is the same circuit normally used to produce oscillations, the tube has been shown as being disconnected from the pump.

To operate the tube the cathodes 2 and 4 are connected together through a resonant circuit comprising the usual inductance and capacity. An intermediate tap 1 on the inductance is connected through a radio frequency choke 9, an anode source 16 and another choke 11, to the anode 5, the positive end of the battery being connected to the anode. The output of the device may conveniently be a coupled coil 12.

Briefly, the operation of the device is as follows: When the anode potential is applied, free electrons in the space between the cathodes are accelerated toward the center of the device by the potential on the anode. They are not allowed to be collected by the anode, however, because of a strong longitudinal electromagnetic field produced by solenoid 14, energized by a battery 15, and controlled by rheostat 16. The electrons, therefore, pass through the aperture in the anode 5 and are decelerated during their approach to the opposite cathode. The movement of the electrons toward the cathode induces a potential therein, and the electrons reverse their direction and are accelerated toward the opposite cathode.

As the voltage builds up across the tuned circuit 6, the electrons, during their oscillation, impact the cathodes 2 and 4 to produce secondaries, and these secondaries build up the oscillating current until an equilibrium is reached and the tube output stabilizes. While there are differing phase relationships between the electrons generating secondaries and those which are collected, it is not believed that it is necessary, in this application, to go into the finer points of operation as these points will be found in the two applications above referred to. The important feature, as far as the present application is concerned, is that the electrodes, processed as I have described, will consistently give a one-to-one emission ratio when an electron impact velocity of twenty volts is attained, thus comparing favorably with sensitized caesium surfaces heretofore used for secondary emitters.

The treatment that I have described above in no way corresponds to the method of forming a good thermionic emitter from the same material. In fact, the thermionic emission at a dull red, for example 750° C. is extremely poor, and for this reason the material which I have described is advantageous in that the cathode may operate continuously in temperatures up to and including a red heat, without thermionic emission disturbing the operation of the device, and I have been able to operate an electron multiplier with the cathodes at 1000° C., a temperature at which alkali metal surfaces would be destroyed.

I claim:

An electronic discharge device comprising an envelope containing an apertured anode, and a cathode capable of producing secondary electrons at a ratio greater than unity upon electron impact therewith, said cathode being formed of a nickel-barium alloy with barium approximately one per cent.

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