point at which a disruptive discharge no longer takes place, which ordinarily is about $\frac{1}{10}$ of a micron of mercury pressure. The Wehnelt or oxid cathode apparently depends on positive ionization for its activity. At any rate its emissivity is increased by an increase in positive ionization. When large amounts of thorium are present in my improved cathode, it is not so sensitive to positive ion bombardment and it is possible to obtain to a large extent the advantages of a thoriated cathode even in the presence of pressures of gas up to atmospheric pressure.

Another proof that the high electron emission is due to a skin of thorium is the fact that metallic thorium itself, particularly when free from surface oxidation, exhibits a very high electron emissivity for a given temperature as compared with tungsten. Difficulties are encountered with the use of metallic thorium as cathode material due to its relatively low melting point and its susceptibility to oxidation.

At 2000° to 2300° K., the active thorium is slowly diffusing to the surface from the interior of the metal. As the temperature is raised a point is reached where the distillation of thorium from the surface exceeds the rate at which the metal diffuses to the surfaces. It is possible, however, to operate a refractory thoriated cathode at a temperature between 2000° and 2200° K. for a long time without destroying its high electron emission, but operation at a higher temperature is not advisable. A sufficiently great electron emission can be secured through the indicated temperature range with an accompanying saving of energy necessary for heating the cathode.

The apparatus shown in Fig. 2 does not differ essentially from the apparatus shown in Fig. 1, plate-shaped anodes 15, 16 consisting of a highly refractory metal such as tungsten being used instead of the film anode of vaporized metal used in the apparatus shown in Fig. 1. The envelop 17 is baked out and evacuated as already described in connection with Fig. 1. The ionizable gas should be removed from the anodes during the final stages of the exhaust after the pressure has been reduced below about $\frac{1}{10}$ of a micron of mercury by subjecting the anodes to an electron discharge from the cathode 18 whereby ionizable gas is evolved, as disclosed in my co-pending application, Serial No. 795,610 of October 16, 1913. This gas should be removed as fast as liberated and the discharge voltage progressively increased, care being taken not to materially exceed the voltage at which blue glow takes place so as to avoid injury to the cathode. The final stage of the evacuation is produced by vaporizing a tungsten conductor in a side chamber (not shown in the drawing), thereby producing the very high vacuum necessary for the operation of the thoriated cathode. The anodes 15, 16 may be both connected to one terminal of a secondary of the transformer 19, by conductors 20, 21, the cathode being connected to the other terminal by conductor 22, including a load circuit 23. The cathode 18 has been merely indicated by dotted lines as being a V-shaped filament supported by terminal wires 24, 25, and maintained taut at its bight by a spring 26, but it is to be understood that it may have any convenient form. Thorium compound, for example, the oxid, is introduced during the process of manufacture as already described. The apparatus here shown is suitable for the rectification of alternating current when the cathode is maintained at incandescence by a battery 27, preferably at a temperature of 1700 to 1800° K.

It is not absolutely necessary that the thorium should be introduced into the body of the metal during the process of manufacture. As shown in Fig. 3 a cathode 28 located opposite an anode 29 is provided with a film of active thorium material vaporized from the coiled filamentary cathode 30 heated by a battery 31. The cathode 30 may consist either of a thoriated cathode prepared as already described, or of metallic thorium. The inclosing envelop has not been shown, but it is to be understood that these parts are to be operated in the high vacuum already indicated as being desirable. When the coil 30 consists of thoriated wire it is first rendered active by heat treatment at a temperature of 2200° to 2300° K., as already described, and is then heated to a temperature of about 2900° K. to distil off active material, some of which is condensed on the cathode 28. When the coil 30 consists of metallic thorium, it should be heated to a temperature near its melting point to distil some of the thorium over on to the surface of the cathode 28.

As positive ionization is very much decreased at low voltages, it is permissible to have present an inert gas at a pressure of say .01 micron when the voltage impressed between the cathode and anode does not arise above the ionizing potential of the gas. Advantage can be taken of this fact to use an electron discharge device containing a thoriated cathode as a voltage sensitive cut-out device. Below the voltage at which disintegration of the surface begins, a device such as shown in Fig. 1 may be used to pass a current of about $\frac{3}{10}$ of an ampere per sq. cm. when the cathode is at a temperature of about 1700° to 1800° K. When the voltage rises above the critical value, the current immediately drops to a very small value, thus practically interrupting the circuit. The cathode may be restored when the voltage