FIG. 1. Tip of NaCl whisker with a single axial dislocation. The surface of the whisker is not visible (500 x).

that these might be perfect crystals; on the other hand, certain whiskers decorated almost homogeneously throughout the volume, suggesting the presence of a large number of dislocations.

Apart from the rather ambiguous results just mentioned, the dislocation structure of a number of whiskers could be observed directly. Figure 1 represents a whisker of NaCl containing a single axial dislocation, as observed in the ultramicroscope. The decorated dislocation is practically all that is visible because the surface of the whisker is deliberately made invisible by immersing the crystal in a liquid of the same index of refraction as the crystal itself; this avoids surface scattering.

FIG. 2. NaCl whisker with several parallel dislocations (600 x).

A number of whiskers contained several dislocations parallel to the axis. Figure 2 represents a case where three roughly parallel dislocations are present; this clearly poses an interesting problem of stability for such a dislocation configuration. It may explain why lattice twists larger than the twist due to a single screw are sometimes observed.

A plate-like whisker was found to contain a lozenge-shaped network parallel to the plane of the plate. Bent whiskers were clearly polygonized after the decoration treatment.

These observations seem to suggest that whiskers can present a variety of dislocation configurations, of which the simplest is the axial dislocation.

A more detailed account of this work will be communicated later.

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Properties of a Thermoelectric Cell*

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A GAS-FILLED diode is proposed here as a useful device for the direct conversion of heat energy into electrical energy.[1-4] A vacuum diode operated with no applied voltage develops an electromotive force between the two electrodes, which depends among other things on the temperature difference of the electrodes. The hot electrode is electrically positive whith respect to the cold collector. When an external load resistor is joined to the electrodes,

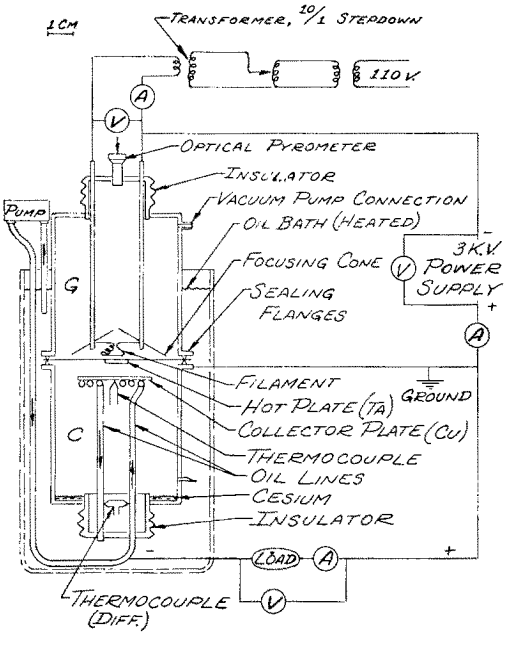

FIG. 1. Schematic diagram of the thermoelectric cell chamber (*C*) and the associated gun chamber (*G*) used for bombardment heating.

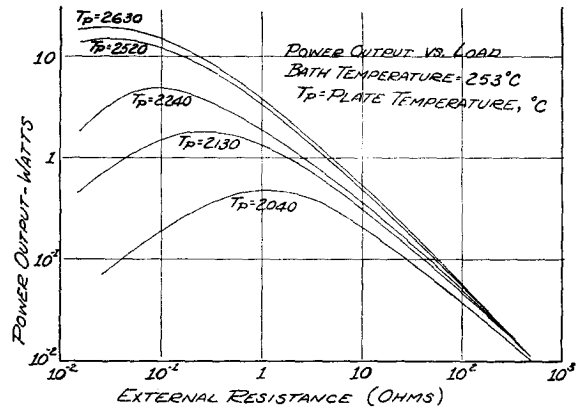

FIG. 2. Power output of the cell in watts *versus* the external load resistance in ohms.

the characteristic cell currents are of the order of one μa per sq cm of emitting surface for electrode spacing of the order of one cm. The current is determined by the space-charge limitation.

The addition of a very small amount of easily ionized gas such as cesium vapor into the cell container changes the cell characteristics in a drastic manner, while the cesium vapor appears to have little effect on the developed emf. The cell impedance is lowered by many orders of magnitude.

One may consider the cell as a thermocouple with the cesium plasma forming one branch. A conducting medium subjected to a temperature difference exhibits a characteristic thermoelectric power. The thermoelectric powers of metals have values of about 1 μv per °C. This value is especially low because of the degeneracy of the electron gas in metals. For nondegenerate conditions, such as in an electron cloud in vacuum, in a plasma, or in a semiconductor, the characteristic value of the thermoelectric power is more nearly a millivolt per degree centigrade.[5,6]

The ideal experimental cell should have a hot electrode, with energy supplied in such a way that there are no extraneous electromagnetic effects other than those produced by the thermoelectric process. The collector electrode must be cooled to a controllable temperature. In order to establish the cesium vapor pressure the entire cell including the chamber walls must be in an isothermal bath at a controlled temperature. For cesium vapor pressures up to the order of one mm of Hg, one must have a bath temperature of about 300°C which therefore prohibits the use of solder, ordinary gasket substances, etc. Yet the chamber must be vacuum sealed so that a static high vacuum can be maintained over long periods. Figure 1 shows the chief features of the cell which is in present use.

The chamber is divided into two parts, labeled *G*, the gun chamber, and *C*, the thermoelectric cell. The gun chamber contains a heated filament held at a potential of one to three kilovolts relative to the walls. The wall separating the two chambers is bombarded by the electron beam at currents of about 0.1 to 0.7 amp. A central spot on the wall, about two square centimeters in area, forms the hot emitter surface. With this bombardment-heating technique, extraneous fields are reduced to negligible values. The cell emitter surface is on the side opposite to that which is bombarded, and the cell enclosure is a good electrostatic shield against the gun fields. The gun chamber is continuously pumped to a high vacuum.

The cell chamber, labeled *C*, contains an insulated collector electrode which is cooled by circulating oil. The oil is drawn from the bath, thus the collector temperature is slightly above the temperature of the chamber walls. The oil cooling system is also used for a rough flow-calorimeter measurement of the heat transported from the emitter to the collector. The emitter electrode surface is tantalum. The collector surface is copper.

Liquid cesium metal is introduced into the cell chamber under an oxygen-free, water-free atmosphere. The chamber is then evacuated and permanently sealed. As shown in Fig. 1, the chamber is immersed in a silicone oil bath which is thermostatically controlled at temperatures up to 300°C, giving a cesium pressure range from 10^{-6} mm Hg to 1 mm Hg.

In operation, the cell electrodes are connected to a variable external resistance with provisions made for observing the terminal potential difference and output current. Figure 2 gives the results of power output *vs* external load resistance for various hot electrode temperature at a bath temperature of 253°C. The temperature of the cold electrode was never more than 50°C hotter than the bath temperature.

From Fig. 2, the peak power observed is 19 w or about 10 w per sq cm of emitter. The maximum short-circuit current observed was 40 amps.

The observed current *vs* voltage generally follows closely a relation of the form, $i \propto (v_0 - v)^2$, where v_0 is the open circuit voltage. However, in some regions of bath and of hot electrode temperatures, wide deviations from this form were observed. Some deviations appeared to be caused by internal (leakage) discharges.

A rough calorimetric determination indicates an "efficiency" of about 5% at the peak power output. Thus approximately 350 w were received by the collector by all processes of radiation, conduction, etc. The over-all efficiency was of the order of 2% since no attempt was made to limit extraneous radiation and conduction losses.

It has only been possible so far to investigate the operation of a particular cell whose design has not in any sense been optimized. In tests which are not yet completed some of the factors being studied are the dependence of cell characteristics on the emitter-collector spacing, collector temperature, cesium vapor pressure, electrode materials, and radiation shielding between the electrodes. These are the principal lines of research which are being pursued at this time of writing.

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Cohesion in Plasma

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FIGURE 1 shows a 4 μsec per frame, framing camera sequence of a *plasma* emitted from dithekite 13 (63/24/13 HNO_3-nitrobenzene-water) detonated through a glass plate by Composition *B* (photographed by Dr. D. H. Pack). Measurements of electron densities in such plasma have shown $\sim 10^{17}$ free electrons per cc. Moreover the plasma observed in the reaction zone of condensed explosives have in them $>10^{18}$ free electrons per cc. These plasma are formed during and by the detonation reaction and exist for several hundred microseconds when ejected into air and other low-density gases. (The average free-electron lifetime is only 10^{-8} to 10^{-7} sec in the reaction zone. Therefore, the plasma serves as a means for measuring the reaction rate, and the reaction-zone length or total reaction time in detonation.) Note the strong cohesion of the plasma of Fig. 1, causing a remarkable retention of