FIG. 2. Structure of a photo-diode and characteristics of the individual rectifying barriers (schematic).

diode" type of characteristic obtained when a metal point contacts certain areas on inhomogeneous germanium crystals. At low voltage, this characteristic is typical of a contact between metal and N-type Ge, but a marked saturation occurs in the forward (conducting) direction at higher voltage. Investigation showed that the geometry of Fig. 2 applies to such cases. There are two rectifying barriers involved, one of small area between metal and N-type Ge, and one of larger area between N- and P-type Ge. Figure 2 shows the characteristics for these individual rectifying barriers, which combine in series to produce the curve of Fig. 1, each half of the curve representing the reverse direction of one of the contacts.

If the layer of N-type Ge is thin, light can reach the $N-P$ boundary, causing pronounced photo-effects. Figure 3 illustrates the photo-conductive effect. The photo-current is instantaneous (within 10^{-5} sec.), varies linearly with light intensity, but varies little with voltage and temperature, thus appearing to be a primary photo-effect. Sensitivities of several milliamperes per lumen of white light are observed. Maximum sensitivity occurs at around 1.3μ with threshold at 1.5μ, the latter corresponding to an activation energy of 0.8 ev. With no voltage applied, a photo-voltaic effect occurs, the current being enhanced in this case by increasing the size of the metal contact in order to reduce its series resistance.

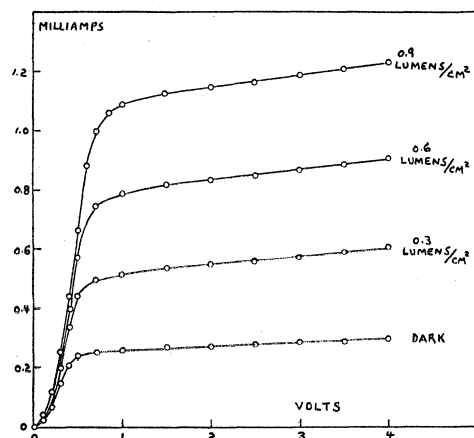The saturation current in the dark is extremely sensitive

FIG. 3. Effect of illumination on photo-diode characteristic (25°C).

to temperature, changing about a factor of two in a 10°C temperature change. The variation is as $i\sim\exp[-e\phi/kT]$, where ϕ is found to have a value around 0.7 volt. This is the order of the width of the forbidden band in germanium as determined from resistivity $vs.$ temperature measurements,[4] and therefore agrees with the barrier height to be expected for a contact between N- and P-type Ge.

Deliberate contacts between different specimens of germanium, including N- and P-type, have been tried[5] and give the sign of rectification expected. The geometry of Fig. 2 leads to greater photosensitivity, however, since the sensitive layer is more easily accessible to illumination. Thin films, as in the case of lead sulfide, would probably be most desirable.

In addition to photo-conductive and photo-voltaic effects, there are associated with these barriers negative resistance and self-oscillations.[6] A detailed description of all these phenomena will be published shortly.

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The Microwave Spectrum of Iodine Monochloride at $4\frac{1}{2}$ Centimeters Wave-Length*

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THE $J=0$ to $J=1$ absorption lines of the pure rotational spectra of ICl^{35} and ICl^{37} have been detected with a microwave spectrometer covering the frequency range of 6500 to 7200 megacycles. The absorption was observed as a lowering of the loaded Q, Q_L, of a resonant cavity into which the gas was introduced, the change in Q_L being measured by noting the fractional decrease in power, $\Delta P/P$, transmitted through the cavity at resonance upon introduction of the gas.[1] For a frequency ν the power absorption coefficient, α, in cm^{-1} is given by

$$\alpha = \pi\nu/cQ_L \cdot \Delta P/P,$$

where c is the velocity of light in vacuum.

A Klystron oscillator stabilized in frequency to one part in 10^6 by the Pound[2] circuit and a cavity with $Q_L=30{,}000$ were used. The rectified current of about one microampere from the crystal detector, which was proportional to the received microwave power, fed into a photo-cell galvanometer amplifier whose output was applied to a recording potentiometer. With the cavity tuned close to its resonance, the frequency of the oscillator was swept through several kilocycles to give a smooth recorder trace of the maximum transmitted power by slightly changing the temperature, and, therefore, the resonance frequency of the wave meter which controlled the frequency in the stabilization circuit. In this way the effect of the dielectric constant of the absorbing gas in shifting the resonance frequency could be easily compensated. The minimum measurable power absorption coefficient was 6×10^{-8} cm^{-1}.

The absorption peaks of the ICl^{35} and ICl^{37} molecules were found at 6980 and 6684 megacycles, respectively, with a possible error of one part in 10^3. The following values for the rotational constants, B_e, moments of inertia, I, and interatomic distances, r_e, have been calculated:

	B_e	I	r_e
ICl^{35}	0.1167 cm^{-1}	2.397×10^{-38} g/cm^2	2.303A
ICl^{37}	0.1118 cm^{-1}	2.502×10^{-38} g/cm^2	2.303A

The value of B_e for ICl^{35} obtained here is in disagreement with that of Curtis and Patkowski,[3] 0.1141 cm^{-1}, obtained from an analysis of the vibration-rotation bands of ICl^{35}.

The absorption peak of 10^{-6} cm^{-1} for ICl^{35} is in agreement with that given by the theory of Van Vleck and Weisskopf[4] for a choice of the line-breadth parameter, $\Delta\nu/c$, at atmospheric pressure of 0.08 cm^{-1} and assuming a linear $\Delta\nu/c$-pressure relationship. The measured half-breadths, linear in pressure over the 2 to 20-mm Hg pressure range investigated, were in harmony with this choice. A preliminary analysis of the line profiles shows the absorption in the wings of the lines to be in excess, by a factor 5 roughly, of that predicted by the Van Vleck-Weisskopf theory.

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The Crystal Structure of Element 43

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THE chemistry of element 43 was first studied by Perrier and Segrè,[1] from samples containing tracer quantities of technetium (Tc) produced by deuteron bombardment of molybdenum. More recently, a long-lived isotope has been found to be one of the products from U^{235} fission.[2] Lately, this long-lived, *beta*-active isotope has been produced by neutron bombardment of Mo.[3]

The material used in this work was a technetium preparation separated from fission products by G. W. Parker, J. W. Ruch, and J. Reed of the Clinton Laboratory. From this original sample, a number of chemical preparations in microgram amounts have been made by Dr. Sherman Fried of the Argonne Laboratory. Two of these proved to be the element itself. The fact that the sample was metallic technetium was shown conclusively by the characteristics of the x-ray pattern itself.

Technetium crystallizes in the hexagonal close-packed arrangement; that is to say, it is isomorphous with rhenium, ruthenium, and osmium. The cell, which contains two atoms of Tc, has the following dimensions:

$$a = 2.735 \pm 0.001A, \quad c = 4.391 \pm 0.001A, \quad c/a = 1.604.$$

The calculated density, based on the atomic weight of 99, is 11.487 g/cm^3. Each Tc atom has twelve nearest neighbors. Six are at a distance of 2.735A—the cell translation—and six at a somewhat smaller distance, 2.704A.

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Mass Spectrometric Study of Fission Element 43

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A SAMPLE of element 43 (Tc) separated from uranium fission products by Messrs. G. W. Parker, J. W. Ruch, and J. Reed of the Clinton Laboratories of the Monsanto Chemical Company was analyzed by a mass spectrometer in order to determine which of the possible fission isotopes have long lives. The existence of a Tc^{99} isotope with a half-life greater than forty years was first predicted by Seaborg and Segrè.[1] Glendenin, from experiments with fission products, set the half-life of a long-lived fission isotope of technetium at more than 3000 years.[2] A long-lived technetium activity was found in fission products by Lincoln and Sullivan,[2] and Schuman.[2] Motta, Boyd, and Larson obtained a half-life of 9.4×10^5 years with a sample prepared by neutron bombardment of molybdenum.[3]

. The sample of fission technetium used for our work was distilled into the ionization chamber of a Nier-type spectrometer as NH_4TcO_4. The resolved ion currents were recorded by means of a vibrating reed electrometer and a Leeds and Northrup Speedomax recorder. The curves obtained in the Tc^+ ion position are shown in Fig. 1. Curve a is the plot of the 98–103 mass range before the technetium was distilled into the source. The six large peaks in the spectrum are due to doubly charged mercury ions which were used as mass standards. Curve b is a plot of the same
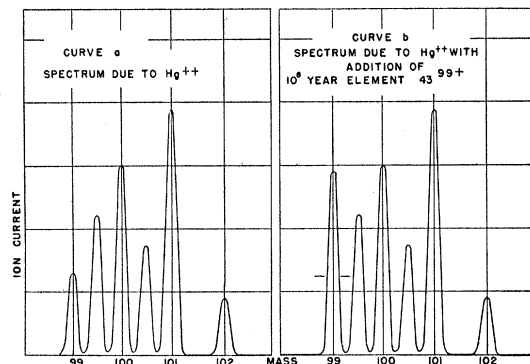

FIG. 1. Mass spectra showing increased intensity at mass 99 when technetium is added.