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Title
Physics-Quarterly, Aug., Sept., Oct. 1948 Sec. 5, Part II.

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Publication Date
1948-11-30

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Supplement to

PHYSICS DIVISION

QUARTERLY REPORT AUGUST 1, 1948 TO NOVEMBER 1, 1948

November 30, 1948

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5. Isotope Separation

W. L. Whitson

Summary

An energy modulating cyclorator was built and operated using UCl_4 as charge material. The intensity of the sidebands was determined by intercepting the beam at 180°. A beam of U^+ ions was energy modulated. The beam was decelerated and collected on a receiver at the 360° position and the modulation observed by varying the magnetic field and also by varying the modulation frequency.

Description of Unit

The name cyclorator has been suggested for the 360° type of isotope separator for which the mass separation depends on the difference in the time of flight. This method of isotope separation has been described in UCRL-167 (Supplement).

The unit is shown in Figure 1. The ion, source a, is at ground potential and includes filament, charge bottle, heaters and arc chamber. The liner, b, is at negative high potential. The ion beam enters the liner at c, travels in a circular path as indicated, emerges from the liner through a wire grid at d, and is decelerated in crossing the space to the collector e. More detail of the source and receiver are seen in Figure 2 where a are the filament leads, and b is the arc chamber. The ion beam is drawn from the arc chamber through the slit, c, and accelerated into the liner through the slit at d.

The wire grid through which the beam emerges from the liner is at e and the receiver box is at f.

Energy Modulation

The beam is energy modulated by applying a high frequency voltage to the liner which is small compared to the fixed high potential which is also applied. The energy given to the ions in the c - d gap in Figure 2 is varied, then, at high frequency. Also the deceleration potential in the e - f gap of Figure 2 varies at the same frequency and in phase with that at the c - d gap. Depending on the time of flight of the ion, and also on a fixed bias applied to the receiver f of Figure 2, the ions will either be collected or repelled. Some details of the high frequency oscillator are shown in Figure 3. The resonant inductance is the coil a and resonant capacity is the fixed vacuum condenser b, the variable condenser c and the capacity from the liner, b of Figure 1, to the vacuum tank wall. The rest of the high frequency oscillator is not shown, but is a modified Hartley oscillator. The d.c. high voltage and the high frequency voltage are applied in parallel to the liner through bushing d and the condensers e block the d.c. voltage from the high frequency oscillator.

Figure 4 is a schematic diagram of the electrical circuit.

iebands

Since ions of any mass arrive at the same place after traversing 360° it is essential in separating the uranium isotopes that only ions of certain mass impinge on the receiver. If, as was the case here, UCl_4 is the charge material some of the ions which compose the beam are

Cl^{++}, Cl^{+}, Cl_2^{+}, U^{++}, U^{+}, UCl^{+}, UCl_2^{+}, UCl_3^{+}, UCl_4^{+}. Of these only the ions which contain U a of interest, and of these U^{++} is the only one for which the 235 and 238 masses cannot be at least approximately separated if conditions are adjusted for separating the two masses of U^{+}.

Table 1 indicates the relative numbers of various kinds of ions. U^{+} and Cl^{+} together are 90% or more of the total beam and the ratio U^{+}/Cl^{+} varies between the extremes 3/1 and 4/3 depending on the arc conditions. For all results given later in this report U^{++} ions and all ions of less mass were removed from the beam by a baffle at the 180° position.

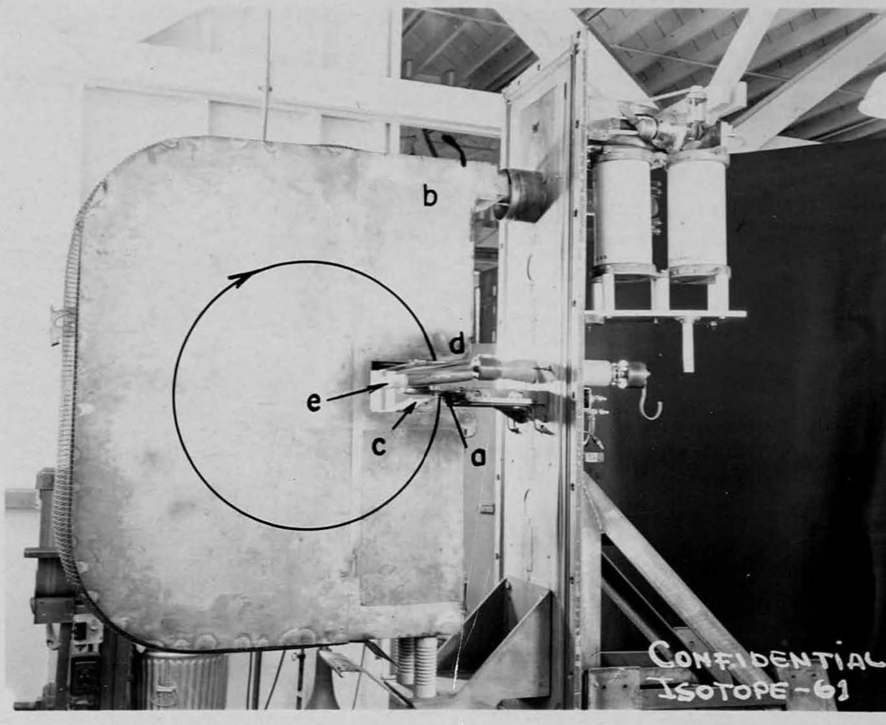
Modulation Observations

Reference to UCRL-167 (Supplement) where the method of energy modulation is described will show that if ions of only one mass are considered and if the first collector is biased slightly higher than the energy of the ions, then as the phase between beam energy modulation and collector potential is changed the current to this collector will be minimum when the phase angle is zero and maximum when the phase angle is 180°. The phase angle may be changed by varying either the magnetic field or the frequency of the modulating voltage.

Figure 5 shows the variation of current with magnetic field. It is considered to be preferable to vary frequency rather than field since in the latter case the radius of curvature of the ion beam varies resulting in different geometry at the receiver and also that field changes will alter the arc and perhaps as a result alter the quality of the beam. Figure 6 shows the variation of collected current with frequency. The positions of the observed current maxima are in very good agreement with those computed from the frequency increments necessary for a phase shift of 360°.

TABLE 1

Arc Voltage	Arc Current	Acceleration Voltage	BEAM				
			Cl	Cl	Cl_2	U	U
55 volts	1.5 amp	30 kv.	.9 ma.	13 ma.	.9 ma.	3.0 ma.	33 ma.
95 volts	2.5	30	1.4	30	1.4	.9	40
140 volts	4.0	31	2.4	25	2.0	3.0	43
140 volts	2.1	31	1.1	17	1.8	1.8	40
160 volts	1.4	31	1.2	21	1.3	3.6	41
75 volts	2.7	31	1.2	15	1.3	2.8	35
140 volts	2.5	31	1.1	13	1.4	1.7	39


b
d
e
c
a
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ISOTOPE-61

FIG. 1

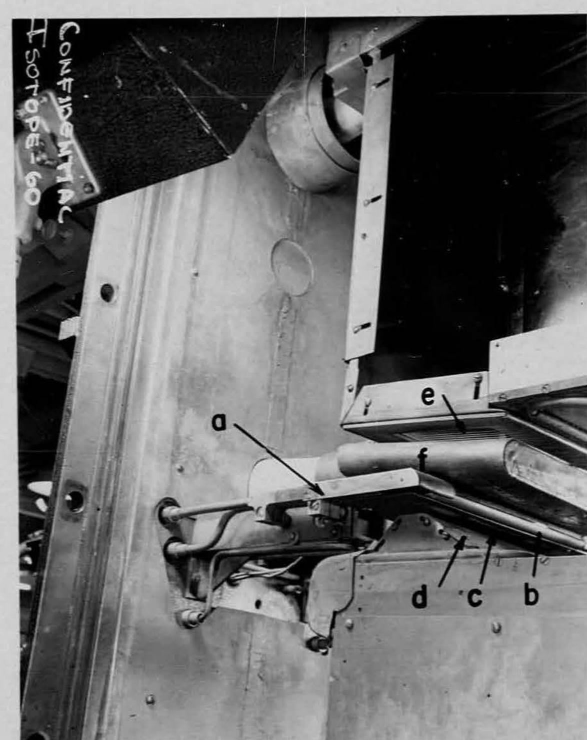
CONFIDENTIAL
ISOTOPE-60
e
a
f
d
c
b

FIG. 2

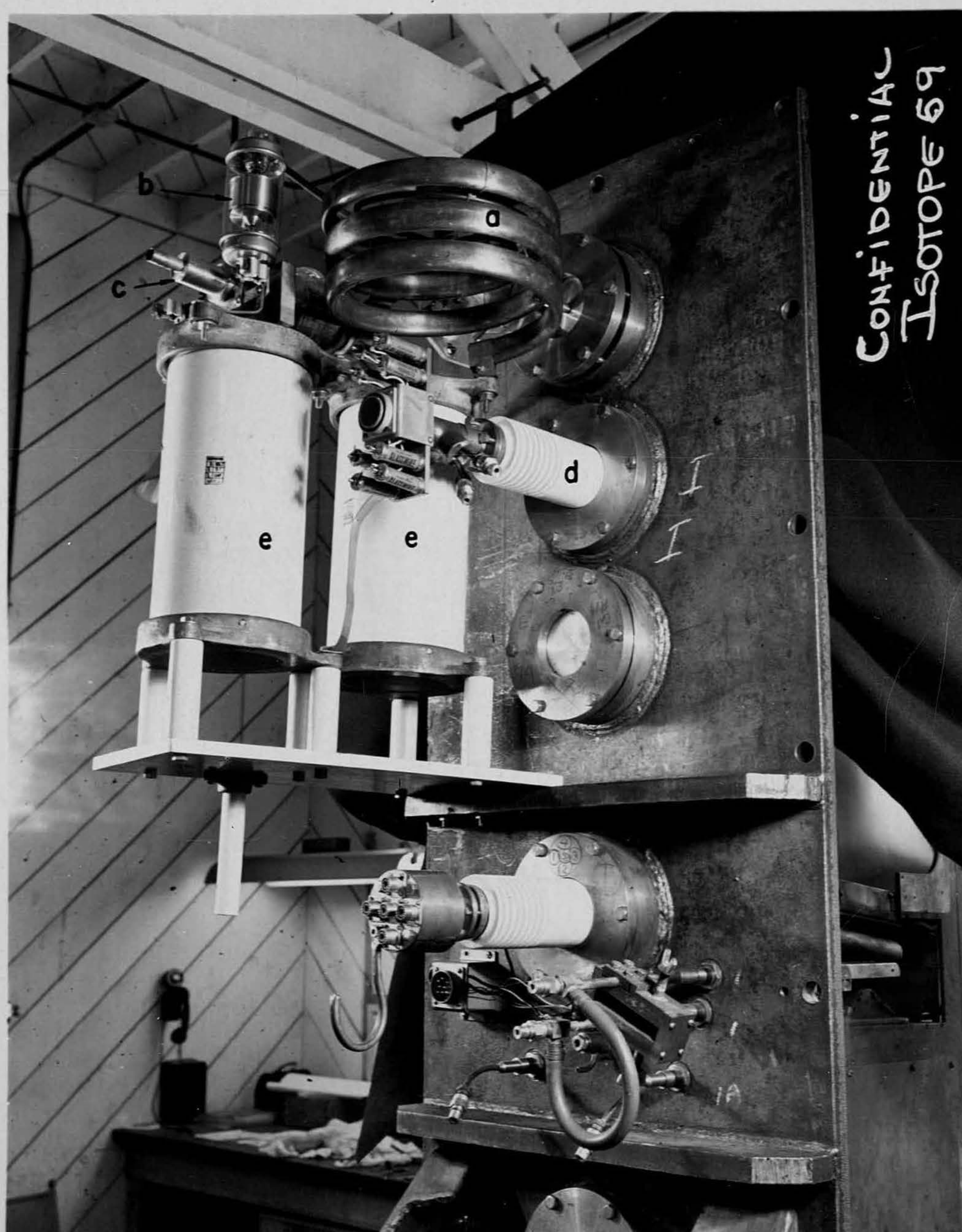

FIG. 3

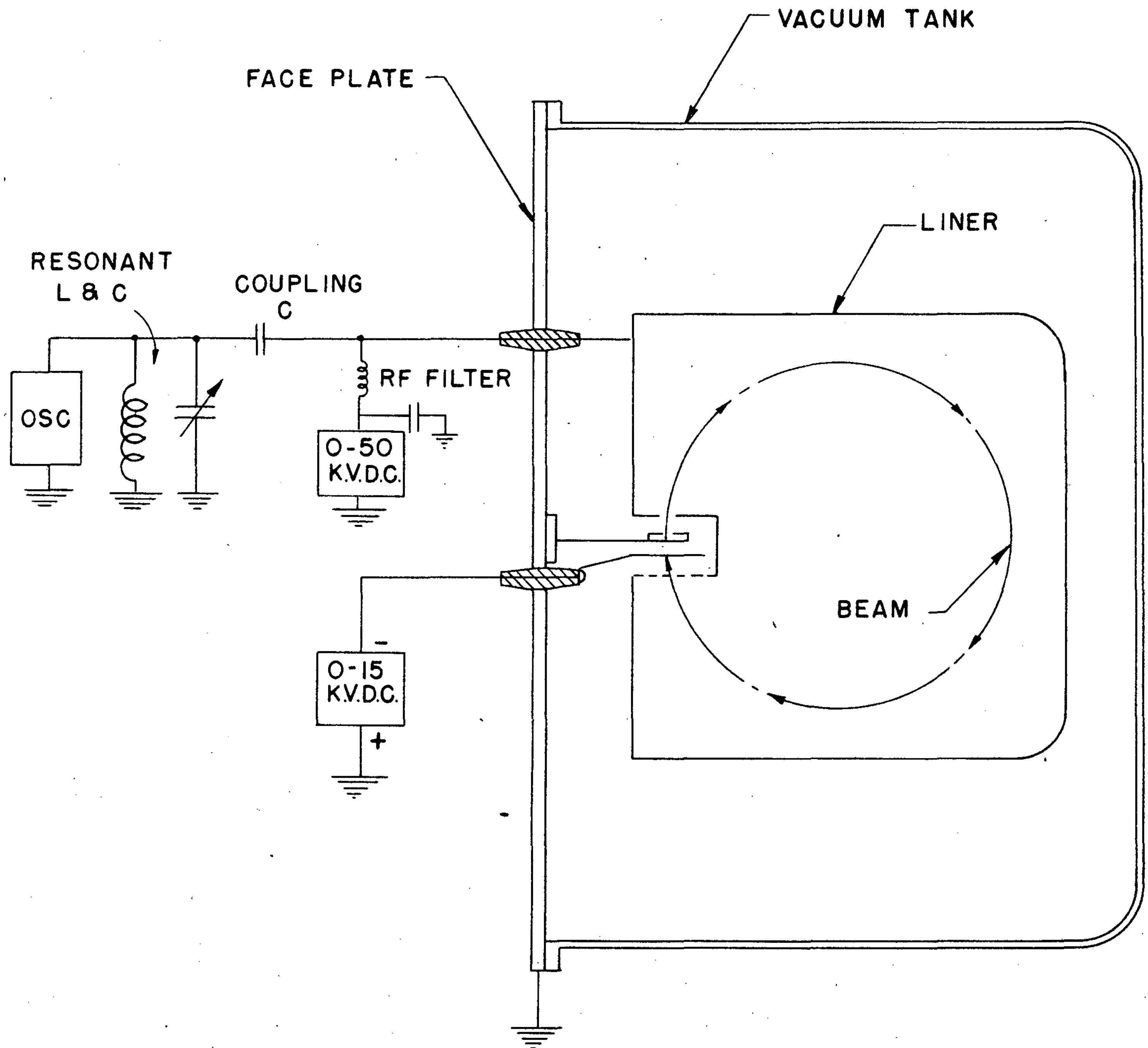
VACUUM TANK
FACE PLATE
LINER
RESONANT
L & C
COUPLING
C
RF FILTER
OSC
0-50
K.V.D.C.
BEAM
0-15
K.V.D.C.
-
+

FIG. 4

13201-1

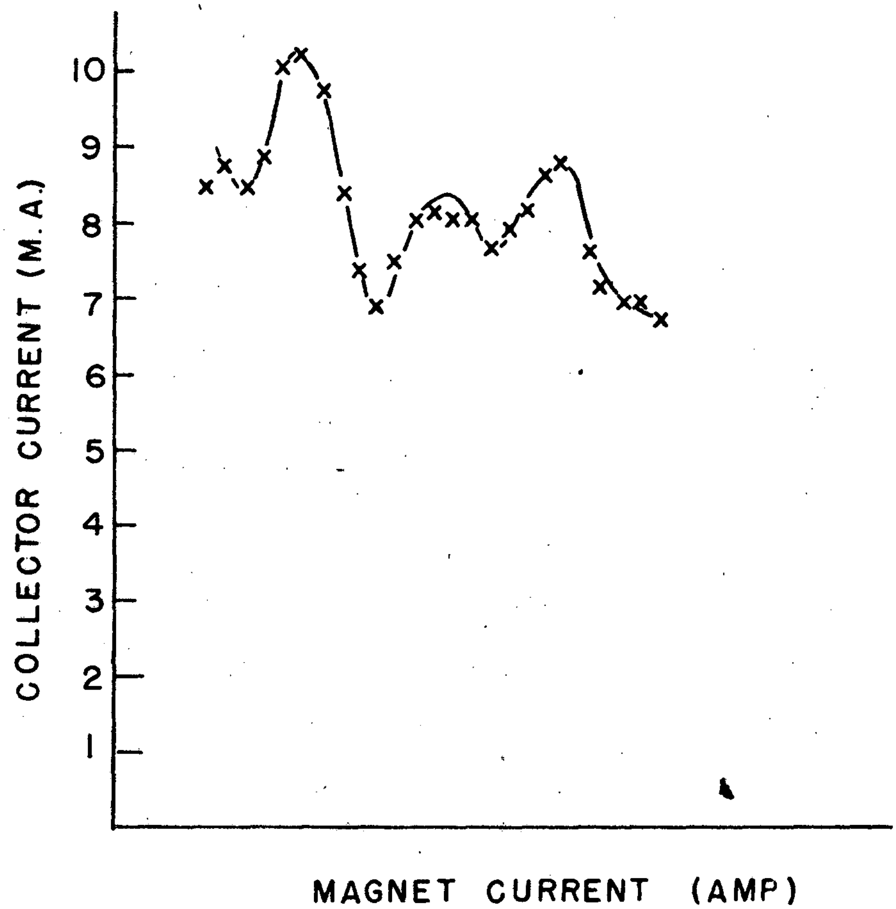

FIG. 5

13202-

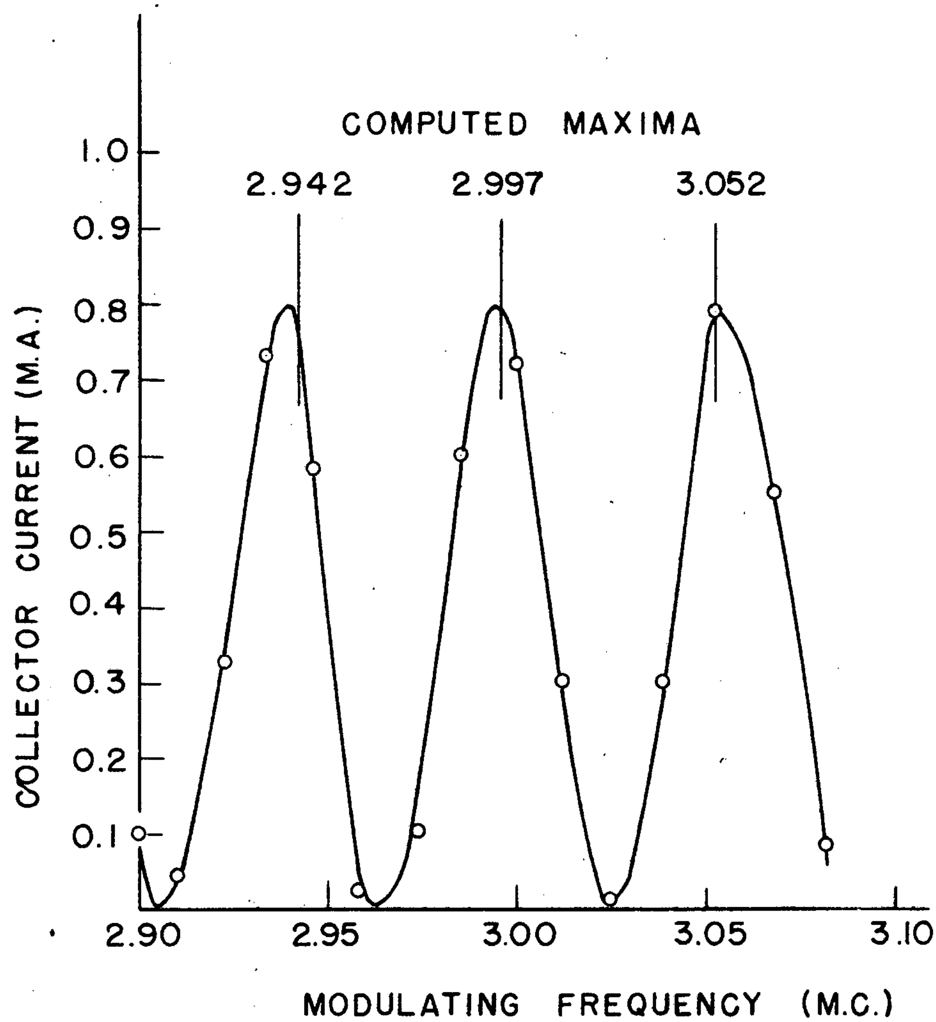
COMPUTED MAXIMA
2.942
2.997
3.052
COLLECTOR CURRENT (M.A.)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
2.90
2.95
3.00
3.05
3.10
MODULATING FREQUENCY (M.C.)

FIG. 6

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