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Radiation Laboratory

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SUMMARY OF THE RESEARCH PROGRESS MEETING OF DECEMBER 8, 1949

H. P. Kramer

December 29, 1949

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Destructive Action of Astatine upon the Thyroid. J. G. Hamilton and C. W. Asling.

It has been known for approximately a decade that the uptake of At^{211} by the thyroid is very similar to the assimilation of iodine by this gland. Since radioactive isotopes of iodine, notably I^{131}, have been effective in the treatment of pathological conditions arising from an enlargement of the gland by virtue of the destructive action of the radiation from these isotopes, it was thought worthwhile to study the effect of At^{211} with a view to its use as a therapeutic agent.

In contemplating the substitution of At^{211} for I^{131} in the treatment of hyperthyroidism two properties of the radiation from At^{211} that might possibly make the latter isotope more effective were considered. At^{211} emits only energetic highly destructive alpha-particles whose range in tissue is short, whereas I^{131} emits both beta and gamma rays with greater range but less powerful action on the immediately affected tissue. In the use of I^{131} for therapeutic purposes there is therefore the danger of damage to the parathyroid gland which is adjacent to the thyroid and regulates calcium metabolism.

In order to examine the effect of At^{211} on the thyroid varying doses were administered intravenously to rats. Blood counts were taken after administration in order to estimate the extent and variation of damage. When small non-lethal doses (10 μc and 50 μc) were given, the animals were sacrificed and autopsied 30 days after injection. With larger doses (83 μc and 150 μc) autopsy was conducted after death from radiation damage took place.

Microscopic examination of the thyroid tissue of an animal injected with 10 μc showed some thyroid follicles intact about the parathyroid tissue. Disorganization was however apparent. The units comprising the tissue structure measured about 50 microns in diameter.

Examination of the tissue affected by a 50 μc administration showed massive fibrosis with fat infiltration of the thyroid. The parathyroid had, however, remained normal. Higher magnification exhibited uniform destruction of the thyroid tissue.

It is now planned to give doses of 1, 3, 6, 30 and 40 μc.

One animal was subjected to a dose of 150 μc. It succumbed after 56 hours and examination revealed an accumulation of body fluids in the gastro-intestinal tract and a severe dehydration of tissue. The thyroid was hemorrhagic.

Table I demonstrates the time-wise variation in the blood count of an animal that received a dose of 83 μc. This animal had survived for a period of two days. Note the decrease in the absolute count and the increase in the polymorphonuclear percentage which indicates severe inflammation and inability of the body to overcome it. No major changes in the gastro-intestinal tract were observed and the thyroid and parathyroid seemed to be in good condition. The adrenals were mottled (hemorrhagic), an indication of severe stress.

Leblanc and Findley in discussing the effect of radioactive iodine on the thyroid have described it as consisting of complete central destruction of the gland and decreasing peripheral damage extending to the parathyroid. Long range rays from radioactive iodine were observed to escape the thyroid tissue. In contrast to these findings, work with At^{211} indicates that lower dosages produce general, uniform destruction of the thyroid without concomitant damage to the parathyroid.

TABLE I

White blood count	13,900	6,850	8,120	5,600
Time	Control	20 1/2 hr.	27 hr.	44 hr.
Polymorphonuclear leucocytes	16%	56%	53%	76%
Eosinophiles	5%	4%	1%	1%
Basophiles	--	--	--	--
Lymphocytes	76%	38%	46%	19%
Monocytes	3%			
Degenerates	--	2%		

Dose At^{211} 83 μc

Rat - 200 gms

Total radiation (estimated) : 175 rep

Showers Induced by 335 Mev Bremsstrahlung. R. Kenney.

Cascade showers induced by cosmic rays have been known and studied in detail for a number of years. The purpose of the present investigation of showers induced by 335 Mev photons from the synchrotron is to take advantage of a controlled high intensity source of high energy γ-rays with known energy spectrum to obtain good statistics and perhaps to establish a criterion for comparing the effectiveness of different synchrotrons and bevatrons in producing showers.

The experimental arrangement is shown in Fig. 1. Rays produced in the synchrotron are collimated and pass through a monitor, after which they enter a semi-infinite column of material in which showers are produced. The aim of the experiment is to determine the total ionization produced in the material as a function of the depth t. Therefore, ideally, a vanishingly thin detector ought to be embedded in the material at the precise depth. The practical approach has been to intercept the beam in a block of material of thickness t, place an ionization chamber immediately behind it, and then, at a depth $t + d$, to continue the material by a semi-infinite column. An attempt is made to reduce the gap d as much as practically possible and then to extrapolate the values obtained to $d = 0$. Figure 2 demonstrates the extrapolation in the case of lead. Particularly for lead there is some doubt regarding the applicability of a linear extrapolation to vanishing gap width since for small thicknesses t the total ionization at $d = 0$ is found to be ten percent higher than at very small values of d.

The total ionization as a function of thickness expressed in gram/cm^2 for the elements investigated is shown in Fig. 3. These curves have been normalized so that the maximum ionization for lead corresponds to 100 of the arbitrary units. The curves have been cut off on the right since the results are too uncertain. Below is presented a comparison between observed slopes of the tails of the curves and those calculated according to Heitler.

Element	Observed Slope	Slope According to Heitler	Energy Check
Pb	0.501	0.475	100
Cu	0.251	0.271	105
Al	0.048	0.056	115
C	0.018	---	112

The column headed energy check represents the integral over thickness from 0 to infinity of the total ionization. Since the total ionization is proportional to the energy loss per unit thickness, dE/dt, this integral represents the total energy of the synchrotron beam and should therefore be constant for all of the elements for which numerical data have been obtained.

If I represents the total ionization observed at a certain thickness, I_C the ionization due to Compton electrons, and I_P the ionization due to pair production,

$$I = I_C + I_P$$

In order to determine the ionization due to pair production, samples were used with the same number of electrons per unit volume and therefore the same value for I_C. If the subscripts 1 and 2 refer to samples of elements that contain the same number of electrons per unit volume it can be seen that

$$I_1 - I_2 = I_{P_1} - I_{P_2}$$

The values of ratios I_{P_1}/I_{P_2} were computed according to Heitler. Fig. 4 shows the resulting values for pair ionization near zero thickness. In order to check the experimental determinations of the portion of the total beam energy that is expended in pair production the integral

$$P \sim \int_0^{335} \phi_{pair}(E) \frac{dE}{E}$$

was evaluated theoretically. Here ϕ is the cross section for pair production as

a function of energy (and hence of thickness of absorber). This integral is shown as a function of Z + 1 in the graph of Fig. 5. It is seen that the experimental points for all elements except lead are in good agreement with the theoretical evaluation.

Progress Report on the 60-Inch Cyclotron. T. Putnam

The cyclotron broke down in April, 1949, after continuous operation since 1944. Long needed major overhauls were initiated at that time and have now been completed. The beam was first observed after the renovation on November 1.

A completely new water cooling system has been installed. Dees, liners, spiders, and associated items of equipment have been replaced. The deflector has been moved outside the dee and has been changed to r.f. operation. The deflector operates essentially on the 150 kv dee voltage with possibility for lateral adjustment provided by a 20 kv d.c. source. The field at the exit strip has been raised so that now there is only a 4.8 percent drop in the field strength whereas formerly the decrease was 5.7 percent.

A comparison between present and former performance shows the improvement due to the renovation.

	Beam intensity - alpha	Power input
Formerly	3-4 microamperes	115 kw
At present	6-12.5 microamperes	80 kw

Another shutdown is planned for the spring when some faulty water lining in the dee stems will be replaced and an attempt will be made to increase the pumping speed so as to assure a better vacuum and thus reduce sparking.

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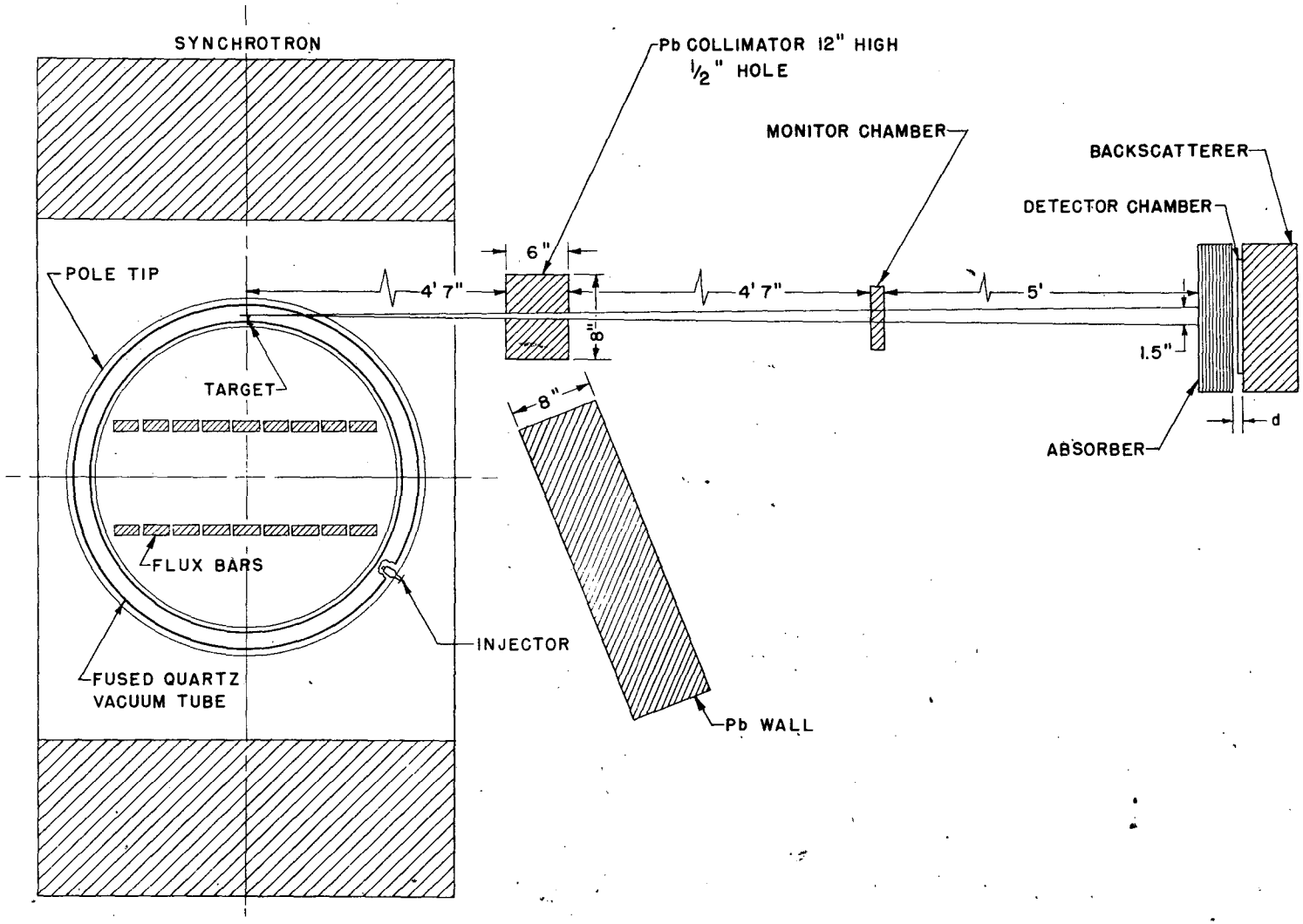
SYNCHROTRON
Pb COLLIMATOR 12" HIGH
1/2" HOLE
MONITOR CHAMBER
BACKSCATTERER
DETECTOR CHAMBER
POLE TIP
6"
4' 7"
4' 7"
5'
8"
1.5"
TARGET
8"
d
ABSORBER
FLUX BARS
INJECTOR
FUSED QUARTZ
VACUUM TUBE
Pb WALL

FIG. 1

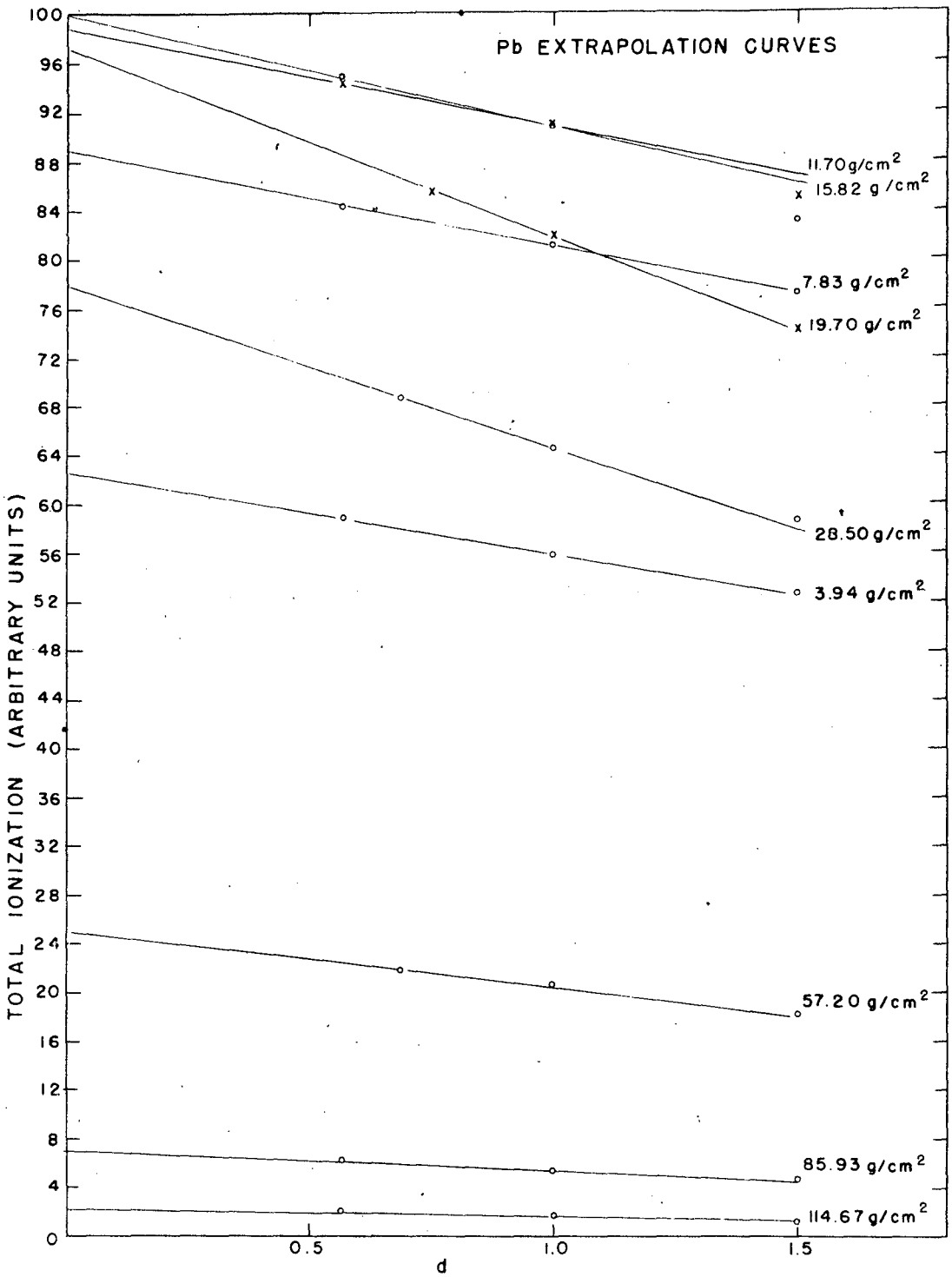
Pb EXTRAPOLATION CURVES
TOTAL IONIZATION (ARBITRARY UNITS)
d
0
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
64
68
72
76
80
84
88
92
96
100
0.5
1.0
1.5
11.70 g/cm²
15.82 g/cm²
7.83 g/cm²
19.70 g/cm²
28.50 g/cm²
3.94 g/cm²
57.20 g/cm²
85.93 g/cm²
114.67 g/cm²

FIG. 2

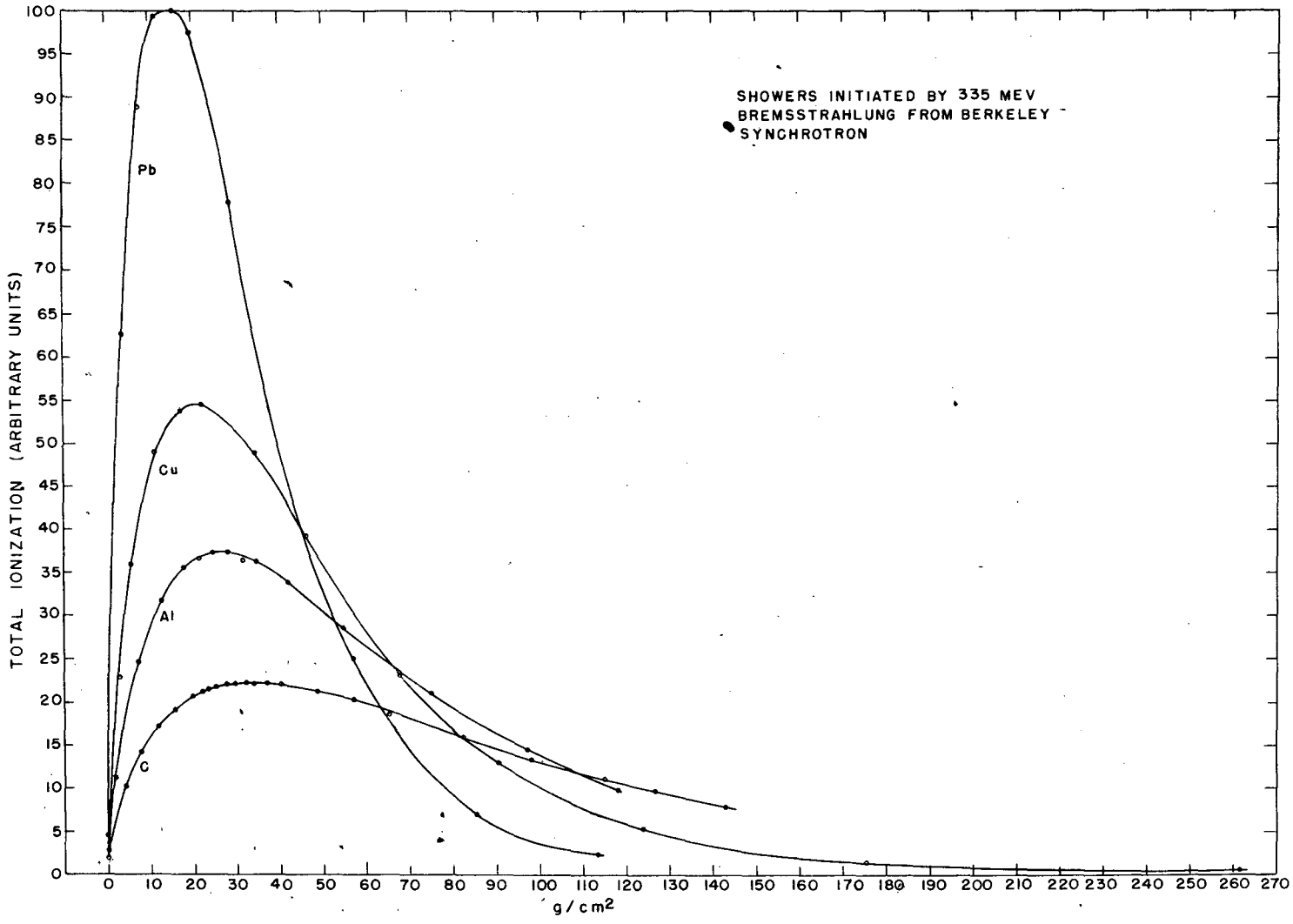
SHOWERS INITIATED BY 335 MEV
BREMSSTRAHLUNG FROM BERKELEY
SYNCHROTRON
Pb
Cu
Al
C
TOTAL IONIZATION (ARBITRARY UNITS)
g / cm2
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270

FIG. 3

OZ 790

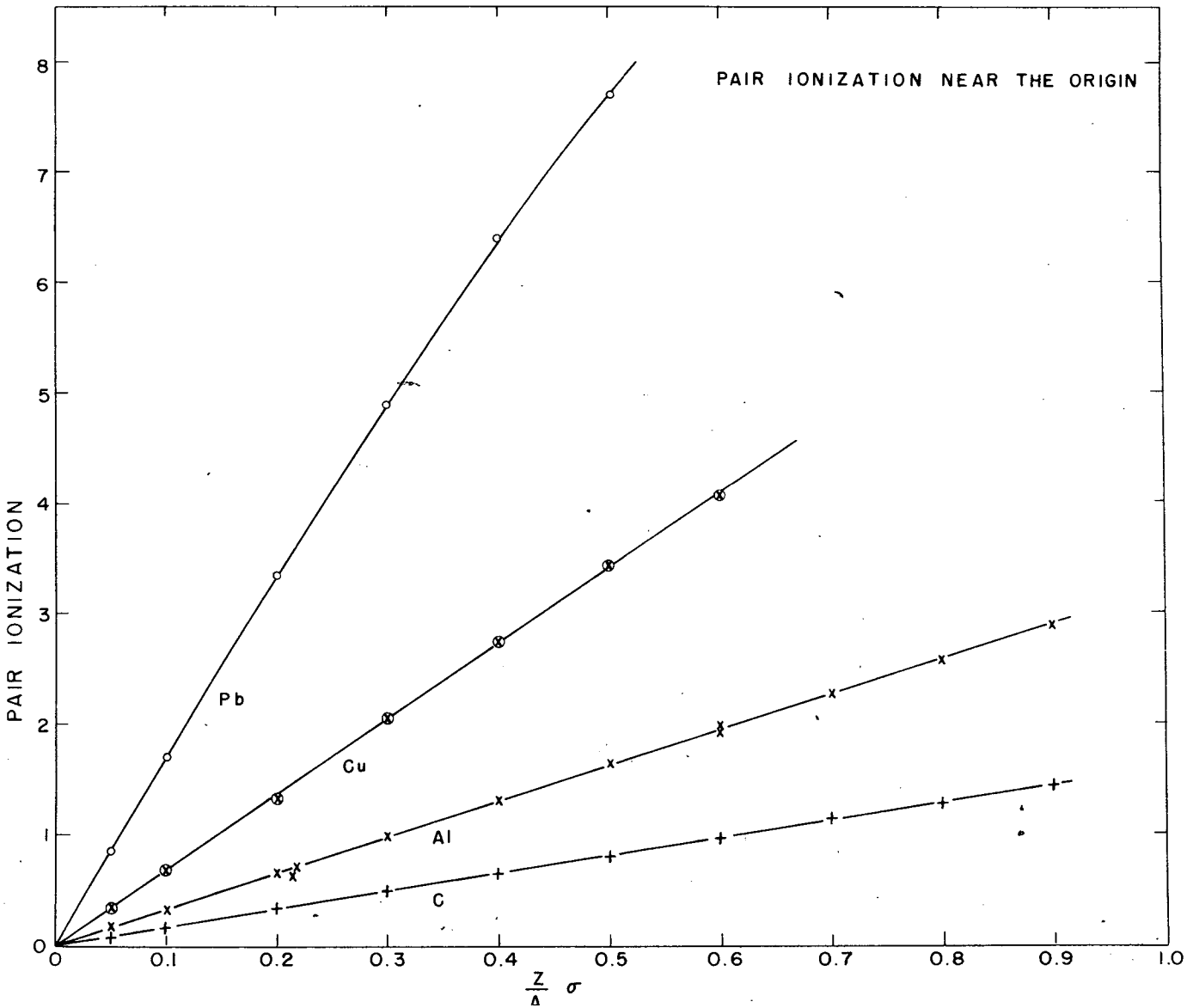
PAIR IONIZATION NEAR THE ORIGIN
PAIR IONIZATION
Pb
Cu
Al
C
0
1
2
3
4
5
6
7
8
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
$\frac{Z}{\Delta}\sigma$

FIG. 4

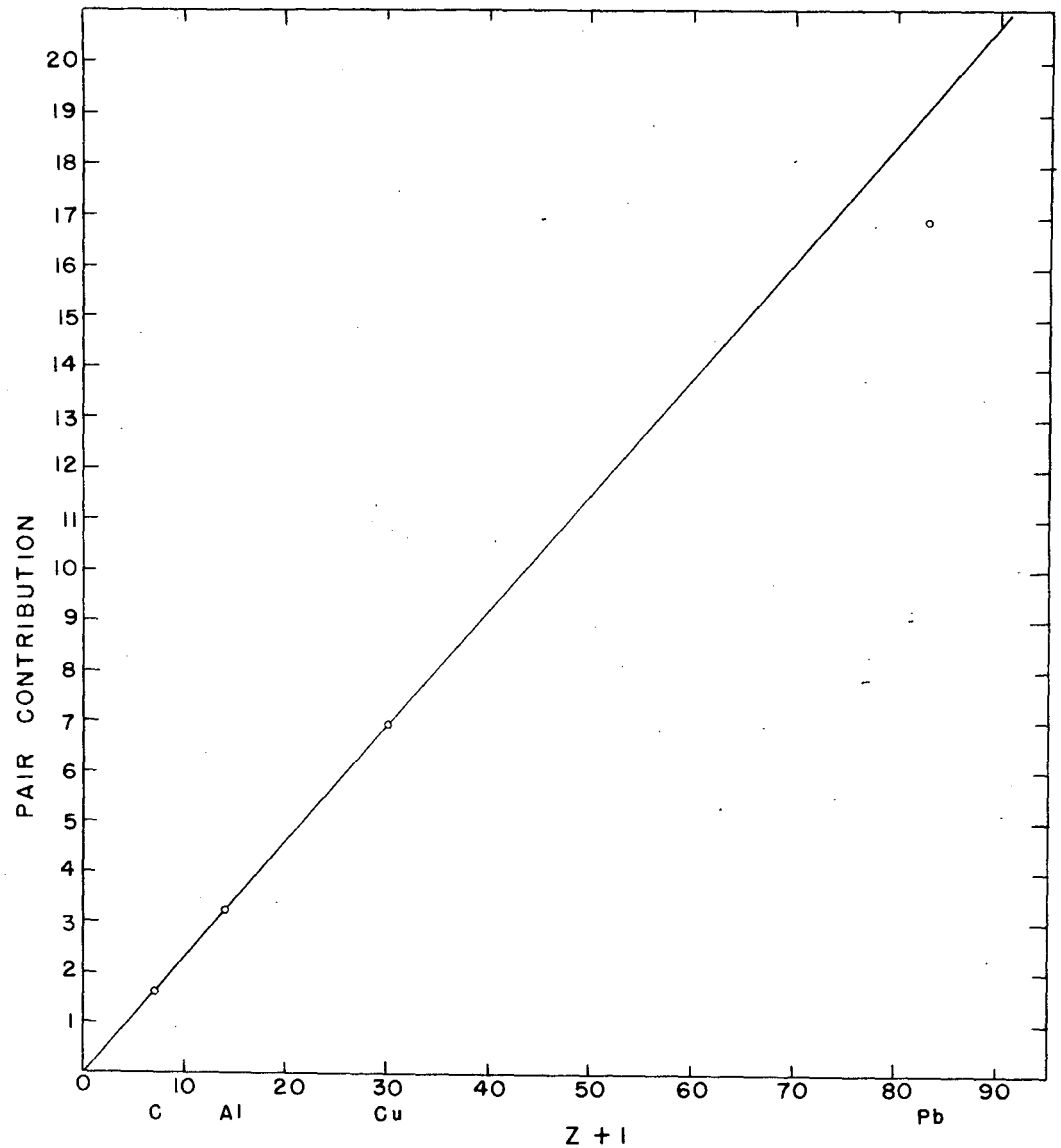
PAIR CONTRIBUTION
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
10
20
30
40
50
60
70
80
90
C
Al
Cu
Pb
Z + 1

FIG. 5