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ESTIMATION OF P^{32} BY MEASUREMENT OF BREHMSTRAHLEN IN AN IONIZATION CHAMBER

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ESTIMATION OF P^{32} BY MEASUREMENT OF BREHMSTRAHLEN IN AN IONIZATION CHAMBER

Paul C. Tompkins and Leon Wish

The absorption of beta particles is always accompanied by the generation of a continuous spectrum of electromagnetic radiation (Brehmstrahlen). The ratio of the energy loss by electromagnetic radiation to loss by ionization increases with the atomic number of the absorber, being some 12 times greater in lead than in paraffin (1). When the average atomic number of the absorbing medium is kept reasonably constant, and the activity is large enough, it should be possible to quantitatively determine the activity of a pure beta emitter such as P^{32} by measurement of the Brehmstrahlen generated within the material of the source.

The feasibility of this type of measurement was tested by means of a "100 per cent geometry" ionization chamber filled to a pressure of 600 pounds p.s.i. with helium. The current was amplified with a Model 30 vibrating reed electrometer (Allied Physics Corporation, Pasadena, California) through resistors of 10^{11}, 10^{10}, 10^{9}, or 10^{8} ohms and the voltage drop measured with a Brown recording potentiometer.

EXPERIMENTAL

The proportionality between P^{32} activity and the resulting ionization measured in the gamma chamber was tested at constant volume and solution composition. A sample of carrier-free P^{32} obtained from the Isotope Production Division of the Oak Ridge National Laboratory was diluted to 10 ml with water in a volumetric flask which was then inserted in the chamber. Further dilutions were made as indicated in Table 1 and the resulting ionization measured. The absolute activity was determined by comparing the beta activity in a standard G. M. counter with a RaE standard and with a P^{32} sample which

Table I

Dilution	μc/10 ml solution	μc/millivolt*	△ mv
stock	24,000	487	+ 3
1-2	12,000	489	+ 5
1-4	6,000	482	- 2
1-8	3,000	485	+ 1
1-16	1,500	483	- 1
1-32	750	481	- 2
1-64	375	482	- 2
1-128	188	483	- 1
1-256	94.0	485	+ 1
1-512	47.0	480	- 4
1-1024	23.5	487	+ 3
1-2048	11.8	483	- 1
1-4096	5.90	483	- 1

Ave. = 484 ± 2.57 μc/mv**

* Based on 10^8 ohm resistance scale. The chamber measures the ion current with known resistance so that the voltage drop is determined from Ohm's Law E = IR.

** Standard Deviation $(\sigma) = \sqrt{\frac{\Sigma \triangle^2}{N}} = 2.57$

had been calibrated by the Bureau of Standards. The μc/mv ratio, as seen in Table 1 is satisfactorily constant above 5 μc/10 cc where the reading was twice background or more.

The half-life (Fig. 1) of 14.3 $\pm$ 0.1 days is that of P^{32} indicating that the instrument is actually measuring P^{32}, and not a gamma emitting impurity.

Since the average atomic number of glass is slightly higher than that of water, one would expect the reading at constant activity to increase with an increasing surface/volume ratio. This was confirmed by measurements made in both a test tube and a volumetric flask by determining the ionization from the same amount of activity contained in an increasing volume of solution. The results (Fig. 2) show that the reading is constant enough for analytical work when the volume is between 7 and 10 cc, and the curves are smooth enough to allow correction of results obtained on smaller volumes.

The effect of increasing the average atomic number of the solution was determined from measurements in .006 M solutions of calcium, strontium, barium, and mercury as the nitrates. The ionization was markedly increased when the average atomic number of the solution was greater than 12 (Fig. 3).

These results demonstrate conclusively that pure beta emitters can be satisfactorily measured through the electromagnetic radiation produced by beta-particle absorption under many conditions encountered in normal chemical work. This procedure has been used to measure several highly active materials encountered in the semihot laboratory of the Division, and has eliminated a number of handling steps, thus decreasing both the hazards of laboratory contamination and personnel exposure. It has been adapted to the direct measurement of P^{32} in animal excreta and organs although the sensitivity is still too low for general use. It is also being used to determine half-lives accurately, the combination of stability and wide range being particularly good for this type of measurement.

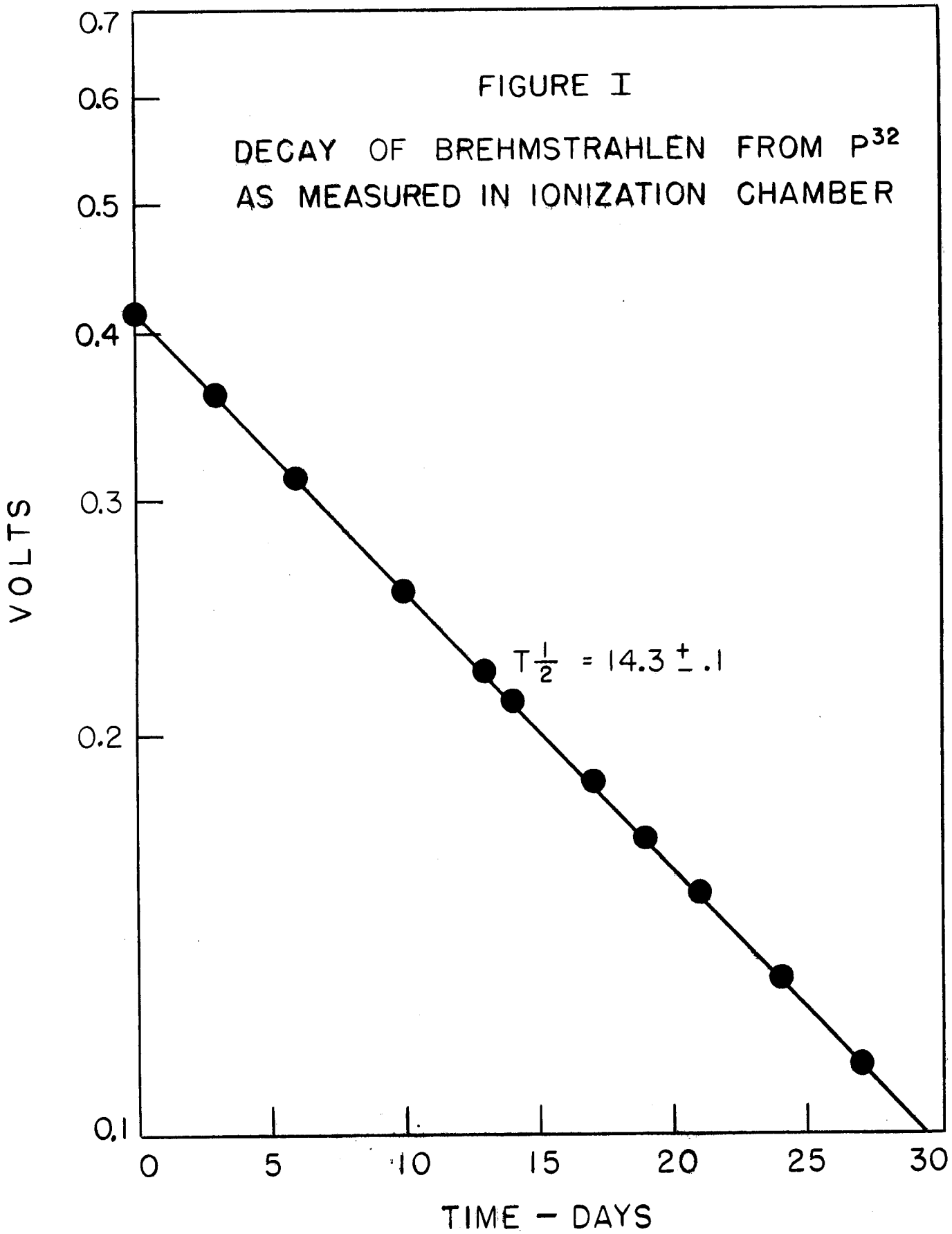


FIGURE I
DECAY OF BREHMSTRAHLEN FROM P^{32}
AS MEASURED IN IONIZATION CHAMBER
$T\frac{1}{2} = 14.3 \pm .1$
VOLTS
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
5
10
15
20
25
30
TIME – DAYS

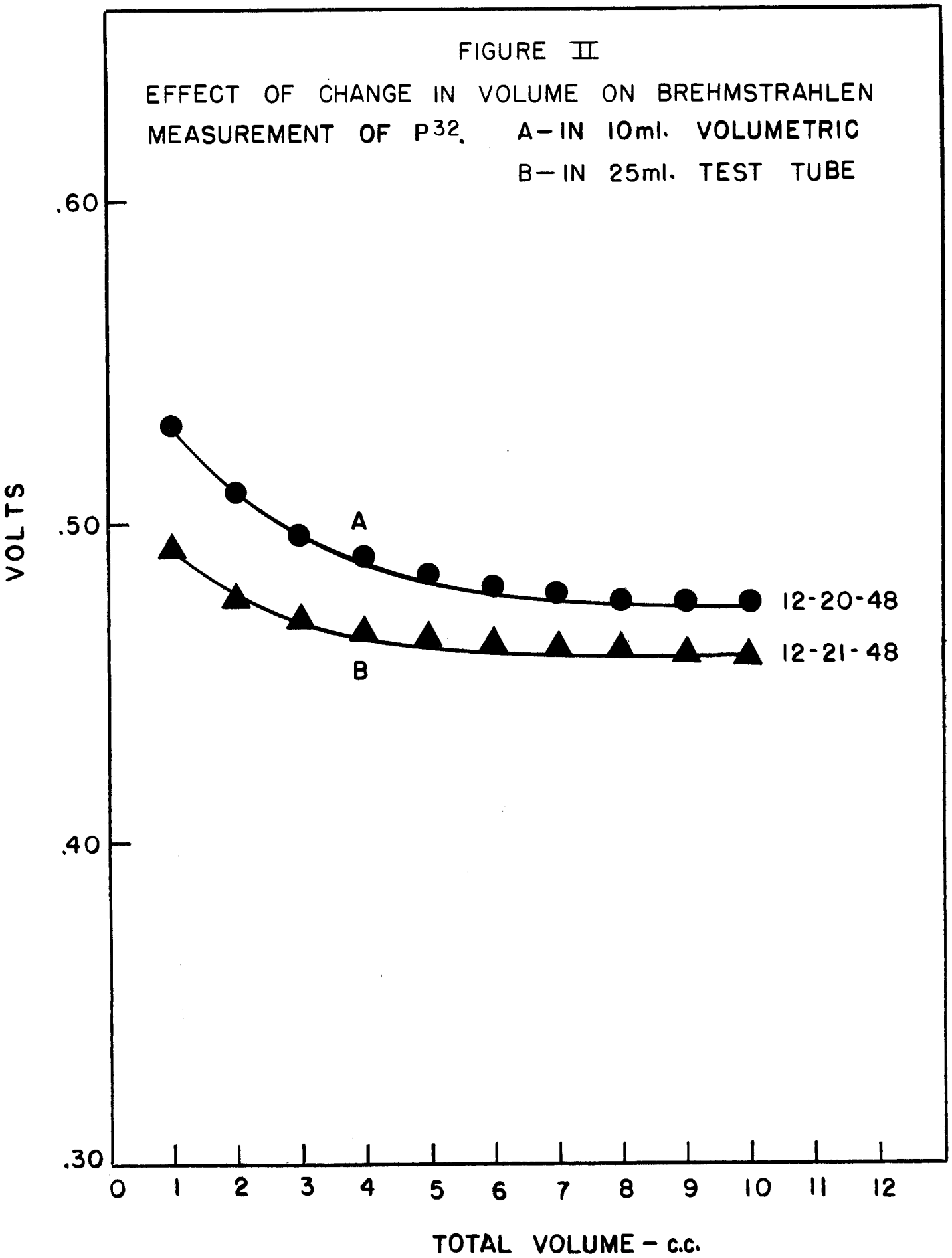
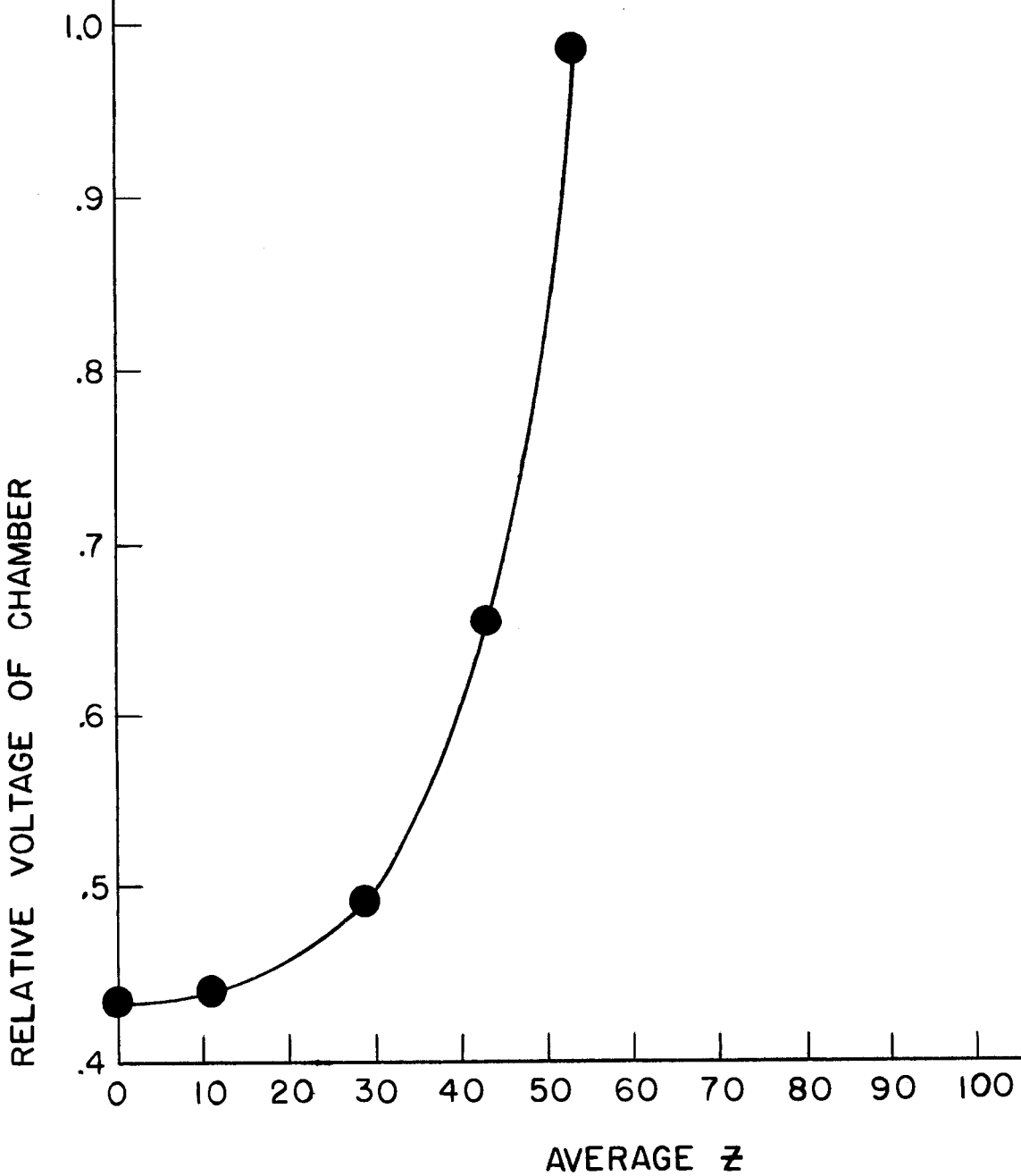


FIGURE II
EFFECT OF CHANGE IN VOLUME ON BREHMSTRAHLEN MEASUREMENT OF P32. A—IN 10ml. VOLUMETRIC
B—IN 25ml. TEST TUBE
.60
.50
.40
.30
VOLTS
A
B
12-20-48
12-21-48
0
1
2
3
4
5
6
7
8
9
10
11
12
TOTAL VOLUME – c.c.

FIGURE III

EFFECT OF CHANGE OF Z ON MEASUREMENT OF P^{32} BREHMSTRAHLEN IN IONIZATION CHAMBER



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