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TITLE

ZINC SULFIDE PARTICLE DETECTOR

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ZINC SULFIDE PARTICLE DETECTOR

By

M. O. Rankin

Instruments Research and Development
Physics and Instruments Research and Development
HANFORD LABORATORIES OPERATION

May 1, 1958

HANFORD ATOMIC PRODUCTS OPERATION
Richland, Washington

ZINC SULFIDE PARTICLE DETECTOR

INTRODUCTION

Fluorescent pigment is widely used in industry to trace flow patterns for various liquids and gases. The powder is used at Hanford for studying atmospheric conditions. An aerosol generator distributes the pigment into the atmosphere and collectors using molecular membrane filters[1] are spaced around the generator for sampling. Wind patterns are plotted by recording the location of each sampler and determining the concentration of particles on each filter.

The purpose of the work was to develop and design an instrument to count these deposited particles on each filter rapidly and accurately. Presently the filters are illuminated with ultra violet light, viewed through a microscope and the particles counted.

SUMMARY

A zinc sulfide particle counter has been developed which utilizes an alpha emitting isotope to activate the pigment deposited on a molecular membrane filter. A minimum of 300 particles deposited on a 0.015-inch diameter filter area can be determined by monitoring the filter with a photomultiplier tube for two minutes. The upper limit of particle detection has not been determined; however, a filter with 20,000 particles has been accurately counted.

OPERATION

The equipment required for this instrument includes a commercial scaler, amplifier, high voltage supply[2], a 2-inch end window photomultiplier tube[3],

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1 AA White grid inch molecular membrane filters, Millipore Filter Corp.

2 Model 206 scaler, amplifier, high voltage supply in one unit, Radiation Instrument Development Laboratories.

3 Model 6292 Photomultiplier tube, Dumont Laboratories.

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and an alpha emitting isotope.

A sketch of the mechanical arrangement is shown in Figure 1, and Figures 2 and 3 are photographs of the instrument. Figure 4 is the wiring diagram of the photomultiplier tube.

In operation the filter is indexed to a position between the phototube and the source. Alpha particles striking the pigment causes scintillations which are viewed by a phototube, and the resulting electrical pulses are amplified and and recorded on the scaler. The total count for a pre-set time varies directly with the number of particles per filter. The total count recorded by the scaler is then plotted on calibration curves (sample calibration curves shown in Figures 5 and 6) to determine the number of particles.

DISCUSSION

Scintillation techniques were employed in the development of the zinc sulfide particle detector. The phototube has a peak spectral response at 4400 angstroms and the zinc sulfide[4] selected fluoresces near this peak.

The calibration filters used for plotting the curves in Figures 5 and 6 were made by mixing a measured amount of pigment with a known volume of distilled water and passing the solution through the filter. These filters were then counted with the aid of a microscope and an ultraviolet light by several persons to determine accurately the number of particles per filter.

Actual field run samples will be used for final calibration of the instrument to insure that calibration samples have the same properties as the unknown sample. It should be noted that atmospheric dust particles will affect total count due to the short range of the alpha particle in a dense substance. The

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[4] Zinc Sulfide 2210, New Jersey Zinc Co.

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size distribution of the selected phosphors must remain constant after the instrument is calibrated because the probability of an alpha particle striking a zinc sulfide crystal varies directly with the diameter of the crystal.

The molecular membrane filter holders used in the field samplers expose a minimum diameter of 0.615 inches for the passage of air regardless of how the filter is positioned in the holder. Therefore the holders used in the instrument expose the same area to the isotope.

A 200 micro curie plutonium source electrodeposited on platinum was used to activate the zinc sulfide particles.

Less than 300 particles distributed on the filter can be accurately counted if longer monitoring times were used. The upper limit theoretically will be determined either by a particle concentration great enough so that one particle covers another or by the resolving time of the scaler which is 5 microseconds. The calibration curve in Figure 5 indicates some saturation, but the calibration of the filter with the most particles is considered questionable; the other points indicate a linear relationship.

The technique employed could be applied to measure efficiencies of various filters by placing an unknown filter and a molecular membrane filter in series in a common stream carrying a predetermined size range of zinc sulfide powder.

Deposits on other types of filters could also be measured with a similar instrument by depositing the alpha emitter on a screen which would be attached directly to the face of the photomultiplier tube. However, with this type of an arrangement the background would be higher raising the lower limit of particle detection due to scintillations from contaminants in the alpha source.

CONCLUSION

The instrument will rapidly and accurately determine the number of zinc sulfide particles deposited on a molecular membrane filter. Distributions

from 300 to 20,000 particles per filter have been accurately counted with the instrument.

ACKNOWLEDGMENTS

The author is indebted to P. W. Nickola for the preparation of the calibration filters and to Henry Kudish for assistance in the initial investigations of the method used.

OPERATION AND MAINTENANCE OF ZINC SULFIDE PARTICLE COUNTER

I. Operation

A. Energize scaler. (Refer to instruction manual of RIDL, model 206 scaler for operation of scaler.)

B. Allow scaler to warm up for at least 15 minutes.

C. Turn fine adjustment knob of high voltage counter-clockwise to stop.

D. Move high voltage course adjustment switch to position number 2 as marked on scaler.

CAUTION: Do not exceed 1200 volts to prevent overvoltaging the photomultiplier tube.

E. Adjust fine adjustment high voltage to 1150 volts.

F. Turn Amplifier gain to 1.

G. Insert samples to be counted into machine and close door. Insert at least one calibrated sample with more than 5000 particles on it and one clean filter into the instrument.

CAUTION: Do not insert anything except millipore filters mounted in the holders adapted for the instrument.

H. Rotate clean filter under the detector.

I. Adjust discriminator until scaler does not count (approximately 1.50).

J. Count for two minutes. Background count should be less than 6.

K. Rotate calibrated sample under detector head.

L. Count for two minutes and compare with calibration chart. (Sample No. 20 with 19,400 particles should count between 1900 and 2000.)

M. Rotate other samples under detector and record total count.

N. Plot total counts on the calibration curves to determine the number of particles.

O. Occasionally re-check background count and adjust discriminator if necessary.

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P. When counting is completed, turn off high voltage and de-energize scaler.

IMPORTANT: Monitor hands and around door of instrument for Alpha contamination after use with each group of samples.

II. Maintenance

A. Scaler.

1. Scaler maintenance can be performed by a qualified instrument technician.

2. Refer to instruction manual for RIDL Model 206 scaler for circuit diagrams and maintenance procedures.

B. Photomultiplier tube and associated circuitry.

1. Circuit diagram is shown in Figure 4 of the attached report.

2. Do not remove photomultiplier tube without a special work permit from radiation monitoring.

3. If removal is necessary, turn off high voltage and remove cables from box.

4. Remove scotch electrical tape and remove entire assembly.

C. Mechanical Maintenance.

1. Secure a special work permit before opening instrument.

2. A 200 uc (3.2 mg) smearable plutonium source is attached to the bottom of the instrument.

3. CAUTION: Handle this source with utmost care.

4. Monitor all surfaces before removing any parts from SWP zone.

5. A radiation monitor should be present.

6. Contact M. O. Rankin - Phone 3369 - before opening instrument.

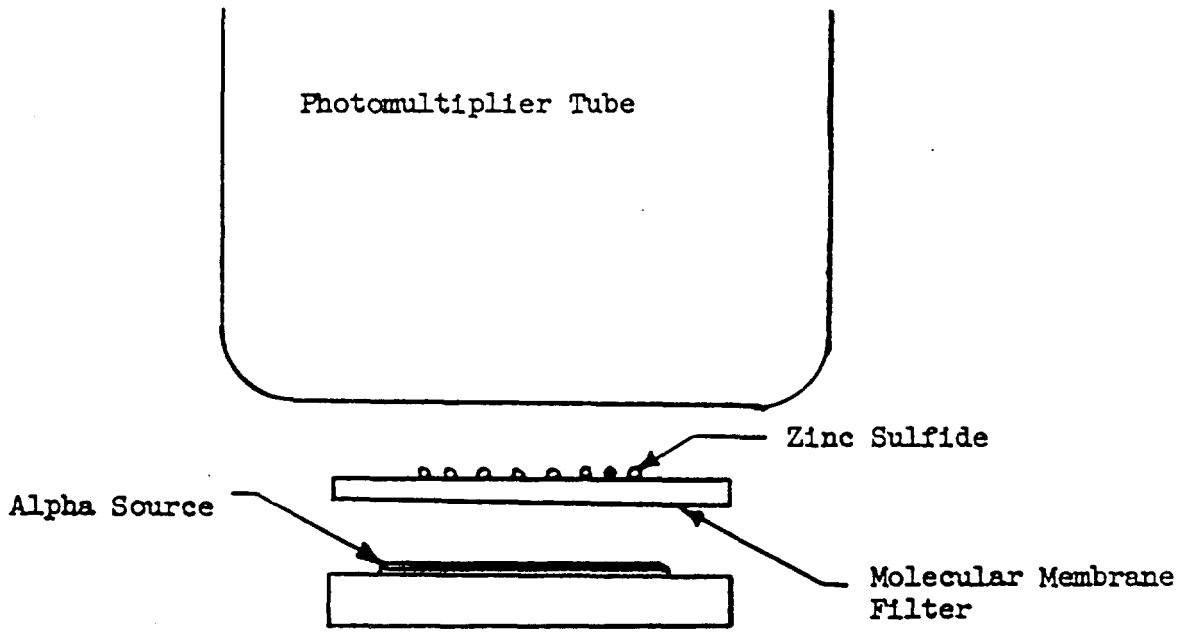

FIGURE 1

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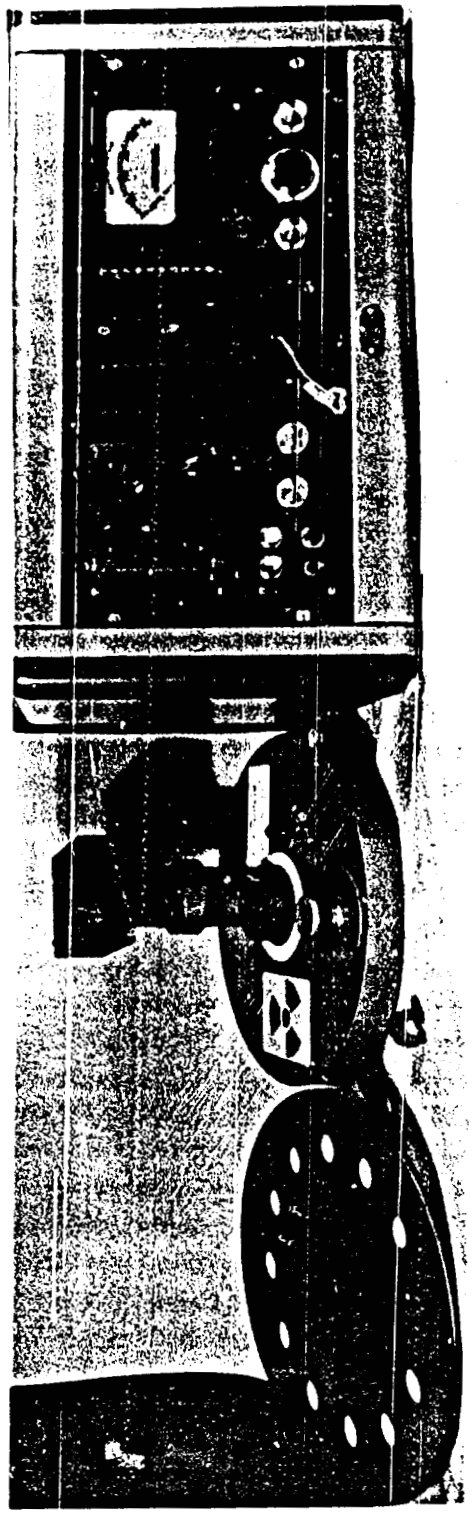

FIGURE 2
Zinc Sulfide Particle Counter

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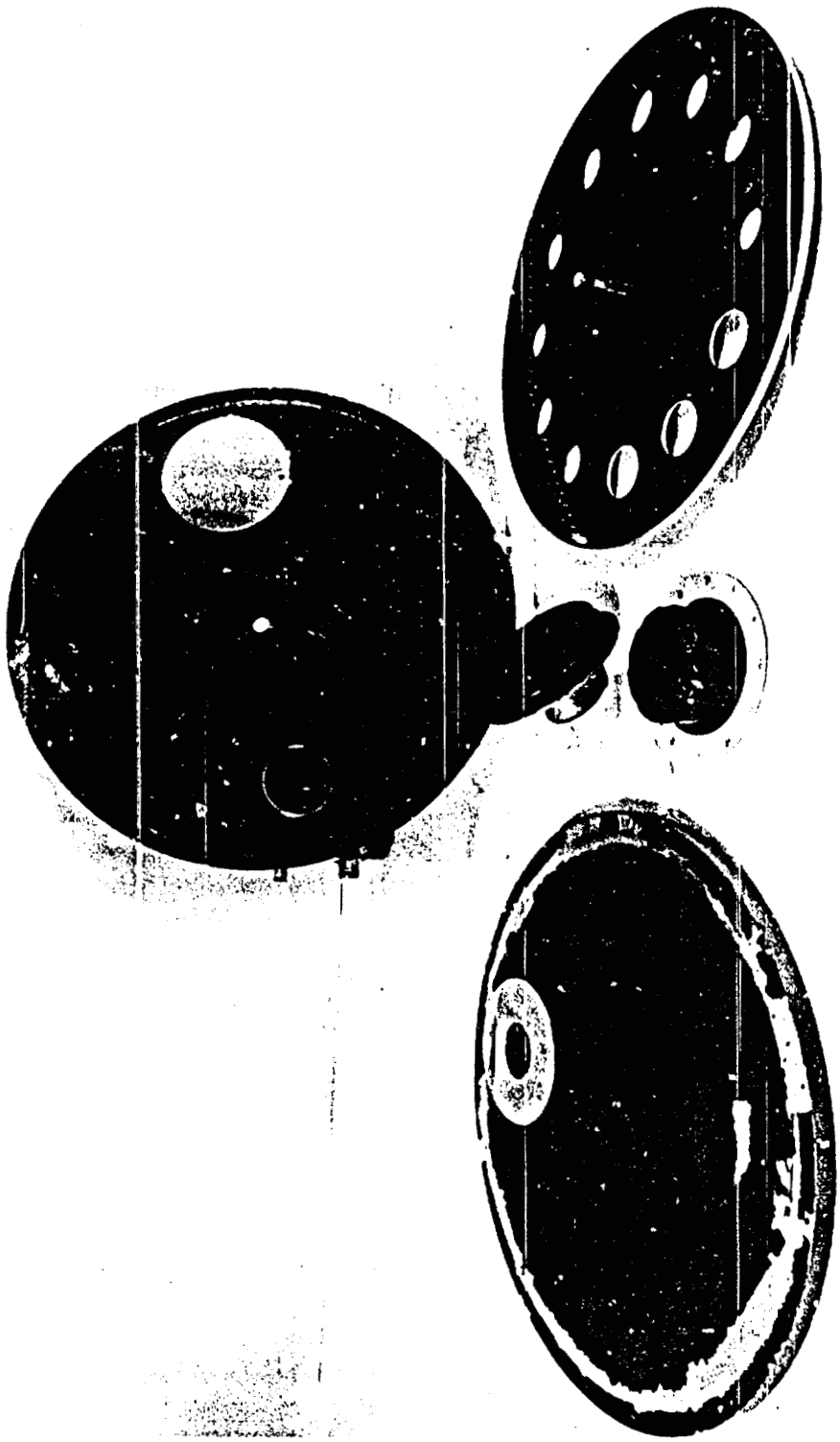

FIGURE 3

Zinc Sulfide Particle Counter Disassembled

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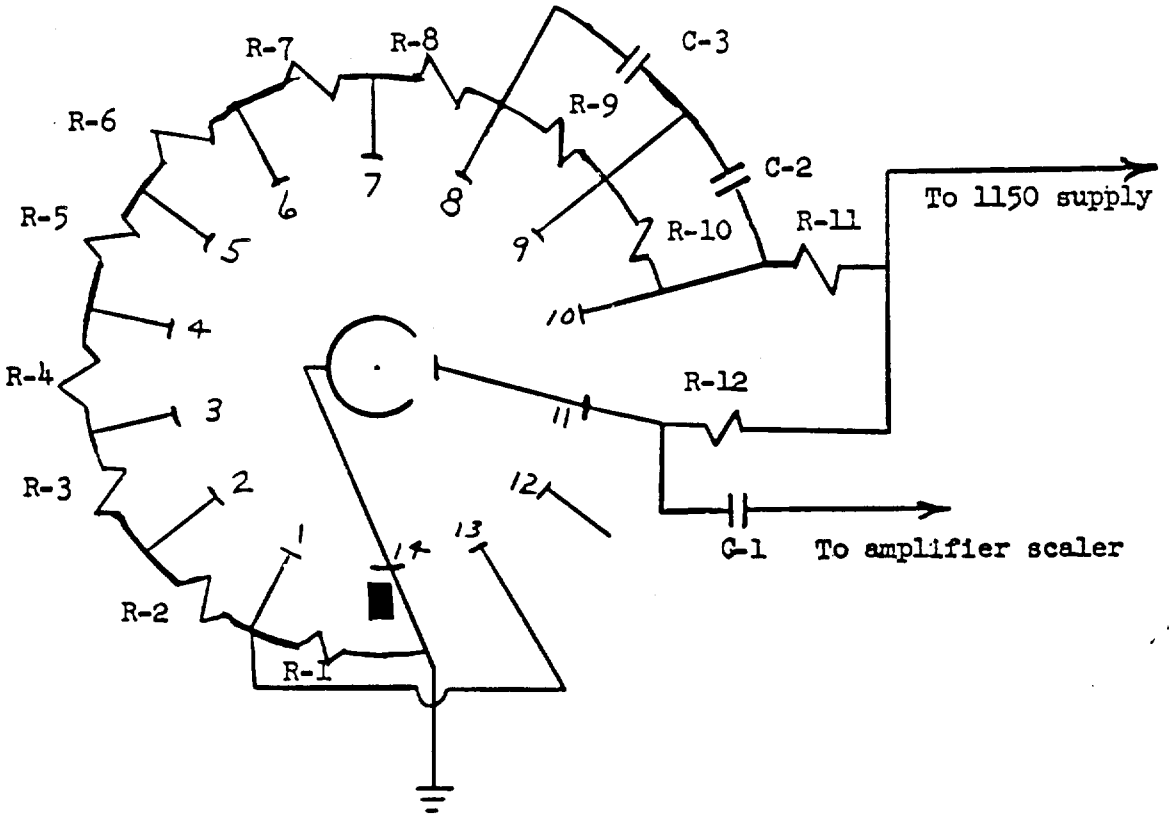
DU MONT 6292



R-1	=	1 Meg, 1/2 w
R-2 through R-11	=	470 K, 1/2 w
R-12	=	47 K, 1/2 w
C-1	=	.01 mfd, 3000 v
C-2, C-3	=	.01 mfd, 500 v

FIGURE 4

PHOTOMULTIPLIER CIRCUIT

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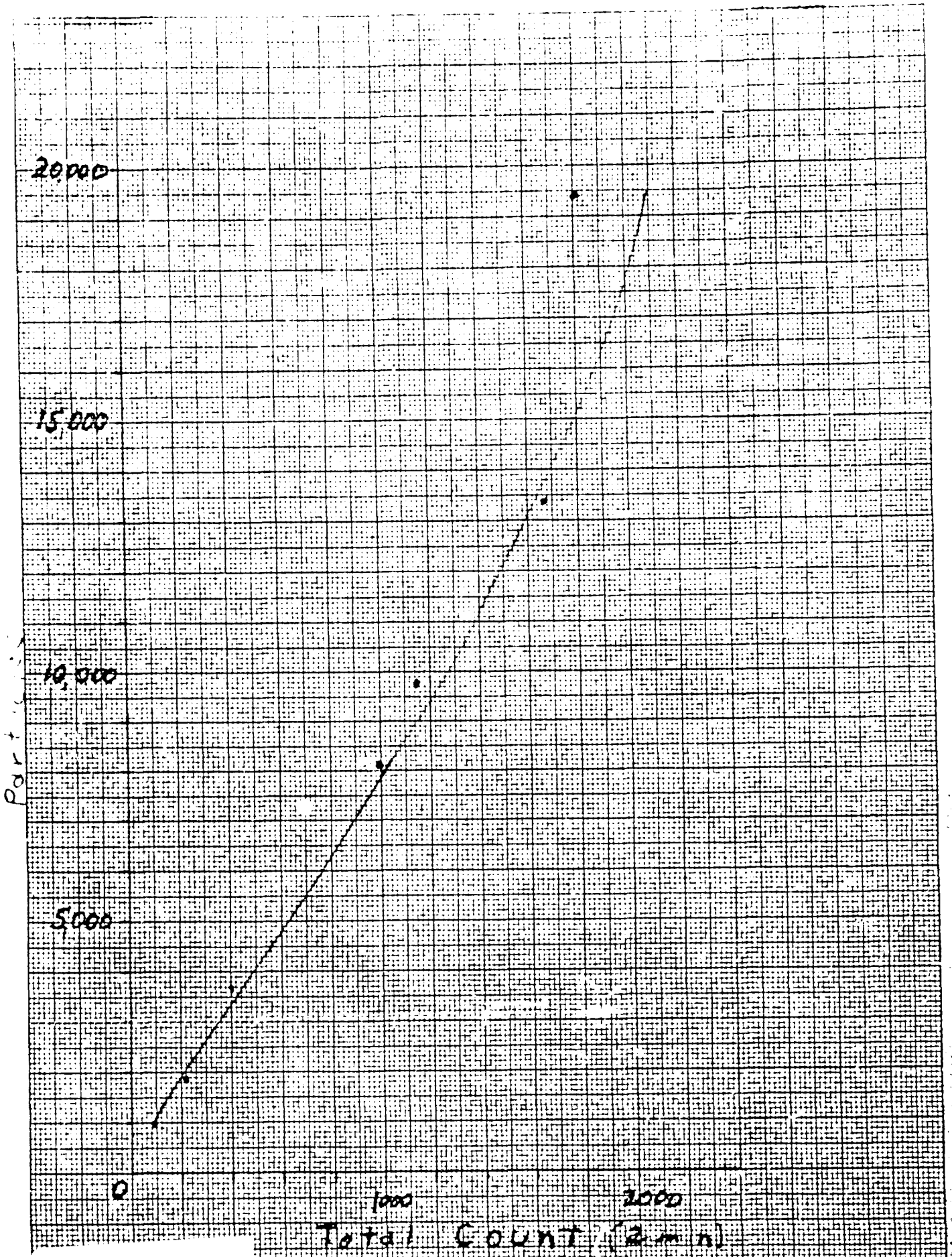

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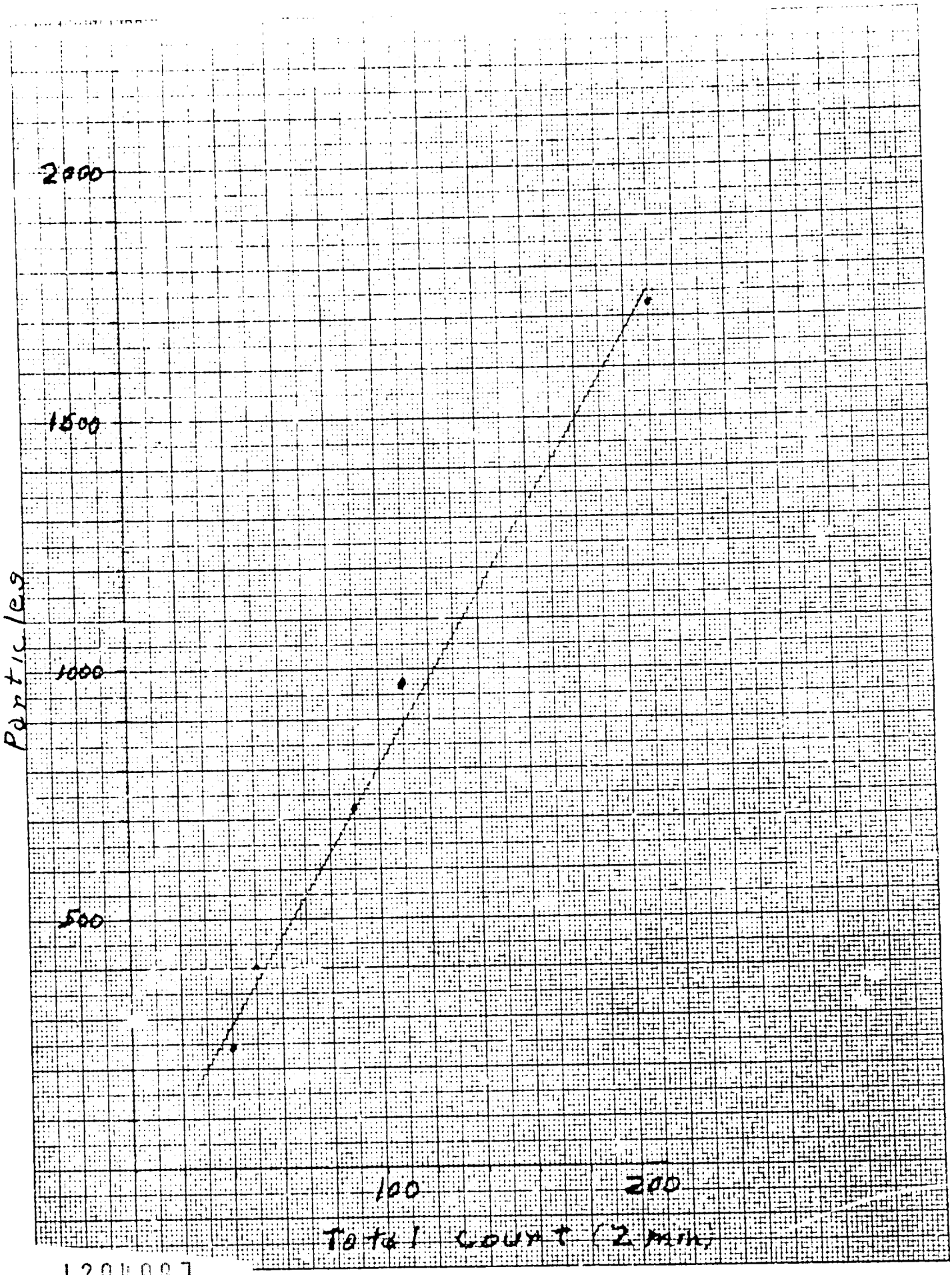
Figure 5



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