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(Supporting Research Volume)

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SUMMARY

The efficient prosecution of the research and process development at Mound Laboratory requires the use of a wide variety of instrumental techniques. Research and development on these techniques constitute the field of Supporting Research. Quarterly progress is reported here on the several projects under investigation.

Very thin, plastic, film absorbers have been made with thicknesses ranging from 6 to 32 micrograms per square centimeter. The problem of evaporating a conductive coating of aluminum on these films has been partially solved (p. 6).

The developmental parallel-plate ionization chamber for alpha pulse-height analysis has been constructed. Minor mechanical changes will be made before electrical tests are run (p. 7).

Complete performance data are given for the high-gain, wide-dynamic-range, nonlinear pulse amplifier. This amplifier gives promise of being of universal application except where pulse-height analysis is required (p. 8).

A continuous monitor for emanation contaminated air using a large-area, scintillation-phosphor-coated sphere has been built and is ready for testing and calibration (p. 21).

A mechanical integrator of improved reliability has been designed for the emanation monitor. Because of delays in delivery, a simpler system will be constructed for temporary use (p. 23).

Problem Title - Thin Plastic Film Absorbers

Report By - J. S. Stanton

Work Done By - J. S. Stanton

INTRODUCTION

A series of thin plastic film absorbers is required for the continuation of studies of low-energy alpha and beta particles. The thickness of these absorbers should range between as thin as possible to the thickness of the presently used electroscope foils. While weighing some of these films, it was discovered that the original film-thickness measurements were in error, and films thought to be too thick were actually quite thin. Films made satisfactorily conductive by vacuum evaporation of aluminum have become excessively wrinkled and somewhat brittle by the process.

DETAILED REPORT

Several methods have been discussed for reducing interfacial forces between the formed plastic films and water.¹ This was deemed necessary so that extremely thin films could be picked up off the water. While weighing test films it was found that the previous thickness measurements were in error, and films that were thought to be thick were actually in the range of 6 to 10 micrograms per square centimeter. Films of this range of thickness can be picked off the water surface with only the application of a drop of "wetting" solution to the water and are of satisfactory minimum thickness. Thick films are made by increasing the percentage of the Formvar E plastic in the solvent. A four per cent solution (by weight) of the plastic in ethylene dichloride produces a film 32 micrograms per square centimeter in thickness when dropped on water whose temperature is 15°C. The thicker films are characterized by developing thin spots near the center as the solvent evaporates. So far no technique has produced films without these spots.

In early experiments with evaporation of aluminum onto the film in a small vacuum chamber, the film was destroyed because of the high concentration of heat from the filament. By using a much larger volume chamber and by keeping the film 12 inches away from the filament, a satisfactorily conductive coating was obtained. For one film the weight increased from 26 micrograms per square centimeter before evaporation to 47 micrograms per square centimeter after evaporation. A new thin film increased to 19.8 micrograms per square centimeter.

With all films processed it was noticed after evaporation and exposure to air that the film wrinkled badly. This is thought to be due to evaporation of moisture from the film when the system is evacuated, but this has not been investigated. The film cannot as yet be satisfactorily stretched over a smaller ring to remove wrinkles.

REFERENCE

1. Stanton, J. S., Rpt. Gen. Res., MLM-603, p. 8, September 30, 1951.

Problem Title - A Large-Area, Parallel-Plate, Ionization Chamber for the Evaluation of Alpha Standards

Report By - J. A. Williamson

Work Done By - J. A. Williamson and E. V. Zaucha

INTRODUCTION

The development of a large-area, gas-flow, parallel-plate ionization chamber was undertaken to provide a suitable means for evaluating alpha standards on mountings up to four inches in diameter. This ionization chamber will be capable of pulse-height analysis.

DETAILED REPORT

An experimental ionization chamber has been built. It was found that the retractable plate would not remain in parallel alignment with the fixed plate during the raising and lowering of the retractable plate. Therefore, the chamber is now being fitted with a guide to keep the plate aligned.

The assembly and testing of the complete parallel-plate counter will continue when this modification is complete.

Problem Title - Counting Systems for Pulses of Wide Dynamic Range*Report By* - W. H. Baker*Work Done By* - W. H. Baker**INTRODUCTION**

During the past few quarters we have accumulated a considerable amount of data on the nature and dynamic range of pulse counting with a proportional ionization chamber. These data have enabled us to develop a much-needed, universal, nuclear amplifier particularly suited for counting weak pulses in the presence of very strong ones. The amplifier can be utilized immediately for counting waste disposal samples, for improved operation of B-wall tubes, and, in conjunction with an absorption chamber, for analyzing unknown contamination in waste disposal samples.

At the present time, one composite amplifier (head amplifier and main amplifier) is used for research counting, four main amplifiers are contemplated for use with monitors for emanation-contaminated air, and sections of the amplifier are being used with several neutron monitors. The features of the amplifier which made it adaptable for universal, nuclear-amplifier operation (except for pulse-height analysis) are high gain, wide dynamic range, nonlinearity, simplicity of circuit design, low power consumption, small size, and the low cost of construction.

The characteristics of this amplifier are included in this report. The complete background, theory, and results can be found in Ad Interim Report, MLM-618, which was written this past quarter.

Several miscellaneous tests of amplifier operation and improvements have been made and recorded. One test indicates that straight line, log-log, gain compression can be approached by using a germanium diode as a plate-load element in the amplifier. An oscilloscope picture of another test shows that the dynamic range of the counting system is limited by the weak pulses probably formed from the detection of single electrons in the proportional ionization chamber.

DETAILED REPORT

The composite amplifier consists of a head amplifier and a main amplifier. The head amplifier (Figures 1A, 1B, 1C) is mounted at the chamber to minimize pulse integration and attenuation. The main amplifier can be mounted on a scaler chassis or can be used separately. It is shown in Figures 1D and 1E.

The redesigned main amplifier has been mounted on a copper-plated steel chassis which prevents oscillations and reduces 60-cycle pickup to a negligible value. The amplifier must have a chassis ground at the input connector when used with the head amplifier, but if it is used without the head amplifier, each stage must be grounded to the chassis to prevent oscillations.

The schematic of the main amplifier, from which overall feedback has been eliminated, is shown in Figure 2. This feedback was eliminated so that we might obtain a wider range of gain control.

The amplifier characteristics are as follows:

See Figure 3	Maximum amplifier gain at midband	103 db.
	Frequency response 3db down	1.25 megacycles
	Frequency response 6db down	1.75 megacycles
	Amplifier gain at 5 megacycles	75 db
	Amplifier sensitivity	64.5 microvolts
	Counter sensitivity after differentiation	58 microvolts
	Pulse duration (refer to pulse photographs Figure 4)	
	Limited pulse output	9.5 volts
	Stability of composite amplifier with simple VR-tube supply (105-125 volt line variation)	Unmeasurable with Ballantine model 304 voltmeter
	Pulse rise time	less than 0.1 microsecond
	Apparent dynamic range	6,000
	Resolving time (τ) with Radium D-E-F	Sample
	Alpha plateau	$\tau = 4 \times 10^{-8}$ minute
	Alpha + beta plateau	$\tau = 2 \times 10^{-7}$ minute

RESULTS

The alpha-initiated pulses which occur at the end of the alpha-plus-beta plateau are shown in Figure 4. Note that the rise time which is preserved throughout the amplifier is of the order of 0.05 to 0.1 microsecond. The rise time as seen on the oscilloscope was probably integrated by both the composite amplifier and the oscilloscope amplifier (0.05-microsecond rise time and 20-megacycle bandwidth). The relative noise output of the amplifier and differentiating network are also shown in Figure 4.

The better alpha plateau obtained with the composite amplifier as compared with the commercial amplifier is shown in Figure 5. Since the alpha plateau obtained with a commercial amplifier rose at a chamber voltage representing relatively small gas amplifications, it was impossible to count weak pulses in the presence of strong ones.

The alpha and alpha-plus-beta plateau obtained with the composite amplifier and commercial scaler is shown in Figure 6. This latter plateau shows that this amplifier is capable of counting weak pulses in the presence of strong ones.

A unique feature of the amplifier is this ability to detect very weak pulses in the presence of strong ones. Because of this ability, it is possible to use the amplifier with a windowless, proportional, ionization chamber to make routine absorption studies of weak beta energies in the presence of strong ionizing particles. The weakest energy that can

be studied is much less than formerly possible when using a mica-window, Geiger-Muller tube. An absorption study gave the data to make the curve of Figure 7. By using a range-energy chart for beta particles¹ the maximum energy of the radium-D was found to be 0.024 million electron volt. This figure is in good agreement with the value of 0.0255 million electron volt reported by Perlman and Seaborg.²

Experiments were made with a diode as a plate-load element of the head amplifier. The circuit schematic and the graph of voltage gain versus negative pulse input is shown in Figure 8. It is to be noted that the curve approaches a straight line on log-log paper as the plate-load impedance approaches the impedance of the diode alone. The maximum pulse-height output dropped from 1.8 volts to 0.1 volt when the diode was shunted across the 27,000-ohm plate-load resistor. Plateaus of a neutron counting system using resistor and diode loads were compared and are shown in Figure 9. The change in the plateau is negligible. This is to be expected since the increased sensitivity when using the diode load is of a small order of magnitude. Any increase in sensitivity at midband may also be offset by the loss in gain at higher frequencies because of the short rise time of the pulse.

Our experience has shown that the upper limit of an alpha-plus-beta plateau occurs when the voltage of the Nuclear Measurements Corporation CC-2 chamber using P-10 gas is about 2,000 volts. This brought up the question, why should this plateau rise? A study of scope pictures (Figure 10) revealed that weak pulses were absent when a polonium-alpha sample was counted at 2,000 volts but that a large number of weak pulses were present above 2,075 volts. It is believed that this is due to the detection of single electrons within the chamber. If true, this would indicate that the chamber is at fault, and the amplifier has sufficient dynamic range to span the usable range of the CC-2, proportional, ionization chamber.

REFERENCES

1. Glendenin, L. E., Nucleonics, 2, 26, January 1948.
2. Seaborg, G. T. and Perlman, I., Table of Isotopes, Rev. Modern Phys., 20, 631, 4, (1948).

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A HEAD AMPLIFIER MOUNTED
ON WINDOWLESS,
GAS-FLOW,
HEMISPHERICAL,
PROPORTIONAL, ION-
IZATION CHAMBER.

B. TOP VIEW

C. BOTTOM VIEW

HEAD AMPLIFIER

D TOP VIEW

E. BOTTOM VIEW

MAIN AMPLIFIER

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FIGURE 1

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AMPLIFIER FREQUENCY RESPONSE.

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FIGURE 3

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A OUTPUT OF 1ST STAGE
(HEAD AMPLIFIER).
1 MICROSECOND MARKER

B OUTPUT OF 2ND STAGE
1 MICROSECOND MARKER

C OUTPUT OF 3RD STAGE
1 MICROSECOND MARKER

D OUTPUT OF 4TH STAGE
10 MICROSECOND MARKER

E DIFFERENTIATED OUTPUT OF FINAL
CATHODE - FOLLOWER 1 MICROSECOND MARKER

PULSE OUTPUT OF NONLINEAR, WIDE-DYNAMIC-RANGE AMPLIFIER (GAIN ADJUSTED TO 15,000 FOR COUNTING). THE PULSES WERE INITIATED BY AN ALPHA SOURCE AND THE GAS AMPLIFICATION WAS ADJUSTED TO THE TOP END OF THE ALPHA-PLUS-BETA PLATEAU. (NOTE FREEDOM FROM OVERSHOOT).

F NOISE OUTPUT OF 4TH STAGE

G. NOISE OUTPUT OF FINAL CATHODE-
FOLLOWER (AFTER DIFFERENTIATION).

REL TIVE NOISE OUTPUT OF NONLINEAR WIDE DYNAMIC-RANGE AMPLIFIER (GAIN = 15,000) BEFORE AND AFTER PASSING THR DIFFERENTIATING NETWORK.

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FIGURE 4

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COMPARISON OF ALPHA PLATEAUS.

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FIGURE 5

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FIGURE 6

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FIGURE 7

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ABSORPTION STUDY OF RADIUM D

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FIGURE 8

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COMPARISON OF RESISTOR AND DIODE AS PLATE LOAD
OF HEAD AMPLIFIER.

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FIGURE 9

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A. OUTPUT OF 3RD AMPLIFIER STAGE CHAMBER VOLTAGE = 2,000

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B. OUTPUT OF 3RD AMPLIFIER STAGE CHAMBER VOLTAGE = 2,075

FIGURE 10. PULSE PICTURE SHOWING THE SUDDEN INCREASE OF SMALL PULSES ABOVE THE ALPHA-PLUS-BETA PLATEAU WHEN USING THE WIDE DYNAMIC RANGE AMPLIFIER WITH AN ALPHA EMITTER IN CHAMBER.

Problem Title - Continuous Monitoring of Emanation-Contaminated Air

Report By - E. A. Reiter

Work Done By - E. V. Zaucha and E. A. Reiter

INTRODUCTION

The problem of continuously monitoring the air in laboratories where the possibility of emanation-contamination is a potential health-hazard is being approached in two ways. The first involves the direct detection of alpha-contamination in the air by counting the scintillations produced on the surface of a phosphor-coated sphere with a photomultiplier tube. In the second method the activity is adsorbed on dust and is deposited on filter paper and then detected by scintillation counter. Both systems will ultimately incorporate an integrator which will combine the reliability of long counts with fast response to sudden changes in the counting rate. This integrator is also described in this volume.¹

DETAILED REPORT

Most of the efforts of the past months have been devoted to the development of the phosphor-coated sphere method in an effort to get one of the systems into operation while the other is being perfected.

A light-tight, vacuum-tight chamber was constructed and a 5-liter, zinc sulfide-coated, spherical flask, filled with mineral oil, was suspended within it. A type-5819 photomultiplier tube was inserted in the neck of the flask with the photosensitive cathode end protruding slightly into the mineral oil at the surface of the sphere. The photomultiplier tube was connected through a wide-dynamic-range pulse amplifier to a conventional scaler.

The system was calibrated by introducing a known concentration of radon in air at atmospheric pressure into the chamber. The initial count for a radon concentration of about 1.5×10^{-11} curie per liter was 66 counts per minute above the background of 17 counts per minute. After the radon came into equilibrium with its daughter products, radium A and radium C', the count was about 193 counts per minute. The results of a second calibration checked with the first within five per cent, and in both cases the chamber returned to normal background count after being evacuated and flushed with room air. From the counting geometry and the sampling volume of the sphere, the counting efficiency of the system is calculated to be about 70 per cent. From these data the counting rate for a tolerance level of 10^{-11} curie per liter is expected to be about 34 counts per minute above background.

An operational unit has been constructed with a blower to provide for the continuous flow of monitored air through the light-tight chamber containing the phosphor-coated sphere. The unit has yet to be tested and calibrated before being checked under actual operating conditions.

CONCLUSIONS

The monitoring of emanation-contaminated air by counting the alpha-induced scintillations on the surface of a phosphor-coated sphere shows promise of being a practical monitoring method. It is hoped that this method of monitoring will provide a reliable and rapid indication of sudden changes in contamination level when used in conjunction with the mechanical integrating system.¹

REFERENCES

1. Rogers, A. J., This Volume, p. 23.

Problem Title - Mechanical Integrator for Improving Counting Statistics

Report By - A. J. Rogers

Work Done By - A. J. Rogers

INTRODUCTION

A mechanical integrating device described previously¹ utilized fixed capacitors for storing a charge proportional to the counting rate. Summation of the charges stored during several successive time intervals and measurement of the total charge during each time interval achieved improved counting statistics without sacrificing rapidity of response. The system reliability was dependent upon the ability of the capacitors to retain their charge over a complete count totalizing cycle. This necessitated the use of high-quality insulation throughout the charge storage unit. This insulation had to be kept clean and dry. These limitations were overcome by the design of a counting rate totalizing and storage system which utilizes spring-driven stepping switches.²

DETAILED REPORT

A mechanical integrator in which stepping switches are used in place of long time constant capacitors and a standard meter in place of a vacuum tube voltmeter is shown in Figure 1. The cascaded stepping switches insert increments of resistance into one arm of a Wheatstone bridge proportional to the counting rate and an alarm is sounded when a predetermined unbalance of the bridge is reached.

This system accomplishes totalizing of counts, and averaging and storage of the counting rate over several successive time intervals. Measurement of the degree of bridge unbalance is continuous and continuing during each time interval. Continuous totalizing is accomplished by subtracting a portion of the totalized count at the end of each time interval to permit the addition and storage of the count occurring during the next time interval. In the event of a sudden increase in the counting rate, each stepping switch is capable of actuating the alarm through its totalizing and storage action alone.

Although designed for use with the continuous monitor for contaminated air,³ it would be useful for any low-level monitoring problem. Because delivery of the necessary stepping switches is delayed, a simpler, temporary system will be designed and constructed for immediate use.

REFERENCES

1. Rogers, A. J., Rpt. Gen. Res., MLM-561, p. 32, May 21, 1951.
2. The use of stepping switches was suggested by E. A. Reiter.
3. Reiter, E. A., This Volume, p. 21.

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fig 11

MECHANICAL INTEGRATOR FOR IMPROVING COUNTING STATISTICS.

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FIGURE 1

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