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Avco

TULSA DIVISION

FIRST

BI-MONTHLY REPORT

NASA CONTRACT
NASw-783
Amendment I

10 April to 10 June
1964

Pulse Counting Detectors for
Low Energy Particles
and
High Energy Photons

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June 19, 1964

National Aeronautics and Space Administration
Chief, Instrumentation and Data Processing
Programs Electronics and Control
Office of Advanced Research and Technology
Washington 25, D. C.

Subject: Contract NASw-783, Amendment I

Gentlemen:

Attached is the first bi-monthly progress report on Amendment I of subject contract.

Our Particle Detection Laboratory has considerably broadened its capabilities over the last few months. This has been brought about by the purchase of a new research laboratory for this division, additional capital investment in specialized equipment and the receipt of additional NASA contracts for closely related instrumentation work. This expanded capability allows us to pursue a much higher level of effort.

More detailed information on any phase of our expanded programs and capabilities is available and we would welcome further inquiries or visits.

Very truly yours,

K. R. Damon

K. R. Damon
Manager, Space Vehicle
Instrumentation Programs

KRD:pm

Avco

TABLE OF CONTENTS

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ILLUSTRATIONS

FIRST BI-MONTHLY REPORT

Contract NASw-783, Amendment I

Scope of Work

The scope of work outlined in this contract covers laboratory facilities operation, fundamental electron multiplier design, and a flight feasibility instrument. Even though each of these areas of endeavor are related and necessary to the coherent performance of the objectives, the specific details are quite diverse. For this reason, the accomplishments in each area will be reported separately.

The laboratory facilities are continually utilized and are being upgraded for the complete testing and evaluation of multipliers for particle and photon detectors. These facilities will continue to be used for the analysis of commercially available multipliers, for continuing life data tests of multipliers evaluated in the initial portion of the contract, for the test and calibration of the flight feasibility model, and, particularly, for the testing and evaluation of each phase of the new multiplier design program. In addition, the laboratory includes capabilities which have been developed under other contracts.

A program has been initiated with the University of Arkansas, Graduate Institute of Technology, with the cooperative objective to design a superior electron multiplier specifically for pulse counting operation, and incorporating as many of the advantages of the several approaches as possible.

The flight feasibility model will be constructed using the best available electron multiplier, in conjunction with spaceworthy circuitry and a retarding potential electron energy analyzer of NASA design.

Statement of Progress

At the reporting date, the laboratory facility is capable of generating controlled ions, electrons, and EUV photons in high vacuum environment, and testing various multipliers and analyzers. During the reporting period, the EUV source has been redesigned to provide a much more intense beam of photons, with a larger relative amount of high energy photons, in a more stable manner. The electron source, and ion source have been made more compatible in regard to control electronics, so that one set of electronics for these sources may be rapidly switched from one to the other. The energy distribution of the electron source has been analyzed and modifications designed and installed to provide a high degree of control.

Two of the multipliers evaluated in the initial contract have been retested for determination of deterioration due to long exposure to atmosphere. The initial results were good.

The multiplier design program has been negotiated with the University of Arkansas, the basic objectives and program plan defined, and initial work begun.

The extremely high frequency response required for pulse counting operation of multipliers and the stringent weight and power requirements of flight electronics combine to make a severe design problem. A considerable amount of effort has been expended on this phase of work.

Evaluation of several circuit approaches has led to the selection of Texas Instruments Series 51 integrated circuit modules for the low frequency portion of the circuits. Special design has been required for a large part of the circuitry; for example, the multiplier amplifier - ruggedized - has a frequency response of 60 mc, a gain of 700, and consumes only 60 milliwatts of power. All of the basic circuit design is complete, with most of the evaluation accomplished, and final circuit fabrication beginning. The retarding potential grid structure has been through preliminary evaluation and the final version is being fabricated.

Schedule Status

The laboratory facility is being maintained at a level sufficient to fully evaluate the designs involved in other phases of the project.

The design program is intended to extend through a nine month period and is presently in its initial phase. An evaluation of accomplishment in terms of schedule cannot, as yet, be made.

The flight feasibility unit is progressing according to the original time estimate. It is anticipated that, by parallel operation of system analysis and final design, a significant reduction in the total elapsed time may be accomplished. Delivery of the first package for test is expected September 1.

The expenditure of funds is consistent with contract progress, with slightly more than 30% of the total funds expended or committed. Approximately 80% of the funds will be used during the first five months of the contract, with a much lower rate of expenditure for the remaining time.

Electron Multiplier Design Program

This design program is to be a joint effort of Avco/Tulsa and the University of Arkansas Graduate Institute of Technology, with W. S. Updegrove of Avco and Dr. T. A. Raju of G. I. T. having project responsibilities. The definition of target performance specifications and testing to these parameters is the primary responsibility of Avco/Tulsa. The theoretical design, the coating techniques and material, and the direction of the relevant portion of the test program is within the responsibility of G. I. T. The initial program plan is according to the following outline.

A. Design Consultation on Test Equipment and Procedures

Since the equipment and test procedures will have significant effect on the overall program, the close coordination of the lab operation is imperative. The Avco laboratory will include:

1. Electron source -- with controllable quantity and energy of electrons.
2. Ion source -- controllable quantity, energy, and species of ions.
3. EUV source with monochromator.

B. Design and Fabricate Optimized Electron Multiplier

1. Select coating material and make test coatings on 1 x 3 plates. Evaluation to be done in a magnetic multiplier.

   The coating material to be used will be selected to have the optimum characteristics for capillary multipliers. That is, maximum secondary electron efficiency at as low an energy as possible, amendable to reasonable techniques of application, and capable of withstanding the environment in which it will be used -- specifically, ion bombardment.

The tests that will be run on test slides of this surface in a magnetic multiplier will need to be carefully scrutinized so that the information will be applicable to the prediction of capillary operation.

2. Construct channel multipliers to evaluate the general characteristics and limitations of this type of multiplier. 6 mil ID will be used with other parameters variable.

   The general characteristics of capillary multipliers is to be evaluated in this phase of the program. The coating material selected from previous experiments will be used. The investigation of coating techniques in this phase is anticipated to require primary effort. Both uniform and non-linear coatings should be investigated, with various total resistance and lengths.

3. Apply results of previous experiments to an optimized design to specific application parameters. Most probable major innovation is to create effect of discrete dynodes at optimum secondary electron energy. It is anticipated that an EUV detector, with perhaps a curved capillary multiplier, may be the most simple approach to this phase.

The parameters of significance to the desired operation of the multipliers are listed and defined as follows:

Multiplier Pulse Counting Characteristic Curve -- This curve is a plot of pulses out, above an arbitrary threshold with a constant input beam, against total multiplier voltage. The curve involves efficiency, gain, and pulse height distribution and has three significant regions. The first, at low multiplier voltages, is the region where pulses increase almost linearly with applied voltage. The second is a plateau region in which the pulses out are relatively constant and is the operational region for pulse counting operation. The third is an ion regeneration region.

Gain, in pulse counting mode, is defined as the average number of electrons appearing at the anode of the multiplier from a single incident event at the cathode.

Efficiency is defined as the number of pulses appearing at the anode, expressed as a percentage of the number of particles or photons incident on the cathode. This measurement presumes a threshold is adjusted so that it virtually eliminates noise output from the multiplier, and that the magnitude of the pulse above this threshold is ignored.

Unfortunately, the above two parameters are difficult to separate. The optimization of both involves the basic operating voltages of the multiplier. The cathode efficiency is a function of the energy and type of incident event and cathode material. The secondary electron efficiency of the dynodes, a function of operating voltage, affects both the efficiency and gain of the multiplier.

Pulse height distribution is defined as the relative number of output pulses of each amplitude, under a constant signal input condition. This is normally found by differentiating a curve of number of pulses occurring above a given threshold as the threshold is varied. This technique is used because this is the basic mode of operation for actual use of the devices, as well as the fact that the speed of response of these devices is such that an amplitude "window" is extremely difficult to obtain.

Pulse width is the time duration that a single pulse is greater than 10% of its peak value.

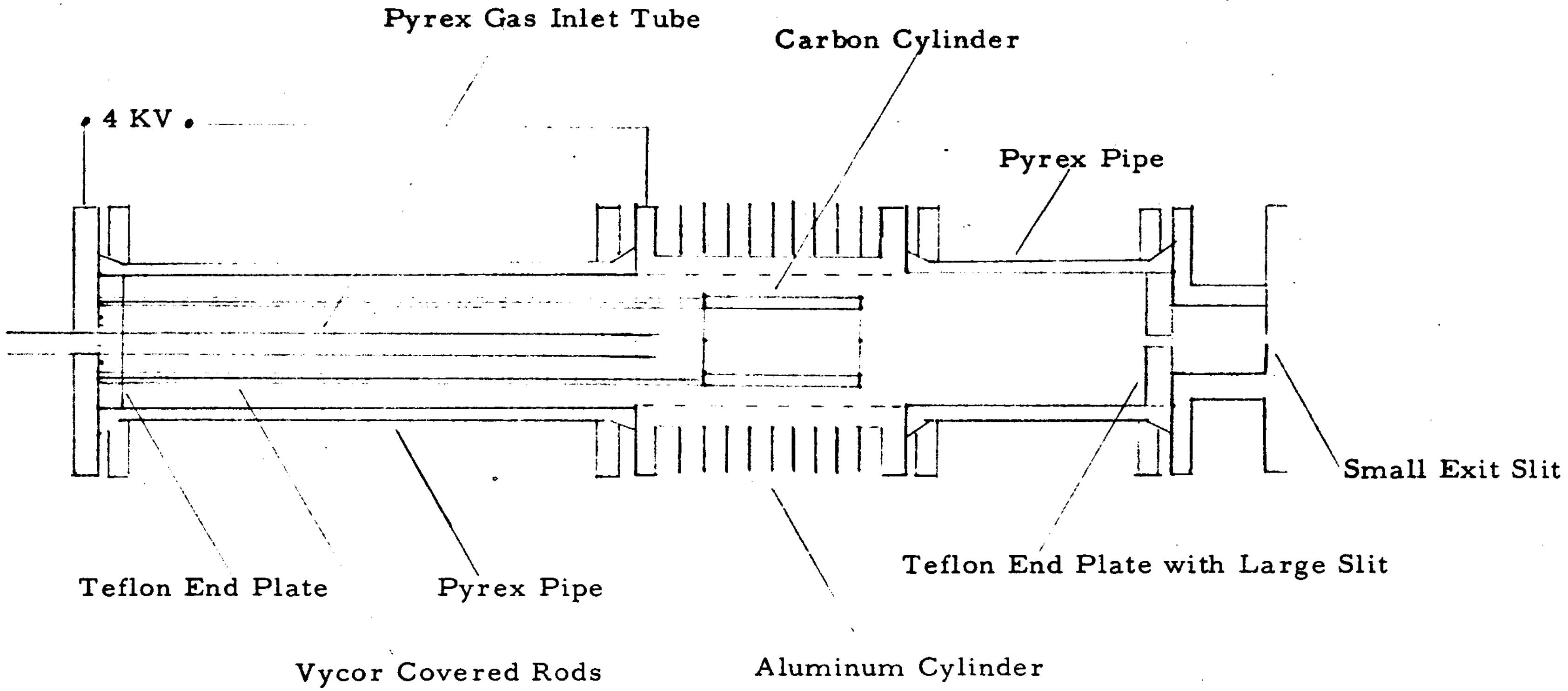
Dead time is the time duration after one pulse before the system will be capable of resolving another pulse.

Response time is the sum of pulse width and dead time. The response time is strongly affected by the characteristics of the amplifier being used, and is most meaningful if the different multipliers are evaluated with the same amplifier.

Concentric Cylinder Extreme Ultraviolet Source

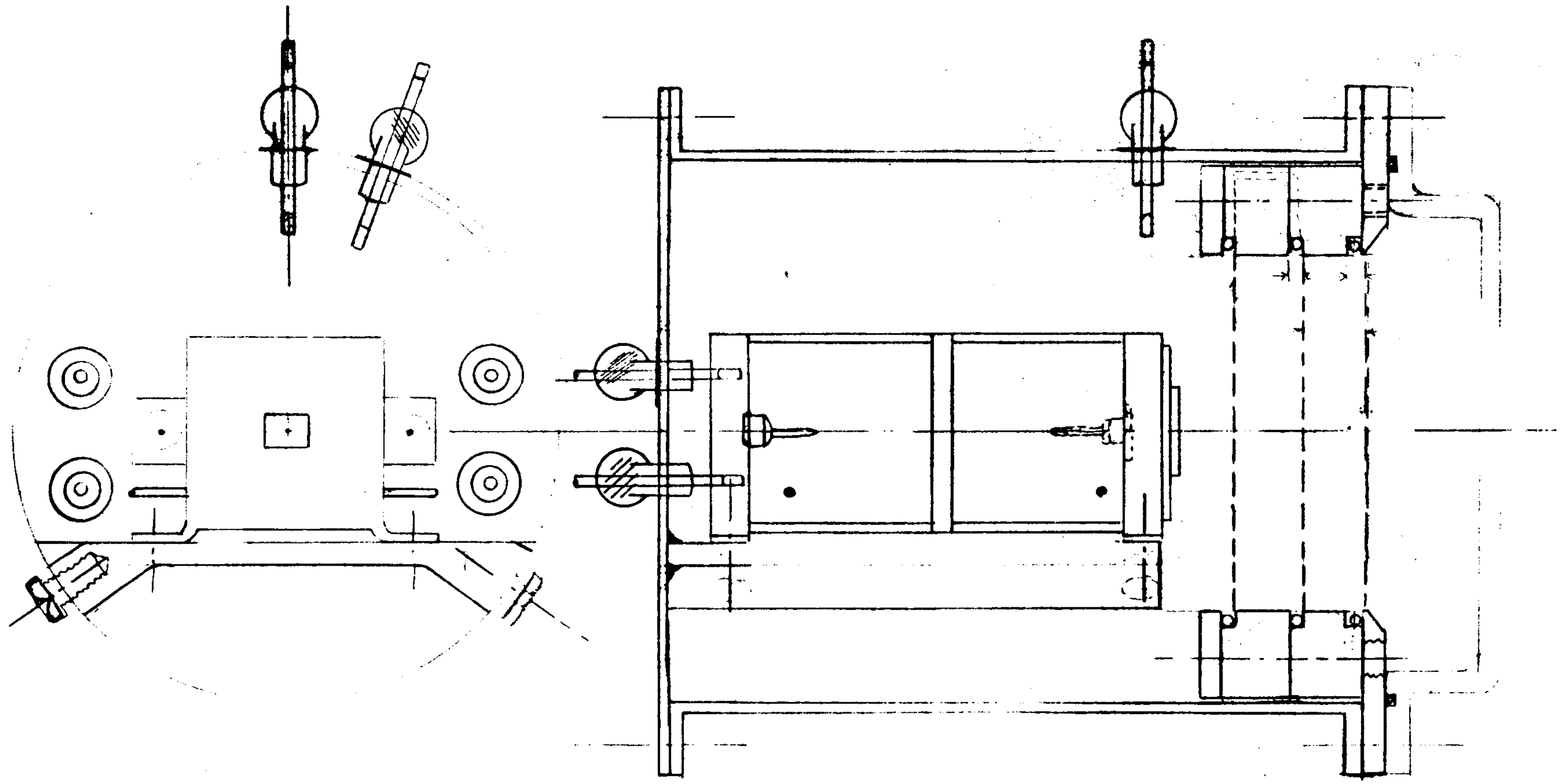
Early work in this laboratory demonstrated that it was quite difficult to obtain some of the desired higher energy EUV spectral emissions using the conventional capillary discharge source. A hollow cathode discharge was designed and built with noticeable increase in output; however, the source was very unstable as well as short lived and developed a large quantity of heat. An air cooled concentric cylinder lamp was designed and built which improved the output by a factor of 10^3, extended the lamp life by a factor of 10 and greatly improved the stability. The lamp is designed to operate on a.c. at about 4 kv at not more than about 100 m.a. The lamp will operate at voltages from about 3 kv to about 10 kv at pressures ranging from 200 to 10 microns. About 40 hours of operation with quite good output is obtained at about 4 kv and 30 ma current with -100 μ pressure before cleaning is necessary. The output is a function of applied voltage and gas pressure with maximum output occurring at the higher voltages and lower pressures.

Figure One is a simple sketch of the c.c. EUV source. Double tough pyrex pipe was selected for the insulating body of the source and the lamp was constructed so it may be readily disassembled for cleaning. The Teflon end plates serve as both gaskets and insulators for the internal discharge. Voltage is applied to the inner cylinder through three stainless steel rods which are surrounded with Vycor tubing. No part of the stainless steel rods is exposed to the discharge. Gas is admitted to the source through the gas inlet tube by a needle seat leak valve. The electrical discharge occurs primarily within the carbon cylinder and very little visible discharge is noted in operation. The source is Convection cooled and the temperature does not exceed about 50°C in normal operation. Both ions and electrons are accelerated axially along the source and a magnet must be used to deflect these particles away from the photon beam. The magnet is placed between the relatively large slit in the Teflon end plate and the quite small slit at the exit.



Concentric Cylinder

Extreme Ultraviolet Source



Sensing Element

Environmental Electron Detector