Report No. 2
on

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J. Allen Hynek
April 15, 1952

THE OHIO STATE UNIVERSITY
RESEARCH FOUNDATION

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Report No. 2

RF Project 480

REPORT

By

THE OHIO STATE UNIVERSITY
RESEARCH FOUNDATION

COLUMBUS 10, OHIO

Cooperator AF CAMBRIDGE RESEARCH LABORATORIES
230 Albany Street, Cambridge 39, Mass.
Contract AF 19(604)-41

Investigation of FLUCTUATIONS OF STARLIGHT AND SKYLIGHT

Subject of Report Progress for the period January 1, 1952 to March 31, 1952

Submitted by J. Allen Hynek

Date April 15, 1952

ABSTRACT

During the second three-month period since initiation of contract work the chief progress occurred in the following area:

(1) The photoelectric photometer, the mainstay of the observational program, was completed and was given extensive laboratory bench tests and its first successful run on the telescope. The first 1P21 photomultiplier tube employed proved to have an unfavorable signal to noise ratio even under dry-ice cooling and tests on six others were made to provide the choice of an acceptable one for project purposes. Since the project involves the measurement of 'noise' in starlight and skylight, a low-noise tube is an obvious necessity.

On the first telescopic run, with signal twice noise, the approximate limiting stellar magnitude is 11.

(2) The survey of the literature described in Progress Report 1 was continued and a first draft of the completed report was read by, and discussed with, Dr. Heinz Fischer of the Cambridge Research Center. It is planned to issue this report as a separate Air Forces Scientific Report and to submit it to a recognized Journal for publication.

There were no changes in project personnel.

INVESTIGATIONS IN PROGRESS

(1) Completion and Testing of the Photoelectric Photometer.

(A) Description of the Photometer. The completed photometer is shown in Figs. 1-4. Fig. 1 shows the completed unit attached to the focal end of the refracting telescope of the McMillin Observatory. The recording instruments are not shown. Fig. 2 shows the instrument itself with the end that attaches to the telescope at the bottom. The part marked A is the tube housing and cooling chamber. Part B is the photometer head, containing the guiding and viewing eyepieces, the diaphragm and filter wheels and the Fabry lens. Fig. 3 shows the same except that the port cover is open, showing the protruding portions of the diaphragm and filter wheels. Fig. 4 is part A of Fig. 2 shown separately. The arrow indicates the non-reflecting glass window through which the star light or sky light passes into the photomultiplier.tube. Fig. 5 shows the disassembled tube housing, illustrating the manner in which the tube leads are fastened to brass "buttons" which come in direct contact with the dry-ice. Fig. 6 shows the bottom view of the assembly, against which the cooling agent is pressed by a spring leaded plunger.

It is well to describe the above features in somewhat greater detail. The photomultiplier tube is mounted in an arrangement similar to that used by DeWitt and Seyfert.[1] Several modifications were made to simplify the

[1] J. H. DeWitt and C. K. Seyfert, "Notes on the 1P21 Photomultiplier Tube When Used for Astronomical Photometry." Pub. Ast. Soc. Pac. 62, 241, 1950.

construction and to make the electrical connections more practical. The rock wool insulation used by these authors was replaced with Styrofoam,

Figure 1

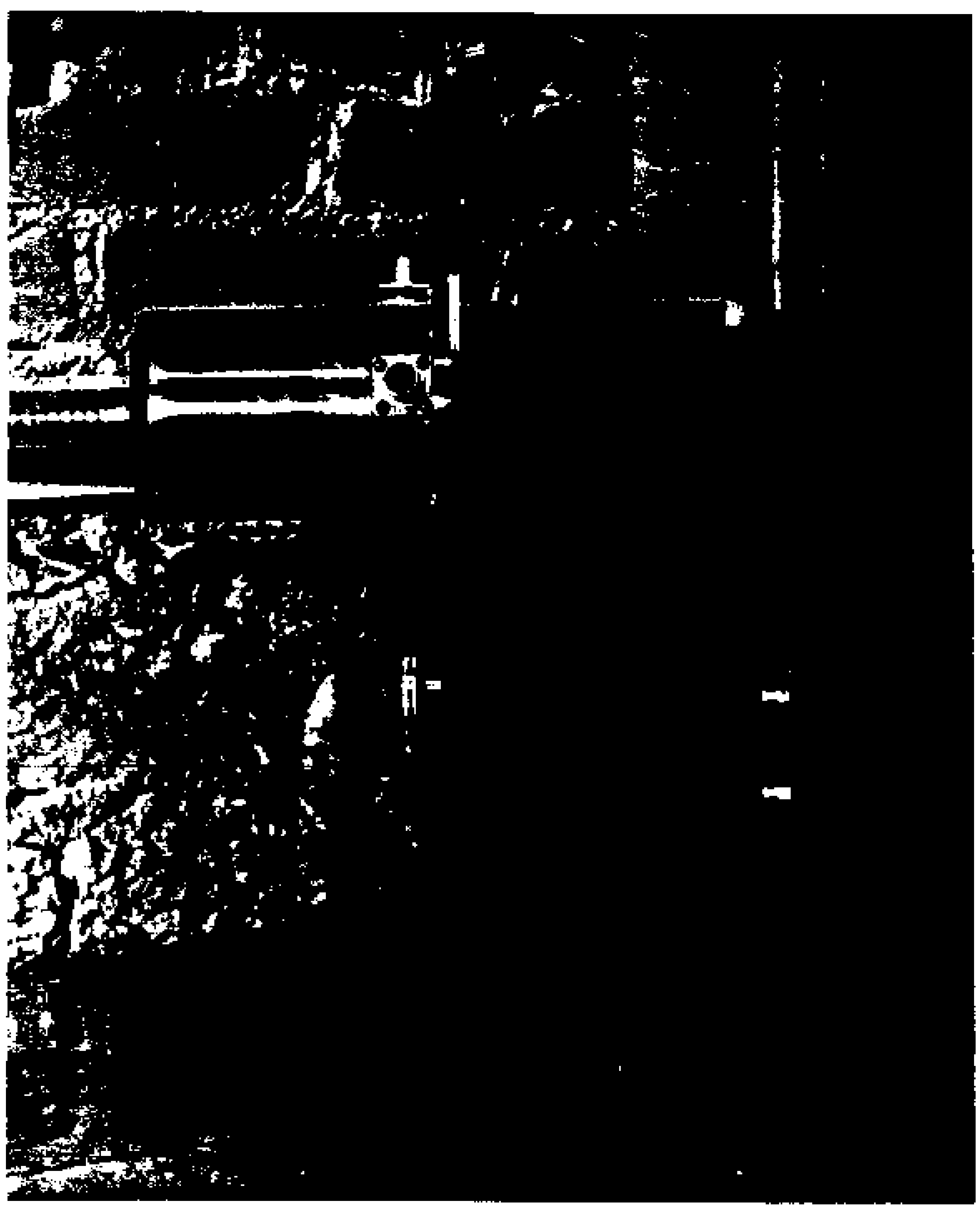

Figure 2

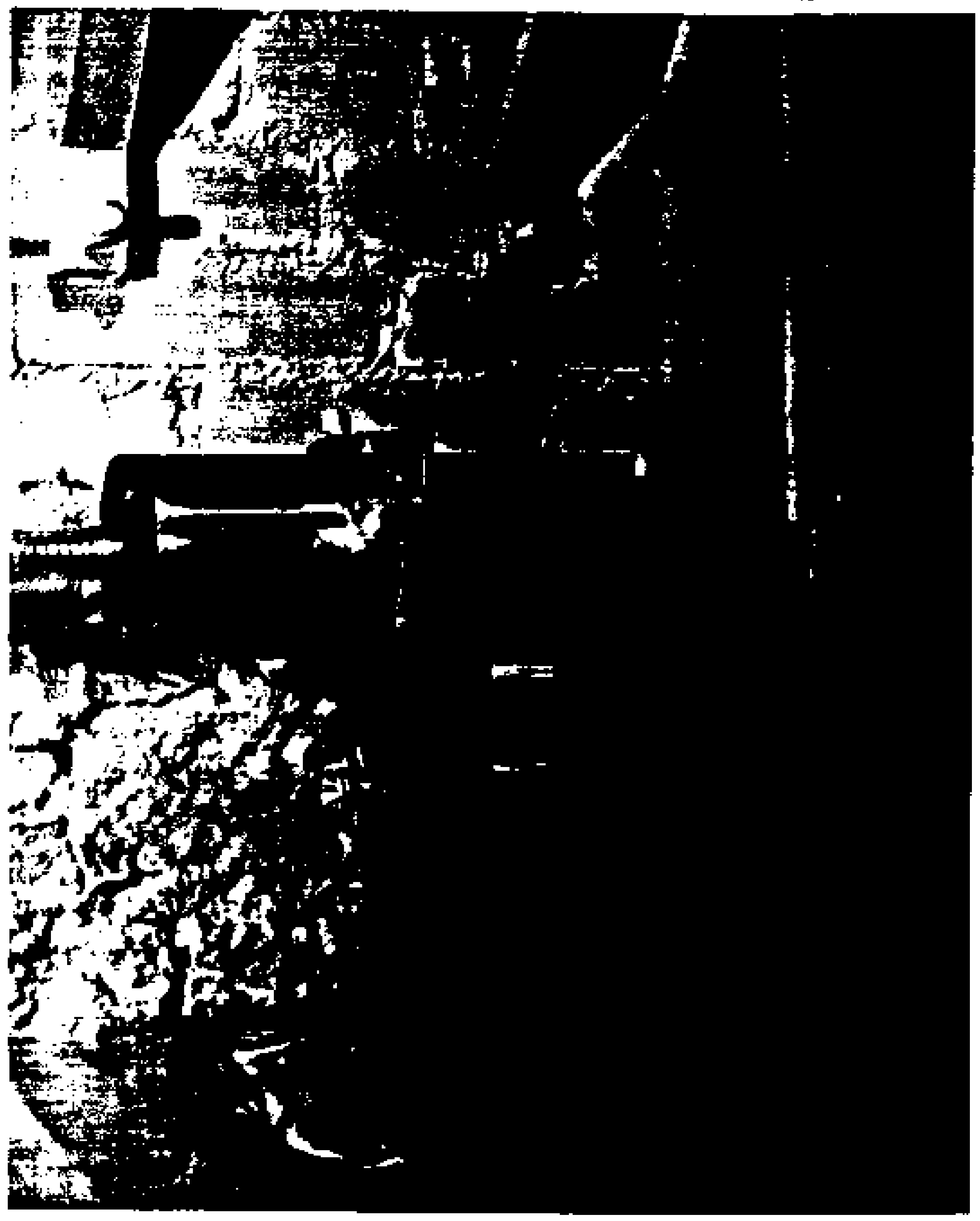

Figure 3

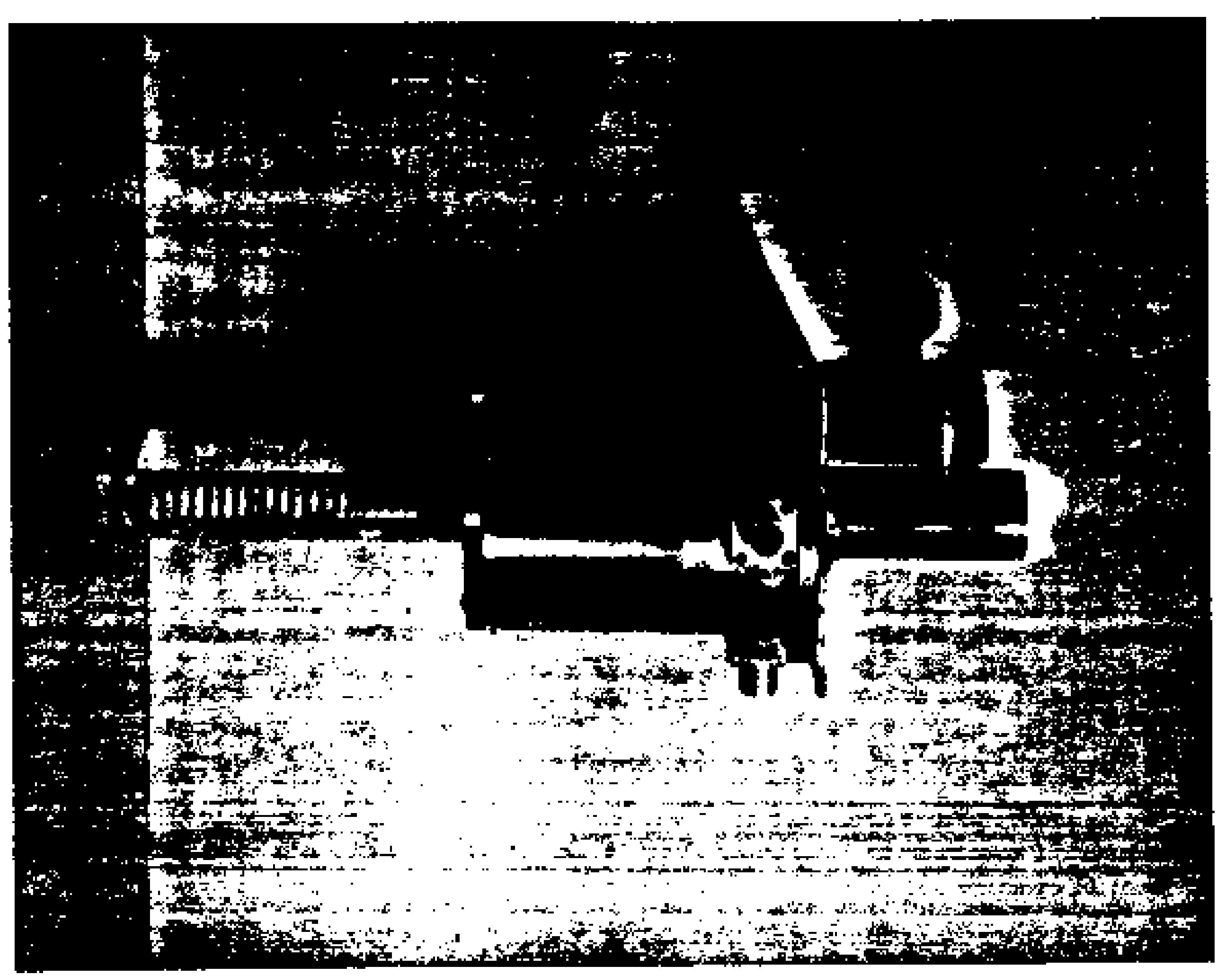

Figure 4

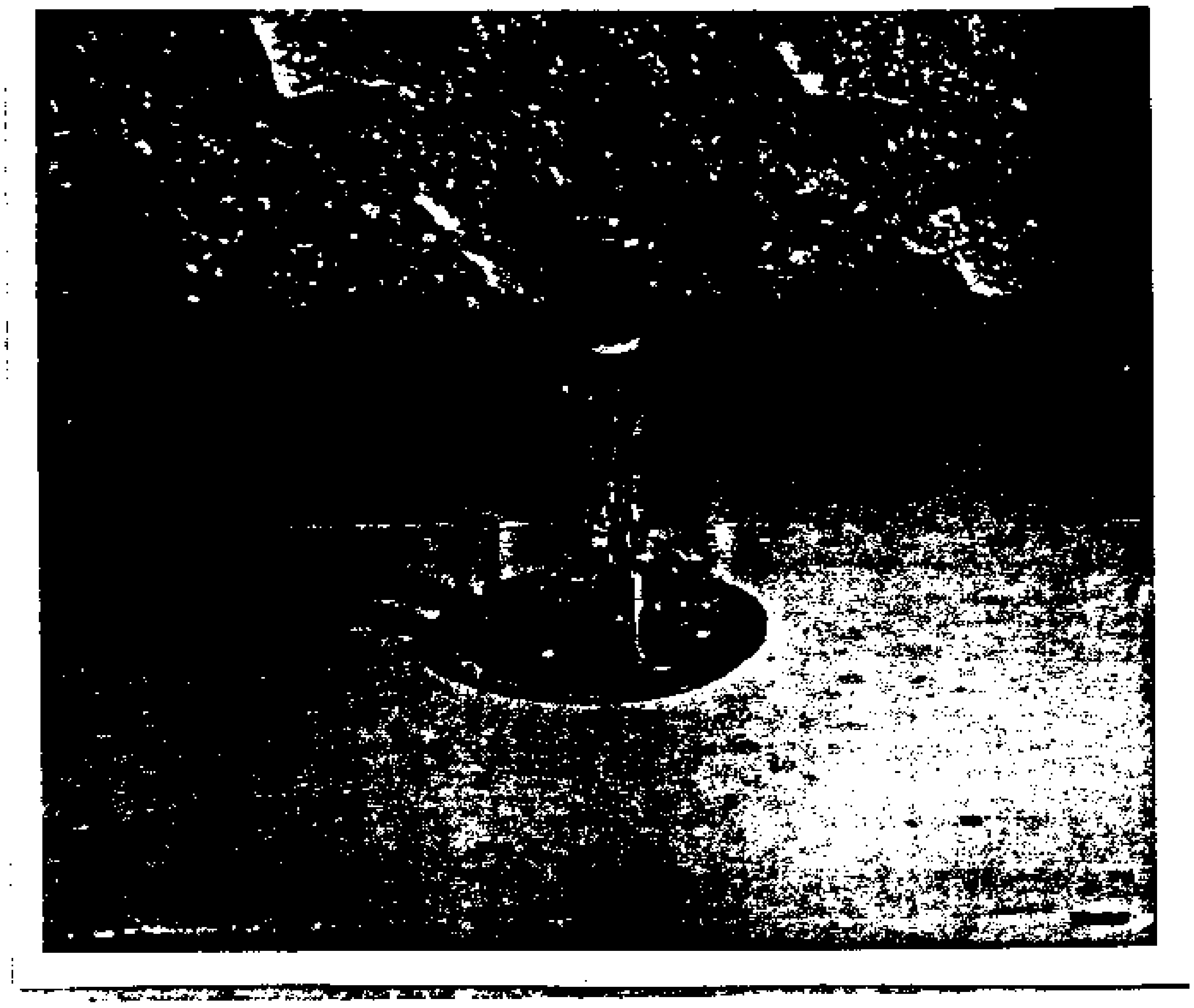

Fig. 5

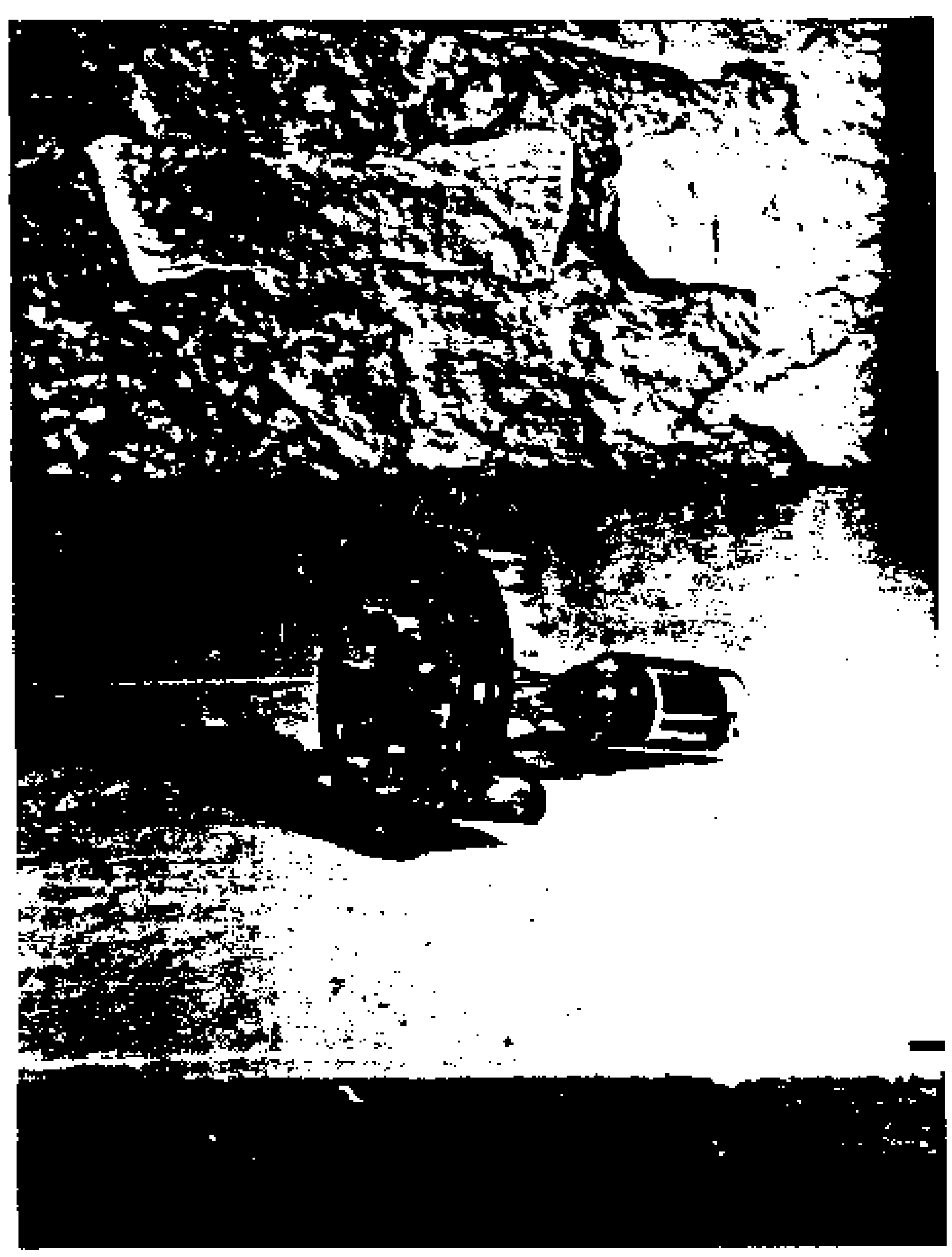

Fig. 6

an air-foam polystyrene which can be machined to fit and which provides excellent heat insulation.

The long copper fins, to which the tube leads were attached so that heat could be conducted from the tube elements, were replaced by brass buttons (Fig. 6) through the lucite plate which separates the dry-ice chamber from the resistor and phototube chamber. The latter is fairly tightly sealed against atmospheric moisture by the use of O-rings. The dry-ice capacity has also been increased so that the dry-ice lasts for four or five hours between fillings.

In our modification of the DeWitt-Seyfert photometer, electrical leads are taken out through the side of the housing directly from the resistor chamber through Amphenol coax connections. It was found that a small O-ring placed over the male fitting of the connector makes it practically leak-proof. The nonreflecting glass window through which the light is incident upon the phototube is also sealed with an O-ring. No moisture condensation on the window has been observed. Such condensation is the scourge of astronomical photometry.

(B) Testing of the Photometer. The multiplier was tested for dark-current, first by the use of a pulse amplifier and scalar unit. The reduction of noise upon cooling to dry-ice temperature was approximately by a factor of 100. Later calibrated tests with a d-c amplifier give the value of 2.9×10^{-10} amperes for the dark current. These tests also gave for the first multiplier tube employed a noise value (no illumination, peak-to-peak on a Brown recorder) of 1.8×10^{-10} amperes. On the telescope, calibration tests indicate that, using the same tube, the photometer would detect stars as faint as magnitude 11 (signal twice noise).

During this report period an amplifier for use with the photometer was also built and tested. It employs a differential cathode follower using constant current tubes as cathode resistors. The linearity has proved good, 0.3% or better over a range of 1.50 to 0.005 volts. The amplifier, however, has certain unexplained instabilities corresponding to a one to two millivolts input signal. It is now being battery operated while an attempt to isolate the trouble is being made.

Through the courtesy of the Hughes - Peters Co. of Columbus, Ohio, seven 1P21 tubes were loaned to us for testing and selection, and another six are soon expected. The following table is included to show the large range in characteristics exhibited by these tubes. If one has to purchase 1P21 tubes before testing, the table indicates that several tubes might have to be purchased before a suitable one would be found.

Tube No.	Signal Noise	Dark Current (amp x 10^{-10})	Noise Peak-to-peak (amp x 10^{-10})	Relative Sensitivity
1	130	2.2	1.8	2.35
2	104	8.0	1.0	1.04
3	145	5.0	1.5	2.18
4	141	5.0	17.0	2.40
5	104	6.0	1.6	1.66
6	1	2.2	0.5	0.004
7	30	6.0	34.0	10.2
8	108	7.0	3.3	3.58

Tube No. 6 appears to have faulty multiplication and, if so, its high dark current must be attributed primarily to an ohmic leakage in the base. A leakage of this order, at least, is to be expected in the other tubes.

The testing technique follows: Tubes were tested uncooled and with bases on (since they were not project tubes). The output current was observed with the tubes unilluminated. The dark current is the d-c component of the signal and the noise, the approximate peak-to-peak variation being superposed. The tubes were then illuminated by a lamp adjusted to a constant value such that readable signals without overloading were obtained for all tubes. The difference between the recorded signal and the dark current reading was taken as a measure of tube sensitivity. The signal-to-noise ratio is here taken as the sensitivity reading divided by the peak-to-peak noise value; it is not the conventional value given by the ratio of the signal to the noise in rms volts.

(2) Scientific Report on Stellar Scintillation

A preliminary draft of a study of the literature on stellar scintillation was completed and discussed with Cambridge Laboratory officials. It is expected that the final draft will be ready by May 1. Word has come that Prof. Chandrasekhar has a paper in press (the Astrophysical Journal) treating the scintillation of stars from a theoretical standpoint. As soon as an advance copy is obtained, a resume will be added to our literature report.

(3) Other Investigations in Progress

(A) Color Curve of the McMillin Refractor. This is being redetermined in order to determine the position of the minimum star image in a given spectral range. The necessary color filters have been acquired and some data have been obtained.

(B) The Effect of Atmospheric Conditions of the Size of Stellar Images. A detailed study of photographic image growth curves under a variety of conditions has been initiated to discover the effects of the atmosphere on image size and growth as distinguished from the effects of the optical system. This information will supplement the photoelectric data and aid in its interpretation.

OTHER SCIENTIFIC ACTIVITIES

Conferences

On March 27-28 Dr. Hynek and Mr. Hosfeld visited the Air Force Cambridge Research Center Laboratories to consult with Dr. Heinz Fischer, Dr. Schneider and Dr. Spencer, and to hear a paper on stellar scintillation be Dr. Wares of the laboratory staff.

PLANS FOR THE FUTURE

The completion of the photometer coincides with the time of expected clear spring weather. This ought to yield the first consecutive observational runs.

The General Radio Wave Analyzer, ordered three months ago, has not yet come, and harmonic analysis of daytime star scintillation must await its arrival. This also applies to our order for an oscilloscope, a magnetic tape recorder, and a Fastex camera.

First concerted observations will be made on the blue sky, to obtain a measure of the order of the instantaneous constancy of very small areas of blue sky, at various zenith distances and in different spectral ranges.

Scintillation studies of stars in the daytime are next on the schedule, and their correlation with nighttime scintillation.

PERSONNEL AND ADMINISTRATIVE MATTERS

Personnel

There were no changes in personnel. As soon as weather permits, Mr. Hosfeld will become our full-time observer, and will be responsible for the obtaining of consecutive observational runs with the photometer.

Fiscal Information

The fiscal balance as of March 31, 1952 was $18,800.00. This balance does not reflect our order and hoped-for receipt of a wave analyzer, a tape recorder, a sonograph, and an oscilloscope. (The Fastex camera is scheduled to be loaned to us by Wright-Patterson Air Force Base.)

Investigator .... Date ....

Supervisor J. Allen Hynek Date April 17, 1952

For The Ohio State University Research Foundation

Executive Director Oram C. Woolpert W.E.H. Date 18 April 1952