50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. PB88-247598

4. Title and Subtitle Continuous Optical Monitoring of Asbestos in Air

5. Report Date

6.

7. Author(s) Stolwijk, J. A. J.

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

John B. Pierce Foundation of Connecticut, Incorporated, Terminal Progress Report

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.

(C)

(G) OH-00647-02

12. Sponsoring Organization Name and Address

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

A continuous optical monitor for the identification and counting of asbestos (1332214) fibers in ambient air, in occupational and residential environments was developed. Early designs consisted of a fiberglass tube with an internal diameter of 1.0 centimeters and a length of 8 centimeters with four internal electrodes. A 2 milliwatt He/Ne laser was positioned down the center of the tube. External air was sucked into the tube and polarizable fibers caused to spin at the quadrature frequency reflecting the laser light at right angles to the long axis of the fiber. A photomultiplier captured the pulses of light generated and fed the data to a small computer. One drawback of the system was that fiberglass and samples of different types of asbestos produced output signals which were very similar. A new design was developed which employed eight electrodes made from round platinum wires. Long fibers were distinguished from short fibers by the narrowness of the beam reflected. A small microprocessor computer was dedicated to picking up the photomultiplier output and analyzing the result. The results obtained with this equipment were being compared to those obtained using membrane filters.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

NIOSH-Publication, NIOSH-Grant, Grant-Number-OH-00647-02, Air-quality-monitoring, Asbestos-dust, Asbestos-fibers, Mineral-dusts, Airborne-fibers, Monitoring-systems, Fibrous-dusts

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages 8
	20. Security Class (This Page)	22. Price PC $5.95 / MF $6.95

(See ANSI–Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4–77) (Formerly NTIS–35) Department of Commerce

R1678

Acc No 1088

Terminal Progress Report

A) Grant Number: OH00647 - 02

B) Period Covered: 9/15/77 - 8/31/80

C) Investigator: Stolwijk, Jan A.J.

D) Institution: The John B. Pierce Foundation of Connecticut, Incorporated

E) Title: Continuous Optical Monitoring of Asbestos in Air

F) Summary Statement:

The overall objective of this study was to develop and test a continuous optical monitor for the identification and counting of asbestos fibers in ambient air, in the occupational and residential environment. During the past three years we have designed, built and tested a number of prototypes of an optical fibrous monitor. The early designs basically consisted of a fiberglass tube with an internal diameter of approximately 1.0 cm and a length of 8 cm with four internal electrodes. A quadrature voltage (400 hertz) was applied to the four electrodes so as to generate a rotating electric field. A 2 mw He-Ne laser with a beam diameter of about 0.8 mm was positioned down the center of the tube. External air, into which was introduced asbestos fibers by a fluidized bed fiber generator, was sucked through the fiberglass tube at from 1 to 2 lpm. The polarizable fibers in the sampled air stream would be caused to spin at the quadrature frequency reflecting the laser light at right angles to the long axis of the fiber. A narrow slit allowed the reflected light from the fiber to fall on a photomultiplier which would generate two pulses of light for every rotation of the electric field. The photomultiplier output was sampled by an A/D converter and entered into a small computer on a real time basis. The sample rate of the A/D converter was originally 6400 per second so that for each rotation 16 samples were taken and analyzed. Early this past year the sampling rate of the A/D converter was upped to about 40,000 samples per second, so that for each rotation about 100 samples could be taken and analyzed. Examples of outputs from this general system using the 400 HZ rotating electric field are given in previous years summary progress report.

While the quadrapole system described above did detect polarizable fibers severe failing of the system became apparent this past year which lead us to consider a new design for the monitor: a) Fiberglass and samples of different types of asbestos produced output signals which looked very much alike, b) when we reduced the applied voltage to slightly less than one-half the maximum

voltage we had available (max voltage was 6,000 volts) the fibers ceased to rotate. This meant we had only twice the minimum electric field required to rotate the fibers, c) since the diameter of the laser beam was less than 1/10 of the diameter of the fiberglass tube, we were seeing less than 1% of the fibers within the air flow, d) an analysis of the aperture which allowed the reflected light to reach the photo-cathode indicated it was about 7° wide, which meant that 7° was the narrowest flash we could see, and e) a computer analysis of the electric field within the fiberglass tube indicated that it varied widely even within the laser beam. We searched this past year for a new design which would overcome these failings. The new design we settled on is described below.

The new design employing eight electrodes is shown in Figure 1. The eight electrodes are round platinum wires about 4 cm long with a diameter of approximately 0.2 mm equally spaced around a ring with a radius of 2 mm. At the center is a glass tube about 6 cm long with an outside diameter of 2 mm and wall thickness of 0.2 mm. The He-Ne laser beam shines down the glass tube and the diameter of the beam is adjusted so as to just miss touching the glass. The peek hole on the side is used to adjust the beam and it is of course covered when the device is in use. Light reflected by particles within the lumen of the tube passes up through the aperture to the photomultiplier cathode. Air is drawn through the tube at an adjustable flow rate. The method used for generating the rotating electric field is shown in Figure 2. Two high-voltage transformers are used. Both transformers are energized with 400 hertz sinusoidal voltages and each is 90° out of phase with the other. A resistor-capacitor network is then used to make the voltage at each electrode 45° out of phase with the adjacent one.

An exact computation of the electric field within the glass tube was made using a computer to ensure that the electric field within the glass was not distorted by the glass. The results of the analysis is shown in Figure 3. The lines of constant potential are shown for one quadrant of the glass tube. The voltage of the electrode on the right is at its peak value, the one at 45° is 45° from its peak and the one at the top is at zero voltage. Figure 3 shows that the lines of constant potential are straight within the lumen (but nowhere else) which means that the electric field vector is the same anywhere within the lumen. This means that the glass tube despite its dielectric constant (about 5.0) does not distort the field. With a uniform electric field in the glass there will be no tendency for polarized fibers to migrate to the walls and the forces on the fiber will be the same anywhere within the lumen.

Re: Grant Number OH 00647 - 02

In the new design we cannot fill the lumen with light for fear it will enter the wall of the glass tube and make it glow. However, this is somewhat offset because of the parabolic nature of the velocity profile within the lumen. We have calculated that 98% of the air flow will be within the inner 90% of the lumen. There will be a small time shift on the light to the photo-multiplier for fibers at the right or left periphery of the lumen but it should only be a few degrees. Our analysis indicates that the effect of the glass upon the transmission of the He-Ne laser light to be negligible.

The characteristic which distinguishes long fibers from short fibers is the narrowness of the beam reflected by the fibers. We have found that for the samples of asbestos and fiberglass fibers we have available that these beams are indeed very narrow: sometimes as narrow as 3°.

We have dedicated a small microprocessor computer to picking up the photomultiplier output and analyzing the result. Since fibers sampled can reflect the beam as narrow as 3°, we sample the photomultiplier output through an analogue/digital converter each 0.5° of rotation. Since the fibers are rotated at 400 hertz we must sample at 720 x 400 = 288,000 conversions per second. While A/D converters and sample/hold input amplifiers are available to meet this demand the computer itself is not fast enough to input the sample, increment an address register, store the sample and determine whether anything interesting is happening. We have, therefore, built an external memory which will store 4096 conversions and at the same time allow the computer to check if the pulse-like signals are arriving and if they are synchronous with the 400 hertz driving signal. When a significant signal is obtained the computer shuts off the airflow, shuts off an external clock, inputs the external memory into its own memory and looks to see what it has found. After analyzing and storing this signal, it will turn on the airflow, and the clock and continue to search for more fibers. At the end of some preset period it will have a count of the numbers of fibers, a measure of the fiber length distribution and a measure of the total quantity of air sampled.

We are currently in the process of testing the new instrument design and comparing its results with samples collected on membrane filters and analyzed for asbestos by the NIOSH recommended method. We also hope to explore the use of the developed instrument to do pattern recognition for particular fiber types.

G) <u>Publications:</u> To date no publications have resulted from this project.

Fig 1

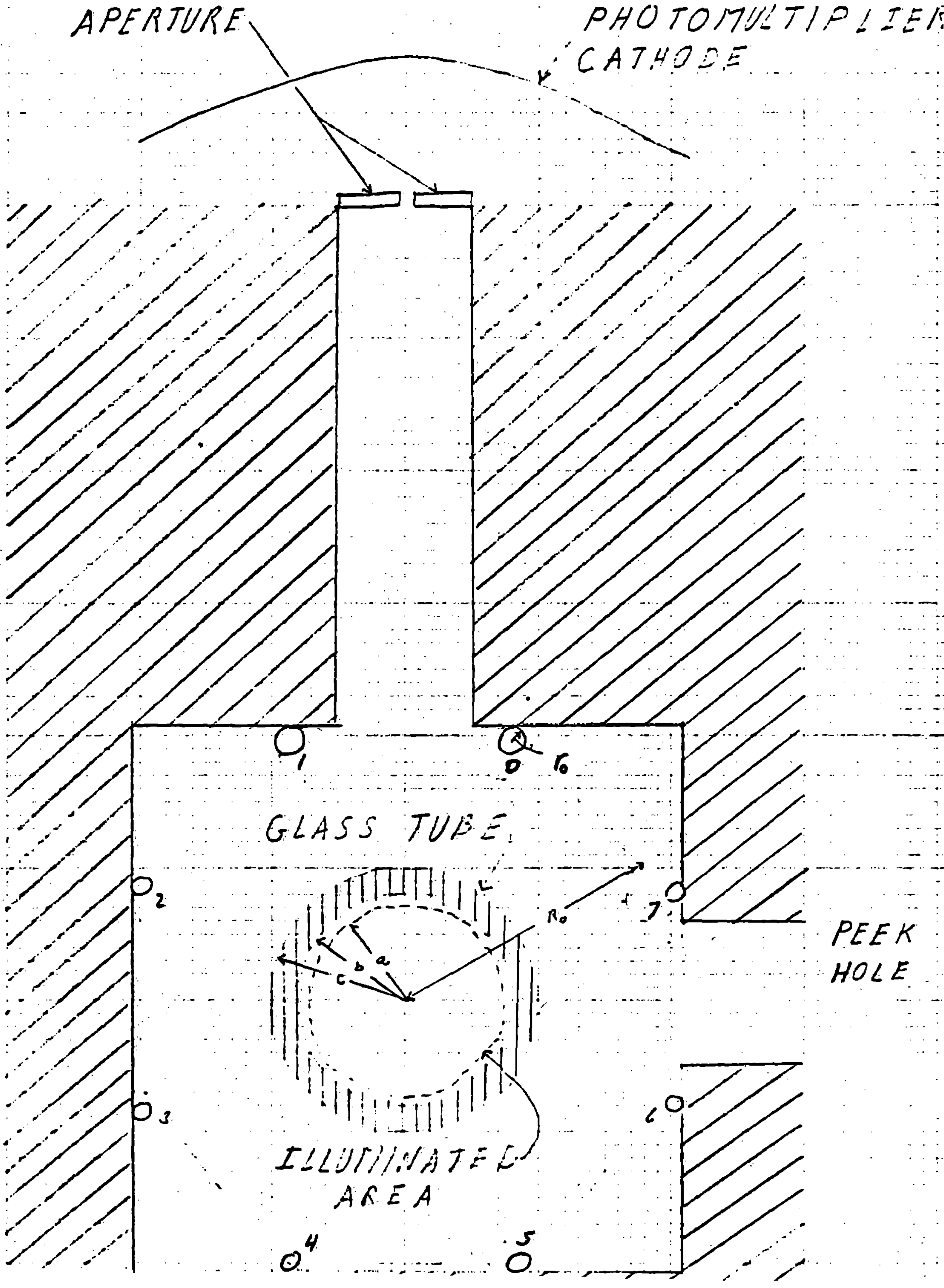
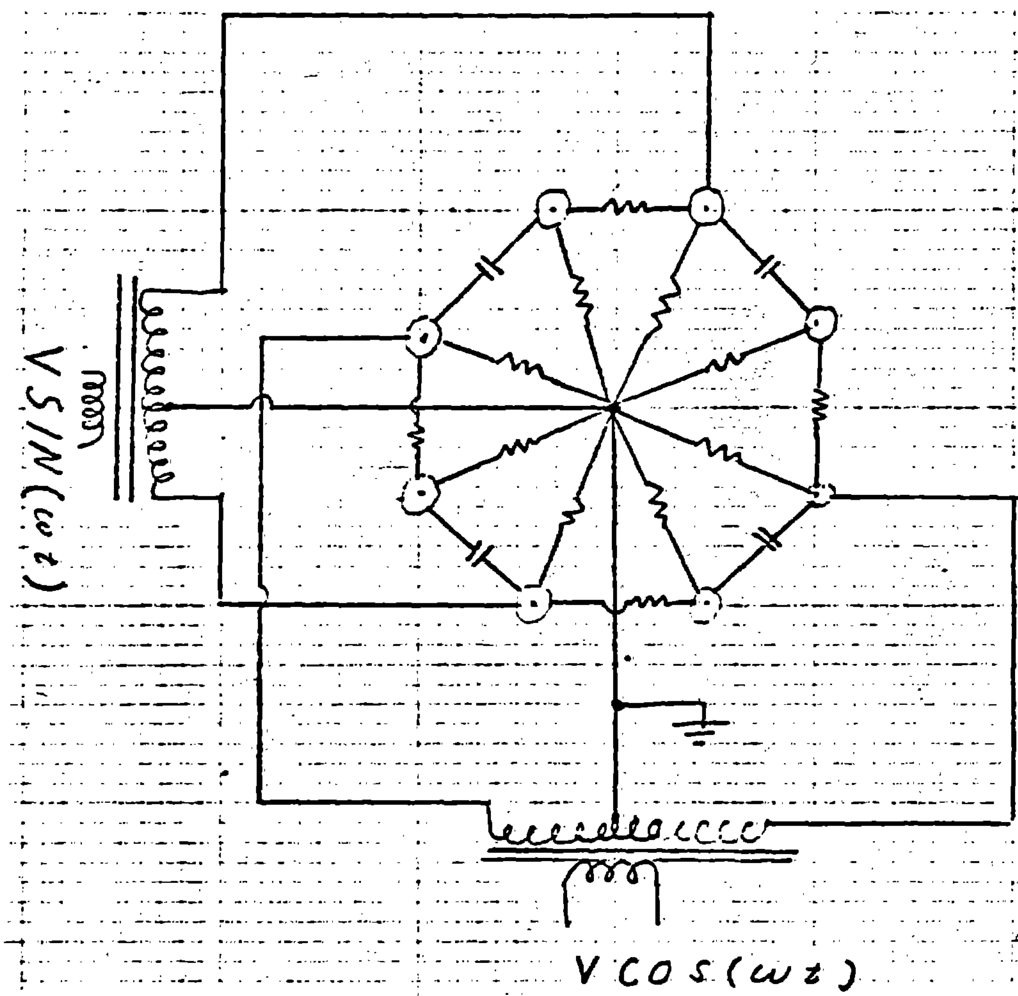
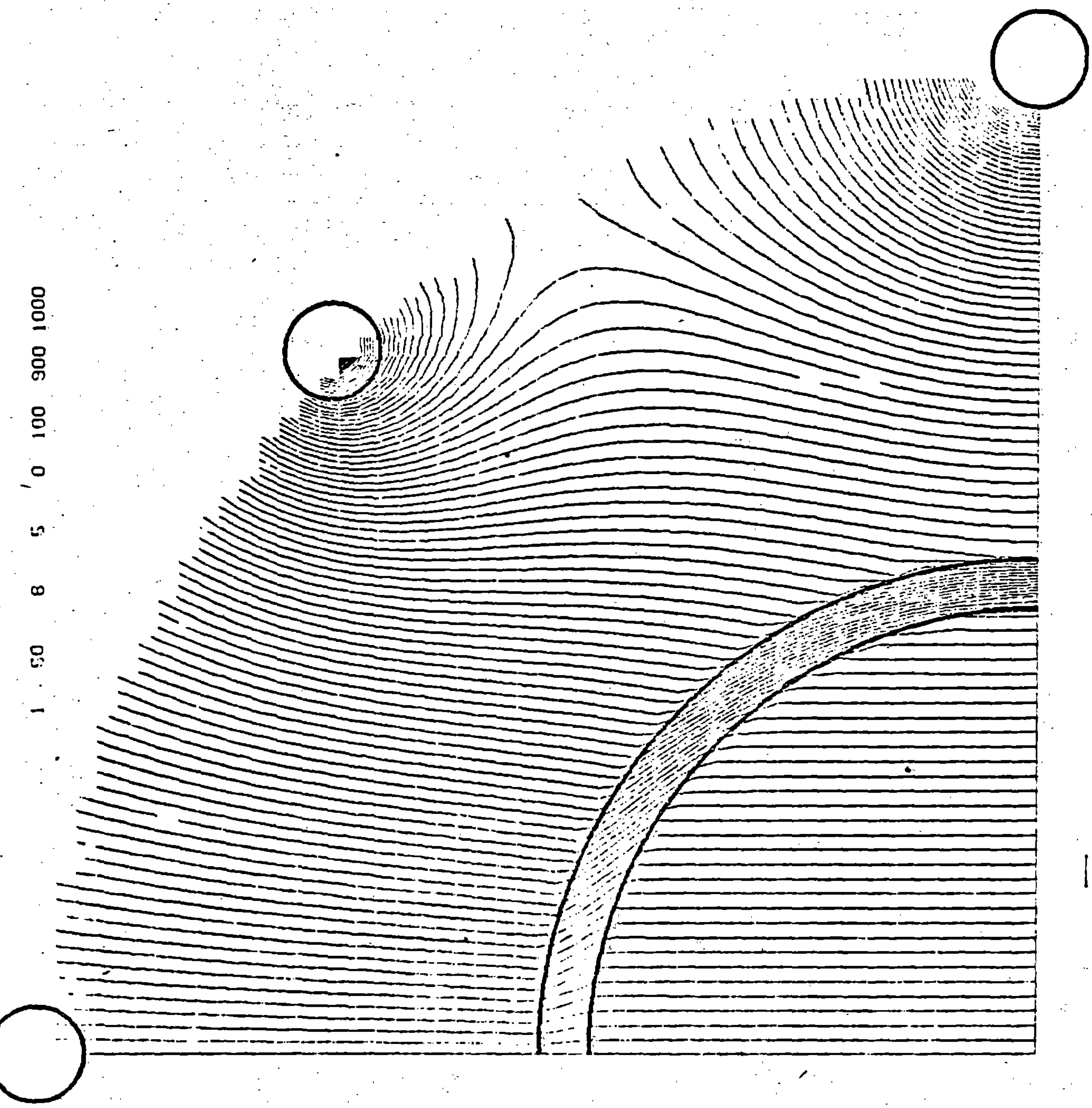

APERTURE
PHOTOMULTIPLIER CATHODE
1
0
r_0
GLASS TUBE
2
7
R_0
a
b
c
PEEK HOLE
3
6
ILLUMINATED AREA
4
5

Fig 2



6

Fig 3



CALIFORNIA COMPUTER PRODUCTS, INC. ANAHEIM, CALIFORNIA CHART NO. 00

MADE IN U.S.A.