DISCLAIMER

UCRL-1732

Summary - Conference on Photomultiplier Development

(under W-7405-Eng-26)

At two sessions held in Washington, D. C., January 28, 1952, the following items were discussed:

(1) Progress of present development at RCA:

(a) Photomultipliers: The two types developed under this contract to date are being turned over to Lancaster production facilities:

4646 - High gain, high output, 16 stage tube, for high-energy particle scintillation counters. (This tube to be known as C-7165 until further notice.)

5037 - Large cathode, 10 stage tube for scintillation spectrometers.

The 4646 should be in production by Fall, 1952; the 5037 should be in production by Spring, 1953. The characteristics of these tubes are presented in the first abstract of the Symposium Proceedings. (Appendix).

(b) Pulse height analysis: No work has been done on this aspect since July, 1951. In closed session, the opinion of the entire committee was expressed that the photomultiplier development has progressed at only a barely satisfactory rate; unfortunately, since RCA is the only concern with any reputable experience in this field, there is little which can be done in a direct way to expedite matters.

The point was again raised that perhaps the AEC should subsidize some other group with interests in this field, both to provide competition and to provide an alternate source for a device of some strategic value. Inasmuch as several policy decisions are to be settled at the next regular meeting (Summer, 1952), this item was tabled until then.

(2) Miniaturized Tube:

The urgent need of the Raw Materials Division for a miniature photomultiplier for use in surveying drill holes on the Colorado Plateau and elsewhere was discussed. In the past, other similar requests for developing tubes intended for special applications have been rejected inasmuch as this contract aims at developing tubes for general research purpose. The RIB representative indicated that handling special jobs through our contract as well appeared to be indeed the simplest method of disposition. It was therefore agreed that the miniature tube would be developed under this contract and that a standby fund commitment equivalent to a 12-1/2% increase of the present contract would be available to finance special projects.

The principal requirement of the miniaturized tube is that it be about one inch in diameter; in other respectsit will probably be similar to the high-gain, end-window 4646.

(3) Transistors:

It was indicated that commercial marketing of these items should occur in the near future, and that AEC subsidy should not be extended unless some pressing requirement develops. Transistors hold much promise in the way of reducing electronic equipment size, power requirements and maintenance costs.

(4) Fundamental investigations:

The problem of fostering fundamental research concerning photo and secondary emission of electrons has been brought up at each meeting. Efforts are being made to locate an academic group both willing and able to undertake a fundamental study. It is generally agreed that improvement of the photo surface represents the last major step which can be taken to obtain another factor of ten in

pulse height definition and speed.

(5) Electron-multiplier structures:

RCA can supply, in small quantities, 931A cages manufactured using treated Ag-Mg secondary surfaces. These can be exposed to the atmosphere; in vacuum they should have a current gain of about 1000.

(Ten 931A structures have recently been ordered by the Laboratory for general use. These will be supplied having 5819 cage mounts, but no bulb.)

Committee members present:

R. Butenhoff, Chairman - Chief, Radiation Instrument Branch
R. Johnson, Secretary - R.I.B.
E. Fairstein (In lieu of P. R. Bell) - ORNL
J. B. H. Kuper - Brookhaven National Lab.
H. D. Levine - New York Office - AEC
R. W. Swank - Argonne National Laboratory
R. J. Watts - Los Alamos Scientific Lab.
L. F. Wouters - UCRL

L. F. Wouters

Appendix

A large phosphor crystal is desirable for gamma-ray spectroscopy and for obtaining complete absorption of high energy particles. A photomultiplier with a large photocathode is necessary in order to realize the full advantage of a large crystal. Tube Type H-5037 was developed for use with large scintillation crystals.

It is also desirable to have a photomultiplier with a gain high enough to eliminate the need for pulse amplifiers with their necessarily limited frequency response. Such a tube is very useful for studying very fast phenomena, for portable survey instruments and for use in cases where the photomultiplier is necessarily in a remote location. Tube Type 4646 is suitable for such applications.

Some characteristics of these two tubes are given in Table I.

TABLE I

Multiplier Type:		H-5037	4646
Dimensions:	diameter	4"	1-5/8"
	length	7"	7-1/2"
Cathode:	dimensions	3-1/2" dia.	1/2" x 1"
	sensitivity	30-50 μa/l	30-50 μa/l
	spectral type	S-9	S-9
	collection eff.	high	high
Gain:	number dynodes	10	16
	gain	10^6	10^9
	overall voltage	1000	2000

The H-5037 uses a cylindrical electrostatic lens to focus electrons from the photocathode onto the first stage of the multiplier. The multiplier structure is similar to the RCA 931-A. The collection efficiency of the electron optical system used is quite good. Preliminary tests indicate that results consistent with the larger photocathode area are obtainable.

The 4646 has a much smaller photocathode area but has, in addition to excellent collection efficiency, a strong electrostatic collecting field in the vicinity of the cathode. This decreases the transit time spread and also makes the tube less susceptible to interference from external magnetic fields. The very high gain of the tube introduces a number of space charge problems. These are met by a special 16th dynode-anode structure. Two lead arrangements for obtaining the output signal from the tube are being investigated. One is a coaxial transmission line system, the other a pair of very short leads brought out through the sidewall of the tube. Voltage pulsesof the order of 40 volts on a 200 ohm line can easily be obtained.

Summary - Conference with Dr. Morton of RCA

(under W-7405-Eng-26)

Dr. Morton feels that the RCA group presently involved in photomultiplier development at Princeton will be kept more than busy into late summer of this year straightening out the following items:

(1) Increasing the space charge limit of the 14th dynode gap in the 4646.

(2) Completing the 5037.

(3) Afterpulsing investigation.

(4) Study of "unknown limitations":

  (a) Fatigue and drift
  (b) Pulse height resolution limitations.

(5) Secondary emission distribution width:

  (a) Loss of collection efficiency or:
  (b) Fundamental reason for width greater than $\sqrt{n}$.

(6) Secondary emission time constant using beam deflection methods.

(7) Miniaturized photomultiplier.

As for future research, considerable discussion ensued on the possibilities of increasing the efficiency of photocathodes. Dr. Morton did not think that a fundamental research program aimed at obtaining a better understanding of photo and secondary emission would be of much interest to RCA, nor that it would necessarily result in better photocathodes. It was mutually felt that such work should be carried on in more academic surroundings, and that a concurrent theoretical study should be sponsored. What is understood about these processes is not available in readily interpretable form, and much of the picture must be deduced by inference from field and thermionic emission and photoconductivity phenomena.

In addition to the completion of the developments just outlined above, Morton indicated two other channels of future interest:

(8) Information storage problems, "time-stretchers".

(9) Semi-empirical investigation of photocathode-phosphor combinations more suited to scintillation counting. This involves primarily investigation of the U.V. region.

He pointed out that most successful photocathodes appear to consist of combinations of semiconductors plus an alkali layer; thus: Cs-Sb, Li-Sb, Cs-Bi, etc. Li-Sb appeared to be particularly promising since it would reduce the residual gas pressure. From what is empirically known at the present time there is no hope of finding a photo-emission material which would not be injured by atmospheric air. Fair secondary emitters such as Ag-Mg, Be-Cu, are known which will withstand such exposure, of course.

Pulse height analyzer problems were avoided in the discussion.

L. F. Wouters

Summary - Telephone Conference - February 28, 1952
(Photomultiplier development under W-7405-Eng-26)

Since the meeting of January 28, R. W. Swank visited Prof. Coomes at Notre Dame University; their group is doing research on thermionic emission for the Bureau of Ships. According to Swank, they employ a technique of measuring deviations from theoretical Schottky emission for determining the magnitude and shape of the potential barrier at metal surfaces. They now wish to extend their method to photo-emission phenomena. Under the general purposes of the photomultiplier development program, this research merits AEC support; eventually, this might also lead this group to attempt a more general investigation of the problem. Accordingly, in order to provide for general discussion without the expense of a formal meeting, a telephone conference was called by the U.C.R.L. representative.

I. The following points were made in favor of supporting the Notre Dame research:

(1) No other feasible program has been suggested in the past two years. (M.I.T. is not interested; Reed College is proceeding along rather unsuited lines.)

(2) Notre Dame has a favorable reputation in physical research.

No objections were raised against proceeding with arrangements. R.I.B. stated that the Chicago office would enter directly into such research contracts, in contrast to the procedure followed for the RCA contract (through ORNL). Professor Coomes will be asked to submit a proposal to a sub-committee consisting of Swank and Butenhoff. The contract will be issued as soon as approval of the entire committee is obtained.

During the conversation, the size of the contract was indicated as being in the neighborhood of $20,000 for the first year. It was specifically

requested that Professor Coomes present:

(1) A brief summary of methods and results of the thermionic emission program.

(2) An outline of the proposed corollary investigation of photo and secondary emission.

II. It was requested that the Pulse Analyzer Subcommittee report in writing as soon as practicable. Comments were made to allow Dr. Jensen to continue on the Navy program for the time being to save AEC funds.

III. The subject of rotating the "meeting grounds" was again brought up; it was agreed to hold the next conference at Argonne National Laboratory (possibly in late summer).

Participants: P. R. Bell - ORNL
R. Butenhoff) RIB
R. Johnson)
J. B. H. Kuper - Brookhaven
H. D. Levine - New York Office
R. Swank - Argonne
R. Watts - Los Alamos
L. F. Wouters - UCRL

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