

23/61

2nd March, 1961

4 MAR 1961

Sub: Items III-J(1) and J(2) of the Agenda of the Eighth meeting of Board of Research in Nuclear Science held at Bombay on Feb. 28, 1961.

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My dear Dr.Krishnan,

Under III-J(1), Anisotropy and Time variations of Cosmic Rays etc.. Dr.Sarabhai had asked for a grant of Rs. 1,76,563 for his anisotropy project for 1961-62 as against Rs. 150,000/- in 1960-61, and the Cosmic Ray Committee had recommended this increased amount "in view of the operational programme envisaged for the project during the coming year, it was felt that the excess expenditure was reasonable and was approved." (see page 118)

Under III-J(2) for air-shower work under Dr.Bibha Chowdhury, he had asked for Rs. 26,944/-.

Consolidating J(1) and J(2) he had asked for Rs. 200,000/- instead of Rs. 1,50,000/-.

We decided at the Board meeting that the Air-shower Project J(2) should be decided after knowing whether Dr.Bibha Chowdhuri will remain in the Physical Research Laboratory.

The amount of Rs. 176,563/- asked for by Dr.Sarabhai was for the anisotropy and time variations project alone and I suggest that in accordance with the recommendations of the Cosmic Ray Committee, this may be agreed to, rounding up the amount if necessary, to Rs. 1,75,000/-.

Yours sincerely,

K.R.Ramanathan

(K.R.Ramanathan)

Dr.K.S.Krishnan,F.R.S.,
Chairman, Board of Nuclear ^{Science} ~~Physics~~,
Director, National Physical Laboratory,
Hillside Road,
NEW DELHI

Copy for information to Shri D.C.Chopra,
Bombay.

PHOTO AND CHEMICAL ENERGY CONVERSION PROGRESS REPORT (for March 1961)

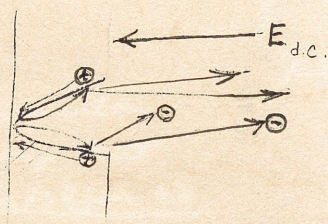
MgO Project - (Project: 9205), K. Ramanathan

A visit to USASRDLD was made on 8th March, 1961. We had a technical discussion with Dr. Dobischek and Dr. Heishmeir on the work we had done during the months of January and February. These discussions were mainly on: (1) conditions at the interface between MgO and Ni substrates for normal self-sustained emission, (2) the theoretical interpretation of the stationary portion and the subsequent decline of the "apparent surface potential."

A visit to Tung Sol Electric Inc. was made on 17th March to discuss the theoretical model we proposed in the Semi-Annual report and also acquainted us with the work being done there.

We have spent this month analyzing and interpreting the admittance versus frequency loci exhibited by an MgO cold cathode diode at various average tube currents. The ultimate objective was to determine if our theoretical model will correctly predict the observed admittance characteristics.

On the basis of our theoretical model consider a plane parallel slab across which a moderate field exists, produced by an external d.c. potential. This slab represents a portion of the MgO coating. Holes drift across this slab under the influence of the field, accumulate at one side and by their presence produce a greater current of primary electrons in the bottom of an adjacent vacuum pore. These primary electrons produce secondaries which appear as plate current.



holes are produced only
in regions immediately
adjacent to vacuum pores

The only important time lag in this process is the average time t for a hole to drift across the coating to the interfacial layer. Now we apply a sinusoidal perturbation to the d.c. potential and compare the phase of this perturbation with the phase of the resulting current. In mathematical terms:

$$V = V_0 e^{i\omega t}$$

$$I = I_0 e^{i\omega(t - \bar{\Delta}t)}$$

$$\therefore Y' = \frac{I}{V} = \frac{I_0}{V_0} e^{-i\omega \bar{\Delta}t} = \frac{I_0}{V_0} (e^{-2\pi i \bar{\Delta}t / \tau})$$

This is the admittance characteristic of our theoretical model. The calculation of the admittance characteristic has been simplified by neglecting individual fluctuations in Δt and the use of an average $\bar{\Delta}t$.

The effect of fluctuations in $\overline{\Delta t}$ appears at high frequencies where there is a departure from loci of perfect semicircular arcs. The fluctuations make Y' a more complicated function and require a more lengthy mathematical treatment. We shall limit the discussion to the low frequency portion of the admittance versus frequency characteristics of diodes with good coating characteristics. In the admittance characteristics of the particular diode most extensively studied¹ there are about 23 experimental admittance versus frequency points plotted. Of these 23, only three points depart by more than the diameter of a point from idealized semicircular loci. There are many interesting correlations that may be made between this expression and experimental admittance data on MgO cathodes. In the following we shall interpret one simple result.

In the region of perfect semicircular loci, we find that the observed admittance Y can be represented as the sum of two admittances Y' and Y'' with special properties.

$$\vec{Y} = \vec{Y}'' + \vec{Y}' \quad (1)$$

where $\vec{Y}'' = G'' + jB''$ (2)

and $\vec{Y}' = k(e^{-iB'}) = k(e^{-i\omega\overline{\Delta t}})$ (3)

Y'' contains a conductance component G'' which varies parametrically with average tube current, I , in such a way that the product I/G'' is approximately a constant, increasing slightly with increasing tube current.¹ The other component of Y'' , i.e. B'' is purely capacitive and is a constant, independent of I , within the limits of experimental error. Y' varies in such a manner as to trace out a circular arc when θ' , the angle formed by Y' and the real axis, is varied. The angle θ' is directly related to the applied frequency, ω , by the relation:

$$\theta' = \omega\overline{\Delta t} = (2\pi/\tau)\overline{\Delta t}$$

where $\overline{\Delta t}$ is the previously defined average time required for a newly created hole to drift down to the interfacial barrier under the influence of the externally applied electric field. τ is, of course, the period corresponding to the ω of the applied field.

It is found experimentally that MgO cold cathode tubes respond to changing voltages as if the cathode possessed electrical properties similar to an inductance and resistance in series. Let us see why this is so. The admittance characteristic of a resistance and inductance in series can be written

$$Y_{LR} = \frac{Y_L Y_R}{Y_L + Y_R} = \frac{\frac{-j}{\omega L} Y_R}{\frac{1}{R} - \frac{j}{\omega L}} = \frac{-j}{\omega L - jR} = \frac{R - j\omega L}{R^2 + \omega^2 L^2} \quad (4)$$

¹"Study of the Cause and Effect of Flicker Noise in Vacuum Tubes," II, A. van der Ziel, Final Report, Nov. 15, 1957, to Dec. 31, 1959, Contract No. DA 36-039-sc-74963 - see figure 60A, page A63.

This can be written in polar form as:

$$(5) \quad Y_{LR} = |Y| e^{i\phi} = |Y| e^{i \arctan(wL/R)} = \frac{1}{\sqrt{R^2 + w^2L^2}} e^{-i \arctan(wL/R)}$$

By expanding $\arctan(wL/R)$ in a series we see that:

$$Y_{LR} = \frac{1}{\sqrt{R^2 + w^2L^2}} e^{-i \left\{ \frac{2\pi L}{R} \frac{1}{\tau} - \left(\frac{2\pi L}{R} \right)^3 \frac{1}{\tau^3} + \dots \right\}} \quad (6)$$

In the range where

$$\left(\frac{2\pi L}{R} \frac{1}{\tau} \right) < 1 \quad (7)$$

$$Y_{LR} \approx \frac{1}{\sqrt{R^2 + w^2L^2}} e^{-(2\pi iL/R) 1/\tau} \quad (8)$$

Comparing (8) with (3) therefore we find that:

$$\Delta t = L/R \quad (9)$$

$$\frac{I_o}{V_o} = \frac{1}{\sqrt{R^2 + w^2L^2}} \quad (10)$$

Our conclusion is that our theoretical model explains observed admittance characteristics very well for diodes with good coating characteristics. A complete summary including all the necessary mathematical details would be too lengthy for this report.

Experimental Work

An electron gun with an MgO cold cathode has been designed to observe if the emission current density from the cathode is uniform over its entire area or whether electrons originate from discrete points that scintillate. Since special activation techniques are required for processing an MgO cathode effectively, we decided to build simple diode structures before sealing the electron gun to the CRT screen. Our diodes had a Ni cathode sleeve surrounded by a Ni mesh which served as a sustaining grid structure. This assembly was mounted on a glass envelope with "Kovar" leads.

Prior to coating the Ni sleeve with MgO, it was sandblasted lightly to help MgO adhere to the substrate. The sleeve was then chemically cleaned in a ternary hydrogen peroxide, formic acid and water system for 2 minutes at 80°C. Proportions giving maximum reduction of Ni was selected as follows:

Distilled water 45%
 Hydrogen peroxide 30% Reagent (ACS) 45%
 Formic Acid Reagent (ACS) 10%

The sleeve was then mounted in a glass envelope. MgO was deposited on it by electrostatic smoke coating technique. For this, a magnesium ribbon was burned in air and held under the Ni sleeve which was kept at a potential of 20K volts to attract the MgO smoke from the burning. The distance between the sleeve and the burning Mg ribbon was approximately 10 inches. The uniformity of deposited coating was excellent. These were observed under a microscope before placing the sustaining grid around it. The coating thickness was estimated at 30-35 *microns*

The assembled diodes were then evacuated to a pressure of 10^{-6} mm Hg before letting oxygen into the vacuum system. The cathode was heated in an oxygen atmosphere to about 750°C for 5 minutes. The tube was then pumped down to 10^{-6} mm Hg and the cathode heated once again to 700°C for 3 minutes. The temperature was monitored by an optical pyrometer.

A voltage of 200 V was applied across the electrodes (Ni sleeve being negative) with UV light shining on the tube. The voltage was raised gradually to observe if the cathode would be primed. However, this did not work. Next, a tesla coil was used for initiating. There were indications of cathode starting - a few blue spots scattered over the cathode area were observed. The cathode did not sustain the emission when the tesla coil was turned off. Later discussions with Mr. Johnson of Tung Sol revealed that the oxygen pressure in the vacuum system should be maintained accurately at 30 mm Hg before heating the cathode for processing. Apparently, cathodes which are not processed this way do not sustain emission well.

Two new cathodes have been made and we expect to process them shortly before starting on the electron gun.

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18/4/61

My dear Krishnan,

I am sending herewith
copy of a report for Krishna. The
report he sent last month is not
here; it has apparently been taken
by Sarabhai with him.

I understand that the Oceanographic
Committee will meet sometime
in the middle of May.

Krishna says he would like to
have your comments + suggestions if
any. A line from you will encourage him.
His address is:

Yours affectionately
K B Ramanathan

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19/61

19th April, 1961

21 APR 1961

My dear Professor Krishnan,

Herewith the resolution of the Cosmic Ray Research Committee on Shri B.N.Srivastava's scheme at Naini Tal. I recommend that Shri Srivastava's scheme may be continued for the year 1961-62.

Yours sincerely,

K.R. Ramanathan
(K.R. Ramanathan)

Encl:

Prof. K.S. Krishnan, F.R.S
Director, & Chairman, Board of Nuclear Science,
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Item No. 3 of the minutes of the Cosmic Ray Research
Committee meeting held at Chandigarh

Research scheme entitled "Study of time variations
of extensive air showers in cosmic rays at Nainital"
(Shri B.N.Srivastava, D.S.B.Government College,
Nainital)

The whole problem of air shower work in India was
discussed at Chandigarh both at the meeting of the Working Group
and of the Cosmic Ray Research Committee. It was agreed that
Shri Srivastava could do useful work by way of building up and
testing a network of five scintillators for air shower work but
that his work will have to be integrated with ~~the~~ that of a larger
group which will ultimately work in Gulmarg. Accordingly the
Committee recommended the continuance of the scheme of Dr.Srivastava
for the year 1961-62. The Chairman of the Committee was authorised
to write to Dr.K.S.Krishnan, Chairman of the Board of Nuclear
Science for the latter's recommendation to the Department.

R.Ramanathan

21 APR 1961

35A/61

19th April, 1961

My dear Professor Krishnan,

I have received from the Radio Propagation Unit ~~with~~ letter No.IGY/16/61 dated April 5, 1961, the drafts of the Contract for continuing the participation of the Indian National Committee for IGY and the U.P. State Observatory, Naini Tal, with the N.A.S.A. group in America. The drafts seem to be acceptable but I would like to make the following remarks. and/

1. The U.P. Government has to agree (Para 3 of agreement) that they will maintain the Observatory in a proper way. They should realise the importance of having a Director with sufficient scientific standing and activity to cooperate with the N.A.S.A. group on equal terms. This is essential if India should benefit from this cooperation in the same way as the N.A.S.A. group would. Since two parties in India are involved, one the U.P. Government and the other the Indian National Committee for the IGY, the responsibilities of the two should be clearly defined. We do not know how long the Committee for the IGY will exist. These internal matters should be settled.

2. Would it not do to make the period of the Contract five or six years in the first instance, instead of ten?

Yours sincerely,

K.R. Ramanathan

(K.R. Ramanathan)

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