LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the twenty-eighth of the preceding month; for the second issue, the thirteenth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Increasing the Charge Sensitivity of Vacuum Tube Amplifiers

For several years various systems of neutralizing the input capacity of vacuum tube amplifiers[1] have been known. These systems have not been widely used nor well understood. For this reason I wish to show the possibilities for their use in increasing the charge sensitivity of vacuum tube amplifiers and also the speed of their operation.

The capacity of the input circuit of a vacuum tube limits the charge sensitivity to the order of 10^{-15} to 10^{-16} coulomb per mm, so that, with a current of 10^{-17} amperes, it takes from 10 seconds to 2 minutes to produce a readable deflection. One of the fundamental circuits for input capacity neutralization is shown in Fig. 1.

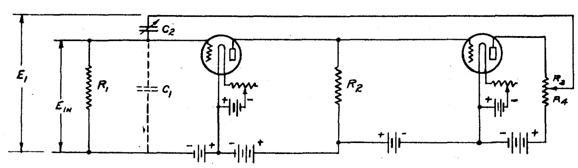

Fig. 1. Input capacity neutralization for low current measurement.

The conditions for complete neutralization are that C_1 equals C_2 and the ratio of R_3/R_4 is such that E_1 equals $2E_{\text{IN}}$. These conditions, of course, are not stable and represent the point at which oscillations start. The amount of capacity neutralization which is possible depends on the stability of the circuit. Preliminary measurements indicate that good operation is possible with the effective input capacity reduced to 1/20 of its original value. It is felt that by careful selection of circuits and tubes this value might be increased at least tenfold.

Charge sensitivites of 2×10^{-17} coulomb/mm have been observed with the FP-54 Pliotron tube.[2,3] By using the above method, this sensitivity might be increased to 2×10^{-19} coulomb/mm, or approximately one electron per scale division, and still retain good stability.

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January 21, 1932.

[1] Brillouin, Patent **1**, 404, 574, January 24, 1922.

[2] Metcalf and Thompson, Phys. Rev. **36**, 1489–1494 (1930).

[3] L. A. DuBridge, Phys. Rev. **37**, 392–400 (1931).

The Effect of Heat on Mercury Bands

It is well known from the work of Niewodniczanski (Zeits. f. Physik **49**, 59 (1928)) and others that moderate heating destroys the 4850 band and enhances the 3300 band in fluorescence and strong heating destroys also the 3300 band. This effect and the effect of heat on other mercury bands may be conveniently observed in a Tesla coil electrodeless discharge. A greatly reduced image of a 15 cm discharge tube was focussed for λ2540 on the slit of a Hilger E31 quartz spectrograph, and the spectrum photographed while the center of the discharge tube was heated by a blow torch. The spectrum for two exposure times is shown in Fig. 1. The difference between the center and edges represents the effect produced by heat. The pressure may be considered to be the same for all portions of the tube.

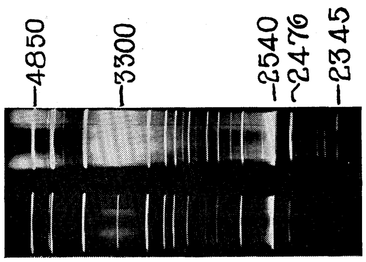

Fig. 1.

Heating is observed to destroy the 4850 band and to greatly reduce the intensities of the bands at 2345, 2476, 2540, and the continuous spectrum between 2536 and 3300. Moderate heating enhances 3300 but strong heating destroys it. The majority of the mercury arc lines are unaffected by heat but 5460, 4358, 4047, and 4077 are noticeably weakened.

The fact that most of the mercury arc lines are not affected by heat indicates that the discharge conditions are nearly the same in the heated and unheated portions of the tube. The weakening of the bands must be due to the destruction of mercury molecules by heat. The weakening of the lines probably results from collisions of the first kind which carry excited atoms to higher energy states.

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January 25, 1932.

The Resultant Electric Moment of Complex Molecules

The purpose here is to express the average resultant dipole moment in a form which may be readily evaluated provided that the potential energy associated with distortion of the molecule is known. The individual moments are assumed constant. A molecule may be idealized as a framework of lines along the valence bonds connecting the atoms. About certain of these bonds there is rotation. The experimental electric moment may be regarded as the vector sum of a series of electric moments lying along each of these lines. The moment along some lines may be zero. Let us begin with some end line and number them consecutively 1, 2, 3, etc., along the longest chain until another end line is reached. At points where there is branching the numbering along the different lines is to be distinguished by primes. Now consider a set of unit vectors lying along these lines with their directions pointing toward increasing numbers. Let θ_j be the angle which two consecutive vectors $j-1$ and j make with each other, being zero when they point in the same direction. Let us choose sets of right-handed rectangular coordinate systems in the following way. Each unit vector j coincides in position and direction with the x_j axis of a coordinate system. y_j lies in the plane determined by x_j and x_{j-1} in such a way that the angle between the positive direction of y_j and the negative direction of x_{j-1} is acute. A right-hand screw progressing along positive x_{j-1} turns through an angle, θ_j, in passing from positive z_{j-1} to positive z_j. The transformation A_j, which when applied to the components of a vector referred to the j coordinates transforms it to the $j-1$ coordinate system, is:

$$A_j = \begin{vmatrix} \cos\theta_j & -\sin\theta_j & 0 \\ \sin\theta_j \cos\theta_j & \cos\theta_j \cos\phi_j & -\sin\phi_j \\ \sin\theta_j \sin\phi_j & \cos\theta_j \sin\phi_j & \cos\phi_j \end{vmatrix}. \quad (1)$$

By repeated transformation each electric moment $c_{xj}e_{xj}$ referred to the j coordinates can be referred to a particular set of coordinates, say the set of index 1. e_{xj} is the unit vector in the x_j direction and c_{xj} gives the magnitude and sign of the electric moment in the x_j direction. The above method of specifying coordinates does not fix ϕ_2, which is taken to be equal to zero, which then determines A_2. The resultant vector sum of the n electric moments referred to coordinate system 1 is then

$$C_{x1}e_{x1} + C_{y1}e_{y1} + C_{z1}e_{z1} = \sum_{j=1}^{n} \prod_{k=2}^{j} A_k c_{xj} e_{xj} \quad (2)$$

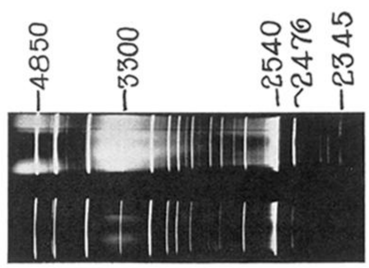

Fig. 1.