I. PHYSICAL ELECTRONICS

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A. PHYSICAL ELECTRONICS IN THE SOLID STATE

1. Characteristics of Junctions in Germanium

Measurement of diode characteristics at very low voltages provides a method for evaluating that part of the diode resistance that is independent of the applied voltage. In the region of interest the current i through the junction itself may be related to the voltage V across the junction by

$$i = i_O \left(e^{V/V_T} - 1 \right) \qquad (1)$$

where $V_T = kT/e$. The quantity i_O is related to the ideal reverse saturation current of the diode and may be determined from the measured voltage-current characteristic. For $V \ll V_T$, Eq. 1 reduces to

$$i = \frac{i_O}{V_T} V = \sigma_O V \qquad (2)$$

and the diode becomes an ohmic conductor with a conductance σ_O. But if the diode has a resistance R effectively in series with it as a result of the resistance of the base material, then Eq. 2 becomes

$$i = \sigma_O (V_O - iR) \qquad (3)$$

V_O being the voltage that is actually measured. Thus, the effect of R is to shift the measured characteristic along the voltage axis by an amount iR. The quantity σ_O is independent of R, however, and can still be determined. If we let $\sigma = i/V_O$, then Eq. 3 gives

$$\sigma = \frac{\sigma_O}{1 + \sigma_O R}$$

from which we have

$$R = \frac{1}{\sigma} - \frac{1}{\sigma_O}$$

This method has been applied to previously determined diode characteristics, and it yields reasonable values having approximately the correct temperature dependence.

With the use of a recently constructed potentiometer, stray voltages from hum pickup have been almost entirely eliminated, and measurement of the voltage on a

sample of 10^5 ohms can be made to an accuracy of 1 μvolt or better. A new tempera-
ture regulator that uses a chopper amplifier to control the heater voltage of the sample
oven and a thermocouple as the sensing element has been constructed. Performance
tests indicate that this regulator will hold the sample temperature constant within
0.025° C for periods as long as an hour.

J. F. Campbell, Jr.

B. ELECTRON EMISSION PROBLEMS

1. Studies of a Planar Dispenser Cathode

A few samples of a dispenser cathode of the capillary type have been furnished by
Siemens and Halske for study. The emitting surfaces are planar and have a diameter of
3 mm. Two of these cathodes were mounted "face to face" with a separation of 1 mm.
Either one could be used as the emitter and the other as the collector. A detailed
study of the current-voltage relation interpreted by the theories and corresponding
tables given in Technical Report No. 321, Research Laboratory of Electronics, M.I.T.,
(reprinted from the "Thermionic Emission" section of Vol. 21, Handbuch der Physik,
1956), permits the determination of the emitter temperature as a function of heater
power. The receiver work-function can be measured to within one hundredth of an
electron volt. This method of analysis also permits the study of variations in the
work-function of the cathode when it is used as a receiver to show changes that occur
as a result of deposits that come from the emitter structure. The receiver can also
be operated at relatively high temperatures and in that manner determine variations
in the work-function with temperature that depend not only on the changing Fermi
level but also on the changing physical state of the collector.

W. B. Nottingham

2. Effect of a Magnetic Field and of a Unidirectional Heating Current
on Thermionic Emission from Molybdenum

Recent measurements on the magnetic field effect show a decrease in total plate cur-
rent with increasing applied field. For a field of 6000 gauss this decrease is 13 per cent
for the current to the four anodes, and 9 per cent in the case of the two guard rings.
The current remains constant up to fields of about 400 gauss; thereafter the decrease is
roughly proportional to the increase in field.

We must now ascertain whether this decrease represents a drop in the emission
current itself or a change in collector current caused by modification by the field of the
trajectories of emitted electrons. With the present tube structure, the latter possibil-
ity cannot be entirely ruled out; the presence of slits between the plates and guard rings
affords a possible means of escape for these electrons.

For this reason, a new, smaller tube has been designed. It preserves the original plan of four separate plates surrounding the filament, but eliminates all apertures and other irregularities along the length of the channel. The new design consists of four flat plates that extend the full length of the filament and overlap in such a way as to insure collection of the total emission current. With this structure, any decrease in plate current could not be attributed to changes in collection efficiency and could therefore be interpreted as a true variation in emission current.

J. Greenburg

C. EXPERIMENTAL TECHNIQUES

1. Electrometer for Currents down to 10^{-12} ampere

The frequency response of the Shelton electrometer has been extended by mechanical redesign of the input circuit to approximately 300 cps on the 10^{-10}-amp scale. The feedback part of the amplifier has also been improved to eliminate an "overshoot" and oscillation found in one of the earlier designs.

J. D. Stettler

2. Use of an Internal Disappearing-Filament Pyrometer in Temperature Measurements

Since the readings of a conventional pyrometer are dependent on the transparency of the tube walls, and since this transparency may be drastically reduced by evaporation of metal or oxides, an optical means of temperature determination which is independent of the transmission of the glass would be useful. In this investigation, an additional filament was mounted within the envelope, placed so that it could be viewed superimposed on the emitting filament and therefore used as an internal disappearing-filament pyrometer.

The pyrometer filament was a straight tantalum wire, 4.5 cm long and 0.250 mm in diameter. For such a filament, the temperature can be computed fairly accurately in terms of the heating current (1). The emitter was a flat ribbon of molybdenum. In taking a reading, the two filaments were viewed simultaneously through a monochromatic filter, and the pyrometer filament current was varied until the two were of equal brightness. The current was then recorded, and the true temperature calculated from the tables in reference 1. The brightness temperature of the pyrometer filament (and hence of the emitting filament) can then be computed. A final calculation yields the true temperature of the emitter. The equation for conversion from true to brightness temperature for the pyrometer filament, and from brightness to true temperature for the emitter, is (2)

$$\frac{1}{T_o} - \frac{1}{T_B} = \frac{\lambda \, \log_e e_{\lambda T}}{C_2}$$

where λ is the filter wavelength, $e_{\lambda T}$ the spectral emissivity at that wavelength and temperature, and $C_2 = 1.438$ cm-°K. In practice these conversions were performed very simply by graphical means.

The results thus obtained were compared with the readings of a Leeds and Northrup optical pyrometer, corrected for the transmission of the glass. At temperatures above 1800° K, the internal pyrometer read somewhat lower than the external, the average deviation being 9° K. At lower temperatures, the internal readings became progressively higher. This is probably due to the effect of end cooling of the pyrometer filament, which produces an erroneously high value of temperature. The useful range of the method could be extended by making a correction for this end cooling; this requires measurement of the filament voltage drop (3).

The deviation in the upper range may well be due to uncertainty in the spectral emissivity of molybdenum, which according to the source used may cause deviations of 10 to 15° (2). In cases where spectral emissivity is more accurately known, I feel that this method, with a few further refinements, could be used to good advantage.

J. Greenburg

References

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