Physical Electronics

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Preface

THIS book is an attempt to provide a concise and coherent introduction to the physical principles governing the operation of electronic devices. It is written for electrical engineers and for physicists who are interested in the way the principles of their subject are applied; pressure on the syllabus not uncommonly pushes this aspect beyond the reach of formal instruction.

Assuming some slight familiarity with the electrostatics of point charges, and with the basic principles of the electromagnetic field laid down by Maxwell, the aim is to explore the region of tension between these very different ideas—a constructive tension, as will appear. Basically, it is a matter of discussing the way in which the physicist tackles the problems arising when the electrostatic point charge finds embodiment in the electron, and their practical consequences. The space devoted to a topic reflects not so much its intrinsic importance, as the unfamiliarity of the basic ideas from which it arises.

My experience in introducing electrical engineering students to the subject indicated the need for a new kind of book. There are many excellent texts on physical electronics, but they are without exception too detailed to be completely suitable. Approaching a subject for the first time, the reader normally lacks the essential knack of seeing the wood without being distracted by the trees, and a certain amount of thinning and pruning is most desirable.

This need to be brief brings us against two limitations. The first, relatively trivial, is that many topics of potential interest have to be excluded. Since in any case comprehensiveness is impossible I have attempted instead to choose those examples which best illustrate the general development of the theme, realizing that in no event shall I please everybody.

The second limitation is more serious. The treatment is largely qualitative and it will no doubt be possible to read the book and yet be defeated by a relatively simple problem, without having acquired that feel for the numerical magnitudes of the quantities concerned which is rightly regarded as an essential part of the scientist's intellectual equipment. It is certainly not my intention to undervalue these things, but rather to suggest that they can only come later, and that algebraic and arithmetic dexterity not

built on a sound knowledge of the structure of the subject is not only bad but dangerous. It is this foundation which is my chief concern here.

Finally, the reader should try the problems. For the most part elementary, they may go some way towards mitigating the limitations of the text which we have just mentioned. To see what kind of *specific* questions can be asked, and to discover the difficulties involved in trying to answer them, is a good introduction to more advanced studies.

Thus while I hope many will find this book necessary, I trust that none may find it sufficient. It is merely an introduction to the books mentioned in the bibliography and the references at the ends of chapters, though I hope that it may continue to serve the reader in his more advanced studies as a kind of guide book relating his work to other aspects of a wide and expanding field.

G.F.A.

Contents

Fundamental Constants

1 eV	$= 1{\cdot}6021 \times 10^{-19}$ joule
electron mass m	$= 9{\cdot}1083 \times 10^{-31}$ kg
Planck's constant h	$= 6{\cdot}6252 \times 10^{-34}$ joule sec
rest mass of proton	$= 1{\cdot}6724 \times 10^{-27}$ kg
rest mass of neutron	$= 1{\cdot}6747 \times 10^{-27}$ kg
velocity of light c	$= 2{\cdot}9979 \times 10^{8}$ m/sec
number of molecules per cubic metre of ideal gas at s.t.p. (Loschmidt's number) N	$= 2{\cdot}6872 \times 10^{25}$ m^{-3} atm^{-1}
Boltzmann's constant k	$= 1{\cdot}3804 \times 10^{-23}$ joule/°K $= 8{\cdot}617 \times 10^{-5}$ eV/°K
electronic charge e	$= 1{\cdot}6021 \times 10^{-19}$ coulomb
(e/m) for electron	$= 1{\cdot}7589 \times 10^{11}$ coul/kg
ε_0	$= 8{\cdot}8542 \times 10^{-12}$ farad/metre
number of molecules in a gram-molecule (Avogadro's number) N	$= 6{\cdot}0249 \times 10^{23}$
Bohr magneton β	$= 1{\cdot}1653 \times 10^{-29}$ weber/metre
μ_0	$= 4\pi \times 10^{-7}$ henry/metre