IN THE
Guild Hall,
HUDDERSFIELD,

The 27th, 28th, 29th, and 30th of January, 1846.

ON THE EVENINGS OF
TUESDAY, WEDNESDAY, THURSDAY,
AND FRIDAY,

PHILOSOPHICAL LECTURES,

Mr. W. Richardson

Respectfully announces to the INHABITANTS of HUDDERSFIELD and its Vicinity, that he will

DELIVER A COURSE OF FOUR

POPULAR LECTURES,

On Electricity, Galvanism, Electro-Magnetism, & Pneumatics.

The above departments of Modern Science will be illustrated by his splendid Apparatus, with which he will perform a variety of Electric, Galvanic, Electro-Magnetic, and Pneumatic Experiments. Mr. R. will exhibit Two working Electro-Magnetic Engines, and his powerful *Coil Shock Machine*, producing 500 Shocks per second, and giving the appearance of
LIFE TO A DEAD BODY!

At the request of a few Friends,

NITROUS OXIDE, OR

To commence at 8 o'clock.

EFFECTS OF NITROUS OXIDE OR LAUGHING GAS.

LAUGHING GAS ! !

To commence at 8 o'clock.

Mr. Richardson will introduce the

Terms of Admission :---To Front Seats, 1s. : Back Seats, 6d. Children admitted at half-price. Tickets to be had of Mr. ROEBUCK, Stationer, King-street ; and at the Guild Hall.

Doors open at half-past Seven o Clock, and the Lectures to commence at Eight.

H. ROEBUCK, PRINTER AND STATIONER, KING-STREET, HUDDERSFIELD.

Electrical and Electronic Systems and Practice I

Macmillan Technician Series

Peter Astley, *Engineering, Drawing and Design II*

P. J. Avar and J. Cross, *Workshop Processes and Materials I*

G. D. Bishop, *Electrical and Electronic Systems and Practice I*

G. D. Bishop, *Electronics II*

G. D. Bishop, *Electronics III*

J. C. Cluley, *Electrical Drawing I*

John Elliott, *Building Science and Materials*

John G. Ellis and Norman J. Riches, *Safety and Laboratory Practice*

D. E. Hewitt, *Engineering Science II*

P. R. Lancaster and D. Mitchell, *Mechanical Science III*

Rhys Lewis, *Physical Science I*

Noel M. Morris, *Digital Techniques*

Noel M. Morris, *Electrical Principles II*

Noel M. Morris, *Electrical Principles III*

Owen Perry and Joyce Perry, *Mathematics I*

A. Simpson, *Light Current Electrical Applications III*

Electrical and Electronic Systems and Practice I

G. D. Bishop

Vice Principal, Bridgwater College

M

© G. D. Bishop 1981

All rights reserved. No part of this publication may be reproduced or transmitted, in any form or by any means, without permission

First published 1981 by

THE MACMILLAN PRESS LTD

London and Basingstoke

Associated companies in Delhi Dublin

Hong Kong Johannesburg Lagos Melbourne

New York Singapore and Tokyo

ISBN 978-0-333-30454-9 ISBN 978-1-349-05736-8 (eBook)

DOI 10.1007/978-1-349-05736-8

Typeset by Oxprint Ltd, Oxford

This book is sold subject to the standard conditions of the Net Book Agreement.

The paperback edition of this book is sold subject to the condition that it shall not, but way of trade or otherwise, be lent, resold, hired out, or otherwise circulated without the publisher's prior consent in any form of binding or cover other than that in which it is published and without a similar condition including this condition being imposed on the subsequent purchaser.

Contents

<i>Foreword</i>	xi	
<i>Preface</i>	xiii	
		<i>Items described</i>
1 The Electrical and Electronic Industries	1	
1.1 A Short History of the Industries	1	Early inventors; a.c. d.c. supply
1.1.1 Electronic developments	2	Radio, TV, computers
Table 1.1 A history of electrical and electronic developments	4	
1.1.2 Changes in manufacturing methods	6	Production methods
1.2 A Survey of Present-day Electrical/Electronic Manufacture	7	The structure of industry; the place of the technician
1.2.1 Industry categories	8	Electrical and electronic
1.2.2 The job of the technician	8	
1.2.3 One typical industry	9	A firm
1.3 An Outline of General Industrial Manufacture	10	Product manufacture; the selling price
Exercises	11	
2 System Types	12	
2.1 Definition of a System and its Components, the Blood Circulation System, the Telephone System, the Electricity Distribution system	12	Inputs, outputs, boundaries; the systems approach; block diagrams
Table 2.1 System types, components, links, aims and examples	13	
2.2 The Nature of Signals	16	d.c., fluctuating d.c.; a.c., pulses, frequency;
2.3 (Table 2.2) Information systems	19	Simple a.c. generator, sinewave;
2.4 (Table 2.3) Power utilisation systems	19	Electromagnetic frequency spectrum;
2.5 (Table 2.4) Control systems	19	Feedback loop, a.g. c
2.6 (Table 2.5) Amplifier systems	20	Radiation from aerials
2.7 Modulation and Transmission	23	Radio telegraphy, modulation, carrier signal, sky waves
2.8 Oscillators	25	Positive feedback, distortion
Exercises	26	
3 System Inputs and Outputs	28	
3.1 Transducers	28	Thermocouples, thermistors, position transducers, solar cell, photo-diode, light-dependent resistor, strain gauge, piezoelectric crystal, microphone, loudspeaker, gas sensor, radar, ultrasonic detectors

3.2 Signal Processing	31	Amplification and attenuation, amplifiers (summing, d.c., log) modulation, varicap diode, AM, FM filters and tuning, bandwidth coding and decoding, synchronising radio detection, superhets, colour TV
3.3 Power Supplies	36	Current, voltage supply rectifiers (half-wave full-wave, smoothing) step-down transformer, bridge rectifier regulation, regulated supply
3.4 Output Devices	38	Electromagnetic devices, solenoid relay, bell, door chime, trip, motor, moving-coil meter
3.5 Cables and Connectors	40	Single conductors, stranded conductors, ratings, power cables, screened cables, multicore cable, Plugs/sockets, soldering, connectors, junction box, conduit, coaxial cables
Table 3.1 Properties of solid wire	42	
Table 3.2 Properties of stranded power cable	42	
Exercises	45	
4 Electrical and Electronic Components	46	
4.1 Electronic Components, Resistors	46	Resistors (wirewound, carbon, power) ratings, series/parallel connection variable resistor, resistivity
4.1.1 Capacitors	49	Basic calculation, permittivity, electrolytic and other types, reactance series/parallel capacitors
4.1.2 Inductors	51	Reactance of inductors, chokes, transformers, efficiency, turns ratio series/parallel inductors
4.1.3 Other components	52	Fuses, crystals
4.2 Semiconductor Components	53	n-type, p-type, diode, transistors, thyristor, triac, l.e.d., liquid crystal, integrated circuits; The systems approach
4.3 Logic Gates	56	Binary arithmetic, basic gates NOT AND OR NAND NOR, flip-flop
4.4 Batteries	58	Dry cells, wet cells, Leclanché cell, layer battery, mercury cell, alkaline cell, nickel-cadmium cell, lead-acid accumulator, internal resistance, discharge rates
4.5 Circuit Symbols	61	BS 3939 for electrical and electronic symbols
4.6 Electrical Power Components	64	Larger currents, voltages, power, power factor, protection
4.6.1 Conductors and switching	64	Distribution boards, bus-bars, screw connectors, joining methods, isolators, arcing suppression
4.6.2 Protection and control	67	Circuit-breakers, trips, ring mains, metering, the unit and payment

4.6.3 Other electrical components	70	Fluorescent lamps, starters, thermostat, simmerstat, ovenstat, three-phase supplies, motor types (shaded-pole, electric clock, universal)
4.7 Component Reliability	76	Failure rates of common components, mean time to failure
Table 4.3 Component failure rates	77	
Table 4.4 Corrected component failure rates	77	
Exercises	78	
5 Measurements and Instruments	80	
5.1 The Types of Signal to be Measured	80	a.c. and d.c.; low-frequency and high-frequency; resistance
5.2 Measuring Instruments	82	Moving-coil, moving-iron, oscilloscope
5.2.1 Moving-coil and moving-iron instruments	82	Internal resistance, ohms/volt sensitivity
5.2.2 Ammeters, voltmeters and ohm-meters	83	Galvanometers, damping, conversions to voltage and higher current ranges and resistance, shunts, multipliers, multimeters, electronic meters
5.2.3 Multimeters	85	X-Y plotter
5.2.4 The resistance bridge	86	Scanning, timebase, Y amplifier, setting up and advantages, instrument earthing
5.2.5 The pen recorder	87	Using multimeters, safety precautions
5.2.6 The oscilloscope	87	Checking diodes
5.3 Taking Measurements	88	Checking transistors with an ohm-meter
5.3.1 Diodes	90	
5.3.2 Transistors	90	
5.3.3 Capacitors	90	
5.3.4 Inductors and transformers	91	
5.4 Measuring Frequency Responses and Gains	91	Use of the oscilloscope, gain calculation, reading frequency and periods, plotting
5.5 Instrument Limitations	91	Frequency responses, estimation of bandwidth, decibel measurements
5.6 Practical Exercises	92	(1) Regulation
		(2) C-R differentiation circuit
		(3) C-R integration circuit
		(4) Operational amplifier circuits
		(5) Operational amplifier circuits to perform (2) and (3) and other functions
Exercises	94	
Answers to Exercises	95	

Foreword

This book is written for one of the many technician courses now being run at technical colleges in accordance with the requirements of the **Technician Education Council** (TEC). This Council was established in March 1973 as a result of the recommendation of the Government's Haslegrave Committee on Technical Courses and Examinations, which reported in 1969. TEC's functions were to rationalise existing technician courses, including the City and Guilds of London Institute (C.G.L.I.) Technician courses and the Ordinary and Higher National Certificate courses (O.N.C. and H.N.C.), and provide a system of technical education which satisfied the requirements of 'industry' and 'students' but which could be operated economically and efficiently.

Four qualifications are awarded by TEC, namely the Certificate, Higher Certificate, Diploma and Higher Diploma. The **Certificate** award is comparable with the O.N.C. or with the third year of the C.G.L.I. Technician course, whereas the **Higher Certificate** is comparable with the H.N.C. or the C.G.L.I. Part III Certificate. The **Diploma** is comparable with the O.N.D. in Engineering or Technology, the **Higher Diploma** with the H.N.D. Students study on a part-time or block-release basis for the Certificate and Higher Certificate, whereas the Diploma courses are intended for full-time study. Evening study is possible but not recommended by TEC. The Certificate course consists of fifteen **Units** and is intended to be studied over a period of three years by students, mainly straight from school, who have three or more C.S.E. Grade III passes or equivalent in appropriate subjects such as mathematics, English and science. The Higher Certificate course consists of a further ten Units, for two years of part-time study, the total time allocation being 900 hours of study for the Certificate and 600 hours for the Higher Certificate. The Diploma requires about 2000 hours of study over two years, the Higher Diploma a further 1500 hours of study for a further two years.

Each student is entered on to a **Programme** of study on entry to the course; this programme leads to the award of a Technician Certificate, the title of which reflects the area of engineering or science chosen by the student, such as the Telecommunications Certificate or the Mechanical Engineering Certificate. TEC have created three main **Sectors** of responsibility:

Sector A responsible for General, Electrical and Mechanical Engineering

Sector B responsible for Building, Mining and Construction Engineering

Sector C responsible for the Sciences, Agriculture, Catering, Graphics and Textiles.

Each Sector is divided into Programme committees, which are responsible for the specialist subjects or programmes, such as A1 for General Engineering, A2 for Electronics and Telecommunications Engineering, A3 for Electrical Engineering, etc. Colleges have considerable control over the content of their intended programmes, since they can choose the Units for their programmes to suit the requirements of local industry, college resources or student needs. These Units can be written entirely by the college, thereafter called a college-devised Unit, or can be supplied as a Standard Unit by one of the Programme committees of TEC. **Assessment** of every Unit is carried out by the college and a pass in one Unit depends on the attainment gained by the student in his coursework, laboratory work and an end-of-Unit test. TEC moderate college assessment plans and their validation; external assessment by TEC will be introduced at a later stage.

The three-year Certificate course consists of fifteen Units at three **Levels**: I, II and III, with five Units normally studied per year. A typical programme might be as follows.

Year I	Mathematics I	Standard Unit	} six Level I Units
	Science I	Standard Unit	
	Workshop		
	Processes I	Standard Unit	
	Drawing I	Standard Unit	
	General and Communications I	College Unit	
Year II	Engineering Systems I	College Unit	}
	Mathematics II	Standard Unit	
	Science II	Standard Unit	
	Technology II	Standard Unit	

Year III	General and Communications II	College Unit	} six Level II Units
	Industrial Studies II	College Unit	
	Engineering Systems II	College Unit	
	Mathematics III	Standard Unit	} three Level III Units
	Science III	Standard Unit	
	Technology III	College Unit	

Entry to each Level I or Level II Unit will carry a prerequisite qualification such as C.S.E. Grade III for Level I or O-level for Level II: certain Craft qualifications will allow students to enter Level II direct, one or two Level I Units being studied as 'trailing' Units in the first year. The study of five Units in one college year results in the allocation of about two hours per week per Unit, and since more subjects are often to be studied than for the comparable City and Guilds course, the treatment of many subjects is more general, with greater emphasis on an **understanding** of subject topics rather than their application. Every syllabus to every Unit is far more detailed than the comparable O.N.C. or C.G.L.I. syllabus, presentation in **Learning Objective** form being requested by TEC. For this reason a syllabus, such as that followed by this book, might at first seem very long, but analysis of the syllabus will show that 'in-depth' treatment is not necessary—objectives such as '**states** Ohm's law' or '**lists** the different types of telephone receiver' clearly do **not** require an understanding of the derivation of the Ohm's law equation or the operation of several telephone receivers.

This book satisfies the learning objectives for one of the many TEC Standard Units, as adopted by many technical colleges for inclusion into their Technician programmes. The treatment of each topic is carried to the depth suggested by TEC, and in a similar way the **length** of the Unit (sixty hours of study for a full Unit), **prerequisite qualifications**, **credits for alternative qualifications** and **aims of the Unit** have been taken into account by the author.

Preface

This book is written for all students following Technician Education Council (TEC) programmes in Electronics Engineering (A2), Electrical Engineering (A3) and Radio and Television Engineering (A2) at certificate and diploma level. It covers the syllabus content of the level I systems content of each programme, written in 'suggested guidelines' form and entitled Electronic systems and practice I or Electrical and electronic systems I.

The content of these units is listed as follows

Electronic systems and practice I
the electronics industry
electronic systems and signals
transducers, sources, amplifiers
circuits and components
interconnections, power supplies
Electrical and Electronic systems I
power utilisation systems
information systems
control systems
a.c./d.c. generators
a.c. apparatus and switching
instrumentation

There are no stated prerequisite qualifications for entry to these units and the standard of mathematics is low. It is assumed, however, that other level I units are being studied in conjunction with the content of this book, namely Mathematics and Physical Science I. After completing this book, the reader will be able to proceed to level II units in Electronics, Electrical Principles and Applications of Radio and Television subjects.

A broad approach to systems technology is given throughout the book and many non-technical systems are mentioned or described. The **systems approach** can be adapted to any system: modern electrical and electronic equipment is often of a modular construction which lends itself to system-type servicing and maintenance. The book starts with a short history of the industry and the gradual development of electrical component technology. The role of the technician in present-day industry is discussed and the structure of typical small and large industries. Chapter 2 describes several systems, their input and output

signals and their links and aims. Any system has at its input and output a transducer or generator, or other device, interconnected by cables appropriate to the signals being transmitted. Chapter 3 describes these devices and the signal processing that takes place in electrical circuits. The black box is then opened up in chapter 4, which describes all the various system components, including batteries and electrical power components; there is also a section on component reliability. Finally, chapter 5 discusses measuring instruments and the ways of using them.

Exercises are given at the end of each chapter, with full answers at the end of the book. Since this unit is mainly descriptive, the majority of the questions are of the short-answer type; the reader is encouraged to work through every question and check the answer when completed. A total of 96 questions is included, together with several practical exercises in chapter 5, where the reader is expected to apply some systems technology to some simple measurements exercises.

G. D. Bishop