Microelectronics and the Engineering Industry

The Need for Skills

edited by N. Swords-Isherwood and P. Senker

Science Policy Research Unit,
Sussex University

Frances Pinter (Publishers) Ltd., London
Nichols Publishing Company, New York

First published in Great Britain in 1980 by
Frances Pinter (Publishers) Limited
5 Dryden Street, London WC2E 9NW

British Library Cataloguing in Publication Data

Microelectronics and the engineering industry.
1. Occupational training – Great Britain
2. Microelectronics
3. Engineering – Great Britain
I. Senker, Peter II. Swords-Isherwood, N
658.31'24 HD5715.5.G7

ISBN 0–903804–76–X

Published in the USA in 1980 by
Nichols Publishing Co. P.O. Box 96 N.Y. N.Y.

Library of Congress Catalog Card Number 80-82111
ISBN 0-89397-094-8

Typeset by Anne Joshua Associates, Oxford
Printed in Great Britain by A. Wheaton and Co. Ltd., Exeter

Microelectronics and the Engineering Industry

Acknowledgements

We are grateful to the Engineering Industry Training Board for sponsoring the research on which this book is based. The book draws heavily on research by several of our colleagues at the Science Policy Research Unit, particularly Roy Rothwell, Ed Sciberras, Mick McLean and Howie Rush. Martin Bell made substantial contributions to the two chapters on welding. Charlotte Huggett, in addition to writing those two chapters made a far more substantial contribution to the book than it was reasonable to ask of any research assistant.

This book would not have been possible without the co-operation of the many people in the industries we studied who gave up so much of their time willingly to contribute data.

Contents

1 Introduction

The structure of the book derives from the development of work at the Science Policy Research Unit for the Engineering Industry Training Board for more than a decade. In 1972, Bell published a pioneering work in which he attempted to assess which new technologies were likely to have a significant effect on the skill and manpower requirements of the engineering industry (Bell, 1972). Bell's work provided a foundation on which we have built the work on engineering processes reported in Chapters 2 (Assembly), 3 (Automated Batch Machining) and 4 (Welding).

Developing this line of research led us to the conviction that, in order to understand industries' skill needs, we must study the characteristics of successful firms compared with relatively unsuccessful firms; identify the critical skills necessary for success; and find out the extent to which these skills are absent in unsuccessful firms (Senker *et al.*, 1976, p.52).

Although the focus of the book is on the United Kingdom, much of the material is of general relevance. Part I contains assessments of the impact of technical change on three important production processes – assembly, automated batch machining and welding. These processes are of crucial importance to the engineering industry worldwide. Chapter 2 considers developments in assembly automation briefly, and points to the differences between the United Kingdom and other countries in the way in which such developments move between the laboratory and the factory. Chapter 3 contains some results of studies of machine shops carried out by ourselves in West Germany as well as in the United Kingdom. These are compared with the results of a somewhat similar study in the United States, carried out by R.T. Lund *et al.* at The Massachusetts Institute of Technology. Chapter 4 examines the importance of welding in the engineering industry and assesses the areas where the application of new types of welding system are likely to be most significant.

Part IIA deals with sectors of the mechanical engineering industry. Chapter 5 examines the position of the British motor industry, but also attempts to assess which of the many possible microelectronic developments are likely to be the most significant in the next few years. With American automobiles now becoming smaller as a result of pressures to reduce fuel consumption, we are moving to the era of 'the world car', in which microelectronics will be significant.

American and Japanese multinational companies are of increasing importance in the British forklift truck industry; trends in technical development in those countries are considered in Chapter 6. European manufacturers are very important in agricultural machinery and textile machinery, discussed in Chapters 7 and 8. American manufacturers are particularly important as suppliers of computers to textile industries. West Germany has long dominated the machine tool industry, discussed in Chapter 9, but Japan seems to be moving fast in the development and installation of very advanced systems. The production and marketing of welding systems is international (Chapter 10). Systems suppliers based in one country often have links with equipment suppliers based in other countries.

Part IIB discusses the skill requirement of electronics and related industries. The convergence of the various sectors of the electronics industries – components, computing, communications, home and office electronics, etc – into 'information technology' is leading also to convergence in skill requirements.

Part III discusses the production of office automation equipment and the likely pattern of office automation over the next few years, focusing on word processing. The 'paperless office' appears to be a long-term, not a short-term, prospect, and there is no evidence at this stage to suggest different patterns of office automation in engineering and other industries.

We emphasize throughout the need to see microelectronics and its skill implications in a broad context. Many chapters build on previous work on the manufacturing processes and industrial sectors considered. In particular, Chapter 3 draws on previous work for the Engineering Industry Training Board and the Automated Small-batch Production (ASP) Committee set up by the Department of Industry at the National Engineering Laboratory. Chapters 6 (Forklift Trucks) and 13 (Minicomputers) also draw on studies sponsored by the Engineering Industry Training Board; as does Chapter 12 (Televisions) which is also based on work by Ed Sciberras for the OECD. Chapters 7 and 8 (Agricultural Equipment and Textile Machinery) are based largely on detailed studies by Roy Rothwell.

The research for Chapter 5 (The Motor Industry), Chapter 9 (The Machine Tool Industry), Chapter 11 (Telephone Equipment), for the two Chapters on Welding (4 and 10) and for Part III on Offices draws on a large number of sources.

The skill implications Chapters (14, 16 and 17) represent an attempt to synthesize the information contained in the rest of the book. But, here again, some specific research, including a number of interviews, was undertaken in order to enable us to draw conclusions. Throughout the book, we draw on a variety of sources, to which reference is made at the end of each chapter.

In view of the inevitable constraints on time and money, many important sectors and production processes are omitted altogether, or covered sketchily. Neither design nor computer-aided design are covered, and nor are the specialized requirements of the semiconductor industry itself. The monitoring of mass production machining, the aircraft and shipbuilding industries are all excluded. We hope to have the opportunity of remedying the more important of these omissions in future research.

Microelectronics components are already widely used in industry and are likely to be used increasingly in the future in ever widening areas of applications. The actual and potential uses of microelectronics cannot all be identified specifically and studied in isolation as can large scale applications of advanced technology such as nuclear power stations or jet aircraft. In some areas – computers for some years, telephone exchanges and office equipment now – the equipments made consist largely of microelectronic components and these components extensively determine the performance characteristics of the products made. In other areas, motor vehicles for example,

TABLE 1.1 Employment in the engineering industry 1973 and 1979

			May 1973 ('000)		*April 1979 ('000)*	
Order VII	–	*Mechanical Engineering*	894.2		909.1	
of which	:	Agricultural Machinery		24.4		28.2
		Metal-working Machine Tools		62.4		64.1
		Textile Machinery and Accessories		32.9		22.7
		Mechanical Handling Equipment		61.5		59.8
Order VIII	–	*Instrument Engineering*	151.3		148.0	
Order IX	–	*Electrical Engineering*	746.7		735.8	
of which	:	Telegraph and Telephone Apparatus and Equipment		82.2		64.9
		Broadcast Receiving and Sound Reproducing Equipment		57.2		45.8
		Electronic Computers		45.6		47.1
from Order VII		Office Machinery		23.4		22.8
Order XI	–	*Vehicles*	782.6		759.6	
of which	:	Motor Vehicle Manufacturing		504.6		470.1
		Aerospace Equipment		195.7		198.6
Order XII	–	*Metal Goods Not Elsewhere Specified*	514.4		526.2	
			3089.2		3078.7	

Source: Department of Employment Gazette.

a principal activity will always involve mechanical construction, and microelectronics will be somewhat peripheral – but may make significant contributions, for example in terms of safety and fuel economy. Similarly, microelectronic components are being used to enhance the performance of machine tools, mechanical handling and other production equipment. This has further significance: the equipment produced by one industry can transform the production processes of the industries in which the equipment is used. So microelectronic components can affect production processes as profoundly as they can affect products.

There have already been important and useful attempts to assess the long-term effects on society of microelectronics (e.g. Barron and Curnow, 1979). There has also been valuable work on the implications of microelectronics for employment (e.g. Rothwell and Zegveld, 1979).

This book has different, but nevertheless practical and important aims. Advanced industrial economies have to adapt themselves to live with microelectronics. Microelectronic components are cheap and powerful, but they cannot just be 'slotted in' to products and production processes. The most important element necessary for an economy to make effective use of microelectronic components in order to sustain or improve the competitiveness of its industries is the education and training of its workforce at all levels.

The implications of microelectronics appear to be very different for the products and systems produced by the industries considered in Part IIA and Part IIB. The products and systems produced in the industry sectors considered in Part IIA – the motor industry and sectors of the mechanical engineering industry – will need to incorporate microelectronics in control systems to improve product and system performance. But the products produced in such sectors will still be based substantially on other technologies – largely mechanical. Part IIB considers industry sectors in which the role of electronics is central to the functioning of the products and systems produced. Table 1.1 attempts to analyse employment in the British engineering industry in accordance with this distinction.

The skill requirements of engineering industries are of vital importance in the economies of all industrialized countries. Table 1.2 shows that employment in the engineering industries

TABLE 1.2 Wage earners and salaried employees in manufacturing, 1977

	Total manufacturing ('000)	*Manufacture of fabricated metal products, machinery and equipment ('000)*	%
United States	19,647	8,257	42.0
Japan	7,195	3,207	44.6
France	5,419	2,297	42.4
West Germany	8,268	3,899	47.2
United Kingdom	7,352	3,300	44.9

Source: OECD, *Labour Force Statistics, 1966–1977*, Paris, 1979.

TABLE 1.3 Employees in employment in industry (West Germany, France, United Kingdom, 1978

	W. Germany		*France*		*United Kingdom*	
	'000	*%*	*'000*	*%*	*'000*	*%*
1. Mechanical Engineering	990.0	24.8	368.3	15.6	835.1	24.9
2. Instrument Engineering	203.3	5.1	78.8	3.3	150.0	4.5
3. Electrical Engineering	1019.3	25.6	494.0	21.0	704.1	21.0
4. Manufacture of office machinery and data processing machinery	75.2	1.9	44.5	1.9	68.1	2.0
5. Manufacture of motor vehicles	646.9	16.2	487.0	20.7	486.7	14.5
6. Manufacture of other means of transport	151.8	3.8	250.9	10.6	440.4	13.1
7. Manufacture of metal articles (except mechanical, electrical, and instrument engineering and vehicles)	899.0	22.6	633.4	26.9	671.5	20.0
Total	3985.5	100.0	2356.9	100.0	3355.9	100.0

Source: Eurostat, *Employment and Unemployment, 1972–1978*, 1979.

in the United States, Japan, France, West Germany and the United Kingdom represent similar proportions of total manufacturing employment in each country. Tables 1.3 and 1.4 represent attempts to use the available statistics to compare employment in the industries considered in Parts IIA and IIB in terms of their relative importance in West Germany, France, the United Kingdom and the United States.

TABLE 1.4 Employees by industry, United States,* 1978

	Employees '000		*%*	
1. Machinery, except electrical	2337.3		27.3	
of which:				
Office and computing machines		351.8		4.1
2. Instruments and related products	654.1		7.6	
3. Electric and electronic equipment	1966.5		23.0	
4. Transportation equipment	1956.1		22.8	
5. Fabricated metal products	1652.6		19.3	
Total	8566.6		100.0	

Source: 'Employment and Earnings', US Government Printing Office, March 1979.

*It was impossible to obtain figures for the United States on exactly the same basis as those presented for West Germany, France and the United Kingdom in Table 1.3 above.

REFERENCES

Iann Barron and Ray Curnow, *The Future with Microelectronics*, London, Frances Pinter, 1979.

R.M. Bell, *Changing Technology and Manpower Requirements in the Engineering Industry*, Engineering Industry Training Board Research Report No. 3, Sussex University Press in association with EITB, 1972.

R. Rothwell and W. Zegveld, *Technical Change and Employment*, London, Frances Pinter, 1979.

P. Senker, C. Huggett, M. Bell and E. Sciberras, *Technological Change, Structural Change and Manpower in the UK Toolmaking Industry*, EITB Research Paper No. 2, 1976.

PART I PRODUCTION PROCESSES

This part consists of three chapters on important aspects of some of the main groups of production processes in the engineering industry: assembly, machining and welding. Each chapter includes a brief assessment of the significance of the group of production processes included in the chapter; an account of some of the principal foreseeable technical changes, many of which will incorporate and rely on microelectronic components extensively; and analysis of some of the principal general trends in employment and skill requirements which are likely to result.

As newer electronic components have been developed, and as their costs have fallen continually and dramatically, the range of production process control applications in which they can be applied economically has widened steadily. Our studies of developments in assembly and welding confirm that, despite the rapid increases in the power of microelectronic components, changes in production processes are likely to continue to be gradual in the next few years. For example, there is very intense activity in several countries devoted to development of programmable assembly. It is most likely that this development activity will result eventually in widely used production systems. But long before this happens, the extensive redesign of *products* to incorporate microelectronic components will have more significant effects on manpower and skill requirements.

In 1972, Bell concluded an extenstive survey of the likely implications of production process change in the engineering industry (Bell, 1972). The only area where he considered that production process change would have a dramatic effect on manpower and skill requirements was in relation to numerically controlled machine tools. But subsequent research, reported in Chapter 3, has indicated that, even in relation to numerically controlled (NC) machine tools, effects on skill requirements are likely to continue to be slow.

Chapter 4 reviews developments in welding processes. The significance of this chapter is broader than is immediately apparent as it indicates the implications of technical change for skill requirements in one of the first areas to be affected significantly by robotics.

REFERENCE

R.M. Bell, *Changing Technology and Manpower Requirements in the Engineering Industry*, Engineering Industry Training Board Research Report No. 3, Sussex University Press in association with EITB, 1972.

2. Assembly

P. Senker

THE SIGNIFICANCE OF ASSEMBLY PROCESSES

Assembly is still mainly a manual process. Any attempt to measure its importance in terms of the number of machines in use is liable to underestimate its significance substantially. A better indication is employment. In 1977, about 10 per cent of workers in the engineering industry were semi-skilled assemblers. To this must be added skilled workers engaged on assembly operations – in particular fitters – not separately identified in published statistics. The economic viability of different types of assembly method depends to a considerable extent on the annual volume of units to be assembled. (see Figure 2.1).

Fig. 2.1 The economic viability of assembly methods

	1–300,000	*Annual output range* *300,000–3 million*	*1 million and above*
Prevailing assembly method	Manual	Manual	Manual
New alternatives	Negligible	Programmable assembly (being developed: US and Japan)	Fixed Programme assembly (already used to some extent) Automatic insertion of electronic components (Japanese use predominantly)