PREM 19/241

M.T.

PART I

PART ~~II~~

Confidential Filing

Responsibility and handling of science matters.
The Future of ACARD. The Question of the Publication of their two latest Reports (on Computer Aided Design and Manufacture; and Technological Change.)

GOVERNMENT MACHINERY

Part I
MAY 1979

Referred to	Date	Referred to	Date	Referred to	Date	Referred to	Date
21.5.79							
~~10.8.79~~							
~~13.8.79~~							
~~2.8.79~~							
~~13.8.79~~							
24.10.79							
~~21.11.79~~							
~~23.11.79~~							
~~30.11.79~~							
~~11.12.79~~							
~~4.1.80~~							
~~25.1.80~~							
28.1.80							
~~31-1-80~~							
~~1.2.80~~							
~~4.2.80~~							
~~8.2.80~~							
~~13.2.80~~							
~~14.2.80~~							
~~25.2.80.~~							
~~27.2.80~~							
28.2.80							
~~Aug 80~~							

PREM 19/241

PART 1 ends:-

Hansard 28.2.80

PART 2 begins:-

Acard Report Aug 80
(Info Tech)

Published Papers

The following published paper(s) enclosed on this file have been removed and destroyed. Copies may be found elsewhere in The National Archives.

1. Technological Change: Threats and Opportunities for the UK
   Published by HMSO on behalf of Advisory Council for Applied Research and Development, Dec 1979 (ISBN: 0 1 630812 5)
2. Computer Aided Design and Manufacture
   Published by HMSO on behalf of Advisory Council for Applied Research and Development, January 1980 (ISBN:011 630814 7)

Signed CAWayland Date 19 April 2010

PREM Records Team

Govt Machinery

in my office, the Civil Service Department and the Central Statistical Office on these dates were as follows :

	Number	Cost £
Prime Minister's Office		
1 January 1976	7	59,000
1 January 1977	7	58,000
1 January 1978	7	62,000
1 January 1979	7	67,000
1 January 1980	5	65,000
Civil Service Department		
1 January 1976	14	90,000
1 January 1977	14	96,000
1 January 1978	11	78,000
1 January 1979	9	69,000
1 January 1980	9	95,000
Central Statistical Office		
1 January 1976	2	17,000
1 January 1977	2	18,000
1 January 1978	3	25,000
1 January 1979	3	27,000
1 January 1980	3	37,000

In the Civil Service Department, the information officer group, in addition to press officers, includes information specialists engaged on publications, and recruitment advertising and publicity. Information staff in the Central Statistical Office are engaged on press liaison, paid publicity and publications.

RESEARCH AND DEVELOPMENT

Mr. Iain Mills asked the Prime Minister if she will list the membership of the Advisory Council for Applied Research and Development.

The Prime Minister: I have appointed six new members to ACARD and have invited Dr. Alfred Spinks to become chairman of the Council. The membership is now :

Dr. Alfred Spinks, CBE (Chairman) formerly Director of Research, ICI Ltd.
Sir Henry Chilver (Deputy Chairman) Vice-Chancellor, Cranfield Institute of Technology.
Sir John Atwell, CBE Chairman, Scottish Offshore Partnership
Sir Robert Clayton, CBE Technical Director, GEC Limited.
Mr. D. Downs, CBE Chairman and Managing Director, Ricardo Consulting Engineers Ltd.
*Dr. D. L. Georgala Head of Laboratory, Unilever Research
*Professor W. B. Heginbotham, OBE Director-General, Production Engineering Research Association.
*Dr. B.C. Lindley Director of Research, Dunlop Limited.
Mr. J. Lyons General Secretary, Engineers' and Managers' Association.

26 R 37

Sir Ieuan Maddock, CB formerly Chief Scientist, Department of Industry.
*Sir Alec Merrison Vice-Chancellor, University of Bristol, Chairman of the Advisory Board for the Research Councils.
*Mr. A. M. Muir Wood Senior Partner, Sir William Halcrow & Partners
Dr. L. Rotherham, CBE formerly Vice-Chancellor, University of Bath
*Mr. J. L. van der Post Chief Executive, Water Research Centre.
Mr. G. H. Wright, MBE Regional Secretary for Wales Transport and General Workers' Union

*new members

FOREIGN AND COMMONWEALTH AFFAIRS

Political and Publicity Organisations (NATO Grants)

Mr. Newens asked the Lord Privy Seal what funds, drawn from the contributions of member States, NATO has provided to political and publicity organisations in the United Kingdom over the last five years; which organisations received grants; and what were the sums paid in each case.

Mr. Hurd: I am informed that over the last five years NATO has allocated £48,190 to such organisations for educational and publicity purposes. This figure has been distributed as follows:

to the Labour and Trades Union Press Service:

1976	£6,000
1977	£6,600
1978	£6,050
1979	£6,535
1980	£7,150 (earmarked)

to British Atlantic Youth:

1976	nil
1977	£1,000
1978	£1,200
1979	£2,000
1980	£2,000 (earmarked)

to the European Atlantic Movement:

1976	nil
1977	£1,600
1978	£1,600
1979	£5,800
1980	nil

In addition, the British Atlantic Committee received £655 from NATO in 1979. This payment was a management fee for the organisation of an international conference held in this country and funded by the NATO Information Service.

Information Officers

Mr. Freud asked the Lord Privy Seal if he will publish in the *Official Report*

R28

Govt Mach

cc Cabinet Office
pa
MAP 28/2

Delta Materials Research Limited

P.O. Box 22
Hadleigh Road
Ipswich
Suffolk IP2 0EG
Telephone: 0473 57494

Dr. A.J. Kennedy

DELTA

Your ref.
Our ref. AJK/JP
Date 27th February 1980

The Prime Minister,
10 Downing Street
LONDON

Dear Mrs Thatcher,

Thank you for your kind letter of 4th February about my service on the Advisory Council for Applied Research and Development. I did appreciate your writing to me in this way.

Yours sincerely,

A member of the Delta Group
Registered in England no. 251337
Registered Office
1 Kingsway, London WC2B 6XF

Ref: A01512

Govt Machinery

Top Copy in Questions

MR. PATTISON

Advisory Council for Applied Research and Development

Your minute of 1st February gave the Prime Minister's approval to the arrangements for new appointments to ACARD proposed in Sir Robert Armstrong's minute of 25th January. Sir Robert wrote to the nominees for the new posts and all have accepted. Furthermore Dr. Spinks has confirmed that he is willing to become Chairman of ACARD, and Sir Henry Chilver has agreed to become Deputy Chairman.

2. It would now be timely to make the changes in membership public. Sir Robert Armstrong considers this might best be done by means of an inspired Parliamentary Question to the Prime Minister, together with a Press Release. I atach drafts.

3. The Council next meets on 7th March. It would be desirable if the announcement of the revised ACARD membership could be made before then.

D. J. WRIGHT

(D. J. Wright)

25th February 1980

DRAFT PQ ON ACARD MEMBERSHIP

To ask the Prime Minister if she will list the membership of the Advisory Council for Applied Research and Development (ACARD).

I have appointed six new members to ACARD and have invited Dr A Spinks to become Chairman of the Council.

The membership is now:

Dr A Spinks CBE (Chairman)	formerly Director of Research, ICI Limited
Sir Henry Chilver (Deputy Chairman)	Vice-Chancellor, Cranfield Institute of Technology
Sir John Atwell CBE	Chairman, Scottish Offshore Partnership
Sir Robert Clayton CBE	Technical Director, GEC Limited
Mr D Downs CBE	Chairman and Managing Director, Ricardo Consulting Engineers Ltd
*Dr D L Georgala	Head of Laboratory, Unilever Research
*Professor W B Heginbotham OBE	Director-General, Production Engineering Research Assoc.
*Dr B C Lindley	Director of Research, Dunlop Ltd
Mr J Lyons	General Secretary, Engineers' and Managers' Association
Sir Ieuan Maddock CB	formerly Chief Scientist, Department of Industry
*Sir Alec Merrison	Vice-Chancellor, University of Bristol Chairman of the Advisory Board for the Research Councils

*Mr A M Muir Wood	Senior Partner, Sir William Halcrow & Partners
Dr L Rotherham CBE	formerly Vice-Chancellor, University of Bath
*Mr J L van der Post	Chief Executive, Water Research Centre
Mr G H Wright MBE	Regional Secretary for Wales, Transport and General Workers' Union

* New members

DRAFT PRESS RELEASE

NEW APPOINTMENTS TO ACARD

The Prime Minister today announced changes in the membership of the Advisory Council for Applied Research and Development (ACARD).

In answer to a Parliamentary Question from [ ]
the Prime Minister said: [Text of Answer]

Note for Editors

The Advisory Council for Applied Research and Development was established in 1976 with the following terms of reference:

> "To advise Ministers and to publish reports as necessary on -
>
> 1. Applied R & D in the United Kingdom and its deployment in both the public and private sectors in accordance with national needs;
>
> 2. The articulation of this R & D with scientific research supported through the Department of Education and Science;
>
> 3. The future development and application of technology;
>
> 4. The role of the United Kingdom in international collaboration in the field of applied R & D."

The retiring members on the Council are:

Sir James Menter (Deputy Chairman)	Principal, Queen Mary College, London University
Dr A J Kennedy CBE	Director of Research, Delta Metal Company Ltd
Sir Peter Matthews	Managing Director, Vickers Ltd
Mr M M Pennell CBE	Deputy Chairman and Managing Director, British Petroleum Company Ltd
Sir Norman Rowntree	formerly Professor of Civil Engineering, University of Manchester Institute of Science and Technology
Sir Frederick Stewart	Professor of Geology, Edinburgh University and formerly Chairman of the Advisory Board for the Research Councils

The Council has published 5 reports:

The Applications of Semi-Conductor Technology (1978)

Industrial Innovation (1979)

Joining and Assembly: the Impact of Robots and Automation (1979)

Technological Change: Threats and Opportunities for the United Kingdom (1980)

Computer Aided Design and Manufacture (1980)

Govt Mach

BK

FILE

cc CO

10 DOWNING STREET

THE PRIME MINISTER

14 February 1980

Dear Sir Norman.

I understand from Sir Robert Armstrong that you have decided to retire from the Advisory Council for Applied Research and Development. I should like to thank you for the time that you have given to the Council since its formation and in particular for your contributions on civil engineering research. The Council's reports have, I know, been read with great interest in Government and industry.

Yours sincerely

Margaret Thatcher

Sir Norman Rowntree

RH

Govt Mach

APPOINTMENTS - IN CONFIDENCE

PRIME MINISTER

Draft to sign, please

MAP 13/2

Ref. A01408

MR. PATTISON

In his minute of 25th January to the Prime Minister about ACARD appointments, Sir Robert Armstrong said that Sir James Menter would be suggesting to Sir Norman Rowntree that he might retire from his position on ACARD. Sir Norman has now agreed with this proposal.

2. Sir Norman has not been a member of any Working Group but has represented civil engineering interests on the Council. Through his initiatives on ACARD, a study is now in hand - jointly financed by the Department of the Environment and the Science Research Council - to identify priorities in civil engineering research.

3. I submit a draft letter which the Prime Minister might send to Sir Norman Rowntree. It is similar to those she has already sent to the other retiring members of the Council.

D.J. Wright

D.J. WRIGHT

13th February, 1980

DRAFT LETTER FROM THE PRIME MINISTER TO SIR NORMAN ROWNTREE, 97, QUARRY LANE, KELSALL, TARPORLEY, CHESHIRE CW6 0NJ

I understand from Sir Robert Armstrong that you have decided to retire from the Advisory Council for Applied Research and Development. I should like to thank you for the time that you have given to the Council since its formation and in particular for your contributions on civil engineering research. The Council's reports have, I know, been read with great interest in Government and industry.

File Govt Mach
cc CO.

10 DOWNING STREET

THE PRIME MINISTER

4 February 1980

Dear Sir Peter,

I understand from Sir Robert Armstrong that you have decided to retire from the Advisory Council for Applied Research and Development. I would like to thank you for the time that you have given to the Council since its formation and in particular for your contribution to its report on industrial innovation. This report has, I know, been read with great interest in Government and industry.

Yours sincerely

Margaret Thatcher

Sir Peter Matthews

10 DOWNING STREET

THE PRIME MINISTER

Fil
ccCO.

4 February 1980

Dear Dr. Kennedy,

I understand from Sir Robert Armstrong that you have decided to retire from the Advisory Council for Applied Research and Development. I would like to thank you for the time that you have given to the Council since its formation and in particular for your contribution to its reports on industrial innovation and joining and assembly technology. These reports have, I know, been read with great interest in Government and industry.

Yours sincerely

Margaret Thatcher

Dr. A.J. Kennedy, C.B.E.

cc CO.

10 DOWNING STREET

THE PRIME MINISTER

4 February 1980

Dear Sir James,

I understand from Sir Robert Armstrong that you gave the lead in the Advisory Council for Applied Research and Development to the view that a regular turnover of members was necessary for the life and vigour of the Council, and that you set the pattern by saying that you felt that you yourself should be among those to go. I share your view, and I think that you are acting with admirable selflessness in setting an example.

I would like to thank you for the time that you have given to the Council in its all-important initial years and particularly for leading the working group on technological change. You must be well pleased with the public reception given to ACARD reports, and with the respected standing of the Council in the scientific community.

Yours sincerely

Margaret Thatcher

Sir James Menter

10 DOWNING STREET

THE PRIME MINISTER

cc CO

4 February 1980

Dear Mr. Pennell.

I understand from Sir Robert Armstrong that you have decided to retire from the Advisory Council for Applied Research and Development. I would like to thank you for the time that you have given to the Council since its formation and in particular for your contribution to its report on joining and assembly techniques. This report has, I know, been read with great interest in Government and industry.

Yours sincerely

Margaret Thatcher

M. M. Pennell, Esq., C.B.E.

NJS to see -
Ian Lloyd Cameron?

MAP 6/2.

AJC brefpl
MJS

CABINET OFFICE
Central Policy Review Staff
70 Whitehall, London SW1A 2AS Telephone 01-233 7089

W 01777

1 February 1980

Govt Mc.

Dear Mike,

The Prime Minister received the report of the Advisory Council for Applied Research and Development on computer aided design and manufacture last November and gave the Council permission to publish it.

I now attach a copy of the printed report, which will be published next Wednesday, 6 February.

I am copying this letter, and the report, to the Private Secretaries to the Secretaries of State for Defence, Employment, Environment, Social Services, Education and Science, the Chancellor of the Exchequer, and the Minister of Transport and to David Wright.

Yours sincerely,

John Ashworth

DR J M ASHWORTH

M A Pattison Esq
Private Secretary
10 Downing Street
SW1

Government Machinery 7

LPO

10 DOWNING STREET

From the Private Secretary

MR WRIGHT
CABINET OFFICE

The Prime Minister has considered Sir Robert Armstrong's further minute (A01293) about appointments to the Advisory Committee for Applied Research and Development.

She is content with Sir Robert Armstrong's explanations, and has therefore agreed to go ahead with the arrangements proposed in his earlier minute on the subject (A01132).

If you can arrange for Sir Robert to write to those who are now to be invited to join, or to have their terms of appointment extended, I will arrange for the Prime Minister to write as proposed to the retiring members. Copies of her letters will come to you in due course.

M. A. PATTISON

1 February 1980

10 DOWNING STREET

Mike.

Joan Porter - who has all the previous appointments papers - confirms that it is the usual practice for the Secretary to the Cabinet to write letters to potential appointees.

Teresa.

1.2.80

PRIME MINISTER

You will have seen in folder one Robert Armstrong's response to your one query about his nominations for new members of ACARD.

If you are content with his explanation, you should now write thanking those who are to step down - four drafts attached.

MAP

31 January 1980

PRIME MINISTER

This one still needs signing.

MAP 1/2

Has been retyped

It is a bit scruffy

Has someone sat on it?

1.

PRIME MINISTER

You had this one query on Sir Robert's ACARD nominations.
Agree now to go ahead with the package?
MAP 31/1

Ref. A01293

PRIME MINISTER

[Consequent letters are in Folder 3]

Yes mt

Advisory Council for Applied Research and Development

Mr. Pattison's minute of 28th January invited me to consider whether the list of nominees for ACARD should include someone from the general area of information technology.

2. We considered whether we should specifically aim for a further immediate appointment to the Council from this area, and would, if he had been free, probably have nominated Sir Kenneth Corfield. But, because of pressures on his time, he has recently declined an invitation to join a new ACARD Working Group on Innovation and we therefore did not proceed with his nomination.

3. We already have Sir Robert Clayton, Technical Director of GEC, as a leading member of the Council, and he is about to take the chair of the Working Group which the Council has established on Information Technology. Sir Robert has assembled a strong team for this study. Since this Group will undertake ACARD's main work in the area over the next year, it seems preferable to wait until we have been able to see the contributions made by individual members of the Group and then invite one or two of them to join the Council and lead its subsequent interest in the subject. I therefore envisage bringing forward names from this area at the end of the year when ACARD next needs new members.

4. I have consulted Sir Kenneth Berrill, who agrees with this proposal. If you are content, we shall go ahead with inviting the five new members listed in my minute of 24th January.

RA

(Robert Armstrong)

31st January, 1980

APPOINTMENTS IN CONFIDENCE

HS

cc Trade Aug 1979
Public Purchasing Policy
Buy British Policy.

10 DOWNING STREET

From the Private Secretary

MR. WRIGHT
CABINET OFFICE

~~BF 4-2-80~~

The Prime Minister has considered Sir Robert Armstrong's minute of 24 January, about the Advisory Council for Applied Research and Development.

She is content that the Report on "R and D for public purchasing" should be published, and she agrees that the Report should be considered in E Committee at the same time as the Treasury/Department of Industry paper on public purchasing policy.

I would be grateful if you could let me have a draft letter to the Department of Industry, commissioning work on the Government response to the ACARD Report.

The Prime Minister has noted Sir Robert Armstrong's nominations for appointments and re-appointments to the Council. She is content with the proposed arrangements to improve rotation. She has no objection to the nominees for these appointments, but has noted that they do not include anyone from the Information Technology area. In the light of the points made by the CPRS (Sir Kenneth Berrill's minute Qa 04410 of 25 January) she would like Sir Robert to consider further whether his list should include at least one nominee from this field.

The Prime Minister is therefore content that Dr. Spinks should become Chairman, and that Sir Henry Chilver should be invited to become Vice Chairman. She will await further advice on the remaining posts, and we will defer writing to those who will be stepping down until new appointments are ready to be confirmed.

MAP

Letters in envelope

28 January 1980

cc Trade Govt Purchasing Policy & Buy British Policy. Aug 79

PRIME MINISTER

1. Agree appointments in paras 2-6?

2. If so, please sign 4 Thank you letters below.

Yes 3. Agree publication of report at flag A, summarized in para 10?

Yes 4 Agree to consider report in E as in para 11?

MAP 25/1

1

Ref: A01132

See note below in conjunction with Sir Kenneth Berrill's note to me on Information Technology.

APPOINTMENTS - IN CONFIDENCE

PRIME MINISTER

Advisory Council for Applied Research and Development

In my minute of 13th November, I suggested that ACARD needed a regular rotation of members and that its new Chairman should be Dr. A. Spinks if Sir James Menter were willing to retire from the Council. Mr. Pattison's minute of 19th November reported your assent to these proposals, provided that the Chairmanship issue could be arranged without trouble, and suggested that Sir Kenneth Berrill should sound out Sir James Menter and Dr. Spinks in order that I might report further to you before an appointment were confirmed.

2. Sir James Menter is willing to retire from the Council. He agrees that ACARD should have a regular influx of new members and sees his own retirement as encouraging this. Dr. Spinks has agreed to become Chairman. The Council will now need a new Deputy Chairman, and I propose that Sir Henry Chilver (Vice-Chancellor of the Cranfield Institute of Technology) should be invited to take this on.

Agreed

3. I attach a list of the present members of the Council. Three (Sir Peter Matthews, Mr. Pennell and Dr. Kennedy) have already expressed their wish to retire, having come to the end of their terms of appointment. We think that in addition Sir Norman Rowntree should retire, and Sir James Menter will be approaching him on this.

4. Departments have been consulted over possible replacements and the following names have found general favour -

Dr. D.L. Georgala,	Research Director, Unilever
Dr. B.C. Lindley,	Research Director, Dunlop
Professor W. Heginbotham,	Director, Production Engineering Research Association
Mr. A.M. Muir Wood,	Senior Partner, Sir William Halcrow and Partners
Mr. J.L. van der Post,	Director, Water Research Centre

There is no one from the information technology area.

As first reserve, we have Dr. R.B. Sims (Group Technical Director, Delta Metal Company).

APPOINTMENTS IN CONFIDENCE

Agreed

5. In addition, Sir Alec Merrison, Chairman of the Advisory Board for the Research Councils, should be invited to join ACARD. His predecessor, Sir Frederick Stewart, was a member until his retirement from the ABRC in April. We have been unable since then formally to invite Sir Alec to join, but we should like the link between ACARD and ABRC to be maintained.

6. As for the remaining members of the Council, four (Sir Henry Chilver, Sir Ieuan Maddock, Mr. Lyons and Mr. Wright) have joined since its formation and therefore their terms of appointment have not yet expired. I propose that the other four (Sir John Atwell, Sir Robert Clayton, Mr. Downs and Dr. Rotherham) be offered one or two year extensions to their appointments in order that a smooth turnover of members may be achieved.

7. If you are content with these various changes, I shall write to the people concerned accordingly.

Agreed ✓

8. I think it would be appropriate if Sir James Menter and the other retiring members were to receive personal notes from you to mark their contributions over the past three years. Sir James has not been the ideal Deputy Chairman, but has put considerable work into the Council and notably into his Working Group, whose report was published on 7th January and seems to have been well received in the Press. I attach drafts.

filed on Trade: Aug 79 Govt Purchasing Policy

Agreed

9. ACARD have now produced a further report, which I enclose. As usual, the Council have requested approval for publication and I see no difficulty with this - indeed it will give substantial support to some of the Government's present policies for R and D.

10. The report discusses the R and D carried out by the public sector (primarily by Departments and nationalised industries) in support of purchasing decisions. In particular, it examines the effect that the large in-house R and D programmes of public sector organisations can have on the competitiveness of their suppliers, especially in export markets. The report concludes from a study of five industries that too much R and D is performed by the public sector in its own establishments. It suggests that, if more reliance were placed on suppliers' R and D, this would enhance their

Tell defence and DoI!

technical competence and would encourage the development of products for use both in the United Kingdom and overseas. At the same time it warns against any sudden transfer of R and D activity to the private sector since firms have become accustomed to relying on the R and D carried out by purchasers. The report proposes interim arrangements to give suppliers greater influence over the R and D programmes of public sector purchasers, which at the moment are too inward-looking. A summary of the principal conclusions and recommendations may be found on pages 1 - 4.

11. This ACARD Report was referred to in the paper on strategy proposals by the Chancellor of the Exchequer (E(79) 84) which was discussed by E last week. The Ministerial Group on Strategy (MISC 14) had selected public purchasing policy as one of the seven issues which in their view deserved to be given high priority in the immediate future. They drew attention to two relevant pieces of work - a forthcoming paper for E on public purchasing policy prepared by the Treasury and the Department of Industry, and this ACARD Report, and suggested that both items should be brought forward for consideration as soon as possible. The Treasury/Department of Industry paper is due to be brought to E shortly, and I suggest, subject to your views, that this ACARD Report might be tabled for E at the same time. It would be relevant to a general discussion of public purchasing policy, and a general steer from Ministers at this early stage might be helpful. Further work would be required subsequently to prepare a specific Government response, and it would probably be appropriate to ask the Secretary of State for Industry to take the lead in arranging for this.

RTA

Robert Armstrong

25th January 1980

ADVISORY COUNCIL FOR APPLIED RESEARCH AND DEVELOPMENT
70 Whitehall, London SW1A 2AS Telephone: 01-233 6139

MEMBERSHIP

Sir James Menter FRS (Deputy Chairman)	Principal, Queen Mary College, London
Dr A Spinks FRS (Second Deputy Chairman)	formerly Director of Research, ICI
Sir John Atwell CBE	Scottish Offshore Partnership
Sir Henry Chilver	Vice-Chancellor, Cranfield Institute of Technology
Sir Robert Clayton CBE	Technical Director, GEC Ltd
Mr D Downs	Chairman and Managing Director Ricardo Consulting Engineers Ltd
Dr A J Kennedy CBE	Delta Materials Research Ltd
Mr J Lyons	General Secretary, Engineers' and Managers' Association
Sir Peter Matthews	Managing Director, Vickers
Sir Ieuan Maddock FRS	formerly Chief Scientist, Department of Industry
Mr M M Pennell CBE	Deputy Chairman, British Petroleum Co Ltd
Dr L Rotherham CBE FRS	formerly Vice-Chancellor, University of Bath
Sir Norman Rowntree	Professor of Civil Engineering, University of Manchester Institute of Science and Technology
Mr G H Wright	Regional Secretary for Wales, Transport and General Workers' Union

Gov Mach.

MAP

CABINET OFFICE
Central Policy Review Staff
70 Whitehall, London SW1A 2AS Telephone 01-233 7089

4.1.80

M.A. Pattison, Esq.,
Private Secretary,
10 Downing St.,
London, SW1

Dear Michael,

ACARD Report on Technological Change

I am sure that the Prime Minister will wish to see a copy of the report as published before the NEDC meeting next Wednesday, and I therefore enclose a copy. Publication will take place on Monday.

I am copying this letter and the report to the Private Secretaries to whom you sent the report on 23 November. (List attached).

Yours sincerely,

John

J.M. ASHWORTH

Private Secretary of -

- S/S for Foreign & Commonwealth Affairs
  - Industry
  - Defence
  - Employment
  - Environment
  - Scotland
  - Wales
  - Northern Ireland;
  - Social Services
  - Trade
  - Energy
  - Education and Science
- Chancellor of the Exchequer
- Minister of Agriculture, Fisheries & Food
- Minister of Transport
- The Lord President

JU

Govt Mach. ✓ MAP

DEPARTMENT OF INDUSTRY
ASHDOWN HOUSE
123 VICTORIA STREET
LONDON SW1E 6RB
TELEPHONE DIRECT LINE 01-212 3301
SWITCHBOARD 01-212 7676

JU/ *Secretary of State for Industry*

11 December 1979

Mike Pattison Esq
Private Secretary to the
Prime Minister
10 Downing Street
London SW 1

Dear Mike

Thank you for your letter of 23 November concerning the ACARD report on Computer-Aided Design and Manufacture. This Department will take the lead, and we have noted the suggestion on the timing of the Government response as shortly before Easter. Dr J A Catterall of RTP Division here will be contacting other Departments in the near future, with a view to co-ordinating inputs.

I am copying this letter to recipients of yours.

Yours sincerely
Peter Mason

PETER MASON
Private Secretary

FILE

Govt Machinery MJ

10 DOWNING STREET

From the Private Secretary

30 November 1979

Thank you for your letter of 28 November, about the Government's response to the ACARD report on "Technological Change".

I can confirm that the Prime Minister would be entirely content for the Secretary of State for Industry to take the lead on this.

I am sending copies of this letter to the Private Secretaries to the Secretaries of State for Foreign and Commonwealth Affairs, Industry, Defence, Employment, Environment, Scotland, Wales, Northern Ireland, Social Services, Trade, Energy, and Education and Science, the Ministers of Agriculture and Transport, to the Lord President, and to Sir Robert Armstrong.

M. A. PATTISON

M.A. Hall, Esq., M.V.O.
HM Treasury.

VLB

CHANCELLOR OF THE EXCHEQUER

Treasury Chambers, Parliament Street, SW1P 3AG
01-233 3000

28th November, 1979

Dear Mike,

You said in your letter of 23rd November that the Prime Minister would like the Chancellor to take the lead in preparing the Government response to the ACARD report on "Technological Change".

We have considered the report and discussed it with the Department of Industry. In the opinion of both departments it would be more appropriate for the Secretary of State for Industry to take the lead in preparing a response. The majority of the recommendations are directed to his department; and it would enable this report to be handled by the same interdepartmental group under Department of Industry chairmanship as the ACARD reports on robotics and computer aided design which have been referred to the Secretary of State.

We should be grateful for your agreement for transferring this report to the Secretary of State for Industry.

I am sending copies of this letter to the Private Secretaries to the Secretaries of State for Foreign and Commonwealth Affairs, Industry, Defence, Employment, Environment, Scotland, Wales, Northern Ireland, Social Services, Trade, Energy, and Education and Science, the Ministers of Agriculture and Transport, to the Lord President, and to Sir Robert Armstrong.

Yours ever,

Mike Hall

(M.A. HALL)
Private Secretary

M.A. Pattison, Esq.,
10, Downing Street

MFJ
Govt Mach

10 DOWNING STREET

From the Private Secretary

23 November 1979

The Prime Minister has received the report by the Advisory Council for Applied Research and Development on 'Computer aided Design and Manufacture' (copy attached) and has given permission for its publication.

She would be grateful if your Secretary of State would take the lead in preparing a Government response to the report. Publication will probably take place towards the end of January; a Government response might therefore be made shortly before Easter, by which time some public reaction to the report will have been received.

I am copying this letter, and the report, to the Private Secretaries to the Secretaries of State for Defence, Employment, Environment, Social Services, Education and Science, the Chancellor of the Exchequer, and the Minister of Transport and to Martin Vile.

M. A. PATTISON

Ian Ellison, Esq.,
Department of Industry.

DSG

MFJ

10 DOWNING STREET

From the Private Secretary

23 November 1979

The Prime Minister has received the report by the Advisory Council for Applied Research and Development on 'Technological Change: Threats and Opportunities for the United Kingdom' (copy attached) and has given permission for its publication.

She would be grateful if the Chancellor would take the lead in preparing a Government response to the report, given the close connection between its subject matter and the NEDC meeting that she is to chair on 9 January. The Cabinet Office are arranging for the report to be published shortly before that meeting, probably on 7 January.

No immediate Government response to the report will be expected, although some reference to it would be appropriate in Ministers' statements at the NEDC meeting. The Chancellor might aim to bring a draft response forward in mid-February, when public reaction to the report will be known.

I am copying this letter, and the report, to the Private Secretaries to the Secretaries of State for Foreign and Commonwealth Affairs, Industry, Defence, Employment, Environment, Scotland, Wales, Northern Ireland, Social Services, Trade, Energy and Education and Science, the Ministers of Agriculture, Fisheries and Food, and Transport and the Lord President and to Martin Vile.

M. A. PATTISON

A.M.W. Battishill, Esq.,
HM Treasury.

Ref: A0720

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F.

MAP.

MR PATTISON

Government Response to ACARD Reports

Your minute of 19th November asked for draft Private Secretary letters commissioning Government responses to the two latest ACARD reports. I attach drafts herewith. I understand that you have sufficient copies of the reports to go with them.

MJV.

(M. J. Vile)

22nd November 1979

DRAFT LETTER FROM MR. PATTISON TO THE PRIVATE SECRETARY TO THE SECRETARY OF STATE FOR INDUSTRY.

[redacted]

The Prime Minister has received the report by the Advisory Council for Applied Research and Development on 'Computer aided Design and Manufacture' (copy attached) and has given permission for its publication.

She would be grateful if your Secretary of State would take the lead in preparing a Government response to the report. Publication will probably take place towards the end of January; a Government response might therefore be made shortly before Easter, by which time some public reaction to the report will have been received.

I am copying this letter, and the report, to the Private Secretaries to the Secretaries of State for Defence, Employment, Environment, Social Services, Education and Science, the Chancellor of the Exchequer and the Minister of Transport and to Martin Vile.

DRAFT LETTER FROM MR. PATTISON TO THE PRIVATE SECRETARY TO THE CHANCELLOR OF THE EXCHEQUER

The Prime Minister has received the report by the Advisory Council for Applied Research and Development on 'Technological Change: Threats and Opportunities for the United Kingdom' (copy attached) and has given permission for its publication.

She would be grateful if the Chancellor would take the lead in preparing a Government response to the report, given the close connection between its subject matter and the NEDC meeting that she is to chair on 9th January. The Cabinet Office are arranging for the report to be published shortly before that meeting, probably on 7th January.

No immediate Government response to the report will be expected, although some reference to it would be appropriate in Ministers' statements at the NEDC meeting. The Chancellor might aim to bring a draft response forward in mid-February, when public reaction to the report will be known.

I am copying this letter, and the report, to the Private Secretaries to the Secretaries of State for Foreign and Commonwealth Affairs, Industry, Defence, Employment, Environment, Scotland, Wales, Northern Ireland, Social Services, Trade, Energy and Education and Science, the Ministers of Agriculture, Fisheries and Food, and Transport and the Lord President and to Martin Vile.

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✓ MAP
GOVT FACTY -

ADVISORY COUNCIL FOR APPLIED RESEARCH
AND DEVELOPMENT

70 Whitehall, London SW1A 2AS Telephone 01-233 6139

21 November 1979

Dear Mr Pattison

PUBLICATION OF ACARD REPORTS

Martin Vile will shortly be letting you have draft letters to commission the responses to the two latest ACARD reports. Meanwhile, I enclose sufficient copies of each for your use.

Yours sincerely
R Courtney

R G COURTNEY

Mr M Pattison
Private Secretary
10 Downing Street
London SW1

Encs

cc Mr Butler

10 DOWNING STREET

From the Private Secretary

B/F 26.11.79.

MR VILE

The Prime Minister has now had a chance to consider Sir Robert Armstrong's submission of 13 November, ref. A0638, about the Advisory Council for Applied Research and Development.

The Prime Minister is reluctant to disturb the existing hierarchy in ACARD if this is likely to cause trouble. I suggest, therefore, that Sir Kenneth Berrill should be invited to sound out Sir James Menter and Dr. Spinks about future arrangements for the chairmanship, and that Sir Robert Armstrong should report further to the Prime Minister on this before an appointment is confirmed.

The Prime Minister is content with the proposals to establish a regular rotation of members, although she sees no need for any excessive rigidity on this. She is also happy to see published the two further reports listed in paragraphs 5 and 6 of Sir Robert's minute. She agrees that the Secretary of State for Industry and the Chancellor of the Exchequer should take the lead in preparing a Government response to the two reports. I would be grateful if you could let me have draft Private Secretary letters commissioning the responses.

M. A. PATTISON

19 November 1979

VLE

See PM's marginal notes [illegible]

Agree proposals on ACARD's: 1. Chairmanship
2: Membership
3: Publication of two new reports
~~7~~: and, 4, ministerial responsibility for reply?
MAP 13/xi

Ref: A0638

APPOINTMENTS IN CONFIDENCE

PRIME MINISTER

Advisory Council for Applied Research and Development

You have agreed to Sir Leo Pliatsky's proposal that ACARD should continue in existence for a further two years and that I should report on its performance in the autumn of 1981. Since the Election the Council has been without a Chairman and I have now discussed with Sir Kenneth Berrill how this position should be filled.

2. I presume that you would not wish to chair ACARD yourself and you have not given any other Minister a co-ordinating role in scientific matters parallel to that of the Lord Privy Seal's in the last Administration. Sir Kenneth sees no great need for a Ministerial Chairman but tells me that the present Deputy Chairman, Sir James Menter, has not shown the leadership that was expected. The Second Deputy Chairman, Dr. A. Spinks (whom you met recently at a Chemical Society dinner), would be a much better Chairman, though the easing out of Sir James would require tactful handling. If you are content with this objective, I shall ask Sir Kenneth to see Sir James Menter and Dr. Spinks to see what he can achieve.

1 Rather than cause trouble – leave things as they are.

3. ACARD's membership also needs to be revised. The current members have in general served for three years and we would like to introduce some new blood. A regular rotation of members will, I am sure, do much to ensure the Council's continuing usefulness. We would aim at appointment from January next of one-third new members, one-third re-appointment for one year and one-third for two years. If you agree we will prepare a list of members on this basis, consult Departments and then submit this to you.

2 Yes – but don't be rigid about it.

4. Meanwhile ACARD continues to be usefully productive. Their Robotics Report had a good Press: I attach copies of a centre page article from the Financial Times and of an article 'Britain needs to use more robots' from the Economist dated 10th November. I also enclose two further reports from the Council who have requested approval for their publication. I see no difficulty with either.

3 Agreed all.

5. The first is on computer aided design and manufacture; it draws attention to the lack of coherence in our national effort in this subject and recommends some organisational changes to improve the effectiveness of publicly financed programmes. It also recommends a very modest programme to improve industry's awareness of computer aids. Chapter 7 (page 21) contains the report's conclusions and recommendations.

6. The second report deals with the implications for the United Kingdom of the rapid technological changes now taking place here and overseas. It contains little that is strikingly original but it firmly rejects arguments that the country can isolate itself from such changes and stresses the need for United Kingdom industry to adopt new technology in order to remain competitive in world markets. The report makes proposals for bringing more technological factors into policy-making machinery such as the NEDC. A summary of its conclusions and recommendations is on pages 1 - 6.

7. Publication of these reports, particularly the second, would lend support to your recent speeches on the need to improve productivity through new technology.

4/ Brief put

8. A Government response to the reports will be needed. The Secretary of State for Industry might take the lead on the first and the Chancellor on the second, given its close connection with the subjects to be discussed at the NEDC meeting that you are to chair in January.

Yes on

Robert Armstrong

13th November 1979

BUSINESS
SCIENCE AND TECHNOLOGY

Britain needs to use more robots

After microprocessors, robots. The British cabinet office wants to stir up much the same sort of enthusiasm for robots (ie, programmable automation) as the government has begun to do in its campaign to get British industry to think about putting microprocessors into its latest products. A cabinet office report published this week suggests that £15m of public money spread over five years could give Britain a fair chance of catching up with countries like West Germany, America, Sweden and Italy in terms of the number of robots used by industry. Japan would still be streets ahead.

Why robots? Because they are not so stupid as they used to be. They can now help make many goods more cheaply than can conventional machines operated by human workers. They don't get bored, go on strike or indulge in high absenteeism. Result: they do a better job. And they will work happily under conditions humans would not tolerate (anyway without big bonuses).

Manufacturing consists mainly of making materials, forming them into various shapes, joining the bits together and then assembling the lot into finished products. Most of the value is added during the joining and assembly processes. These two processes also determine how successful a product will be in the marketplace. Because:

- Quality and reliability depend critically on the method of joining (ie, welding brazing, soldering, glueing or riveting) used and the skill with which it is applied. Robot joining machines do a far more consistent job than men.
- The cost of a manufactured item depends largely on the productivity of the assembly method adopted. Microprocessors and new electronic devices are giving robots a sense of sight and touch as well as a crude ability to make "intelligent" decisions. That looks like extending the range of jobs they can do. Robots are now expected to bring the cost and quality benefits of the mass production techniques used in big industry to small businesses based on batch production methods. (Remember: 40% of all engineering products made in Britain are made in batches of 50 or less.)

There are about 6,000-7,000 industrial robots in use around the world today. Half are in Japan, a quarter in the United States and the rest in Europe. Britain has only 60-70 robots, West Germany around 500 such devices.

The vast majority of today's robots are used for simple "pick-and-place" tasks—like feeding pieces to a lathe for machining. The rest do slightly more complex jobs—such as cutting metal, spraying paint or welding up parts. They do so by following optimum paths programmed into them. Few robots have yet been used commercially for assembling complicated products like car gearboxes or even washing machines. That is the next step, needing the second-generation robots that are at present being developed.

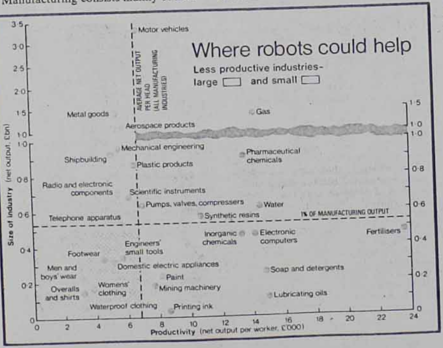
The British cabinet office report, prepared by the Advisory Council for Applied Research and Development, pinpoints where it thinks robots ought first to be applied in Britain to reap the maximum advantage. It has analysed 30 different industrial sectors in terms of net output and added value per employee in 1977 (see chart).

Two conclusions emerge immediately. Industries in the top left-hand corner of the chart make a big contribution to Britain's total industrial output; unfortunately, they have under average productivity. They include telephone manufacturing, aircraft assembly, shipbuilding and many sectors of electrical and mechanical engineering. These are the industries which would benefit most from wider use of intelligent automation.

A second group of industries, in the lower left-hand corner of the chart, would also benefit from adopting robots on a large scale. The garment industry is especially ripe for automating in this way.

Britain has not failed to keep abreast of the theory of robot development. Far from it. It has a number of research establishments inventing better ideas for robots which are the envy of the world. But, as in so many other areas of innovation, it has failed to apply its own ideas commercially. For this, the cabinet office report blames (correctly) the chronic shortage of engineers in British industry capable of adapting robots to manufacturing processes. It recommends:

- A major effort aimed at getting lots



Financial Times Wednesday November 7 1979

The robots are coming-but not to Britain

By DAVID FISHLOCK, Science Editor

THE public's perception of robots is conditioned at present by such anthropomorphical imitations as the Daleks of Dr. Who and the cackling creations which fall about at the idea of a housewife still peeling potatoes. The Cabinet Office, or rather its advisers on engineering and applied science, have a different perception; one we would all do well to heed.

For them, the robot is a versatile tool which will become as important to the manufacturing industries as, say, the machine tool is today. It is a tool destined to do many of the repetitive tasks at which human fingers fumble on assembly lines for seven or eight hours a day. It is a tool which will be programmed to perform its task of putting things together, oblivious of the clock which it anyway cannot see, of Monday morning, of tea-breaks, of heat, noise or fumes; oblivious, in fact, of any of the myriad of environmental aberrations which cause assembly-line output and product quality to fluctuate between wide extremes during a normal working day.

Britain today is ignoring this kind of robot—the "intelligent" robot—the Government's technical advisers say. The number at work in Britain's factories is minuscule compared with its big trading rivals—Japan, the U.S. and West Germany. Yet "failure to apply them will result in our industries being progressively less able to compete with either the high-productivity industrialised countries or the low-labour-cost developing countries," says a report published by the Government yesterday.*

This report is the third in a fascinating series of studies of technological change and how Britain is responding — or, rather, failing to respond. The source is the Government's Advisory Council on Applied Research and Development, which has already spawned stimulating reports—on silicon "chips," last autumn, and on industrial innovation early this year. They share a lucid exposition of the technological advance, and a bluntness about the consequences for Britain of continuing to ignore it.

ACARD's latest report finds Britain "in great danger of being left a long way behind in the application of programmable automation and robotics." The evidence suggests that, properly used, automation both raises productivity and improves quality. Failure to use it is likely to leave the industry uncompetitive both in quality and cost—"greater threats to employment than the displacement of labour by machines," ACARD contends.

Contribution to total output

To establish a baseline for manufacturing performance in Britain, the study has drawn upon the statistics of the 1977 Census of Production, and compiled from these the accompanying chart. It shows the contribution that some major sections of industry make to total national output, and also their output expressed as added value per employee. The choice of industry shown here is governed partly by the purview of the report itself and partly by the need for clarity in its presentation. The utilities—electricity, gas, water—are included as benchmarks. (Coal and steel, on the other hand, are missing because it did not prove easy to interpret the figures in a comparable form.)

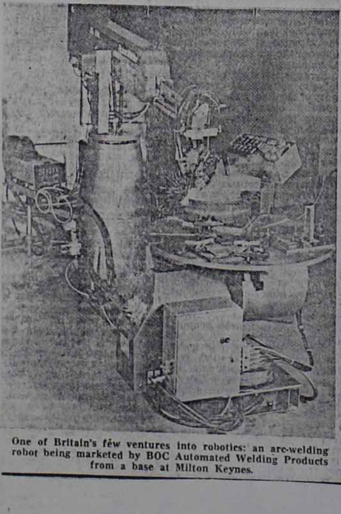
The industries which can expect to benefit most from automation in the shape of robots are clustered on the left-hand side of the chart, the area of less-than-average added value per employee. They include motor vehicles and shipbuilding, as one might well expect, but also aerospace products, scientific instruments, radio and electronic components and telephone apparatus.

The relatively poor factory performance of these sectors is reflected in the way Britain's share of the world market has been falling, and in the way the value per ton—a crude measure of the technical sophistication of the product—has dropped below that of its imports. Failure to reverse this situation, says the study, would pose a serious and permanent threat to UK employment through the loss of Britain's competitive manufacturing ability. "The countries that now have the lowest levels of unemployment are those that have made the best use of available technology."

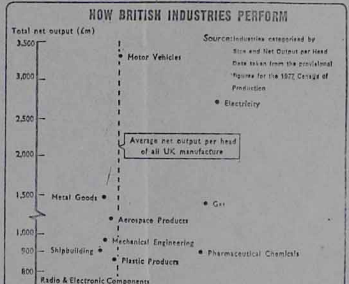
The technology considered by ACARD is not only the robot—the machine which, in this context, puts things together—but the joining techniques which will keep parts assembled. They include welding, brazing, soldering, adhesive bonding, fastening (bolts, rivets, spring fasteners, etc.) and stitching. The catalogue of possibilities is still expanding with the emergence from research of new techniques such as friction welding, "super-glues" and the use of lasers and electron beams.

Automatic assembly of mass-produced items such as motor-car sub-assemblies and the TV chassis has been a major goal of the production engineer for the past 20 years. Around 1960 the TV industry was beginning to use automatic machines to thread such electronic componenets as transistors and resistors into printed circuit panels, in preparation for automatic soldering of hundreds of joints simultaneously. A decade later one major British TV maker had abandoned his assembly machine and reverted to the idea of using rows of women again to thread the components by hand. His "robot" was simply too complicated. The slightest hiccup anywhere in a long sequence of workstations and the entire machine stopped assembling. It had no intelligence of its own and had to wait for a man to repair it. It spent more time stopped than assembling.

Today's robot tends to perform a single task, albeit often a complex one by the standards of the early machines. It costs about £30,000 — and a realistic view of charges for interest, depreciation, care and maintenance, etc., probably adds another £15,000 a year. Its counterpart at home is the washing machine or cooker which can be programmed to carry out a sequence of operations at predetermined temperatures, times, etc.—though without the robot's ability to sense, pick out, and place.



One of Britain's few ventures into robotics: an arc-welding robot being marketed by BOC Automated Welding Products from a base at Milton Keynes.



'Blind and not very clever'

Today's industrial robots are blind and not terribly clever. Manufacturers worldwide have bought far fewer than the robot-makers were forecasting in the early Seventies. But Britain, with almost none at work today, has no cause to congratulate itself, for it has accumulated none of the experience of tomorrow's approach to manufacture built up by other leading industrial nations. This experience will prove immensely valuable in introducing the new generation of robots now marching upon the factory gates.

Sir Henry Chilver, chairman of the ACARD working party which produced the report, said yesterday that robotics was potentially one of the world's biggest growth industries.

According to ACARD, some 6,000-7,000 first-generation industrial robots were at work worldwide last year. Half of them were working in Japan, one-quarter in the U.S., and one-quarter in Europe. Britain, however, could boast only 60-70 robots. The annual output of Britain's one manufacturer of industrial robots is derisory—fewer than 50 a year. The Department of Industry has commissioned a more detailed—and more technical—study of this disturbing situation from Ingersoll Engineers which is shortly to be published.

Still more to the point, however, the nations which are using robots today have national programmes which encourage their use and further development. Japan in the Sixties, acknowledging the lead the U.S. had built up in mainframe computers, set out to compete by developing robots. Currently it is engaged in a seven-year project, costing £25m, to demonstrate the principles of fully-automated manufacturing plant. One government-supported demonstration, at Kawasaki Heavy Industries, aims to assemble a small agricultural petrol engine almost entirely by robots. Another, at Toyota, includes robot welding of motor-cycle frames and axle housings.

West Germany has a Government-supported programme entitled "the humanisation of life at work." It aims to improve working conditions — for example, by keeping the worker away from hostile environments. The German Research Society also spends generously on engineering research, £20m a year, including the development of systems for factory automation. Sweden and Italy have also made much greater progress than Britain.

The U.S. Government is supporting manufacturing technology—including automated assembly—through the National Science Foundation. Its Automation Research Council has called for a joint government-industry programme on which $300m would be spent over seven years. It also has such powerful research centres in robotics as SRI International in California (formerly the Stanford Research Institute) and the Charles Stark Draper laboratory at MIT in Cambridge, responsible for some of the most advanced automation of the space programme.

Britain not only has no national programme on factory automation, it has almost no research and development on robots. Not even the Engineering Board of the Science Research Council, which has sponsored research into other neglected aspects of manufacture, has yet seen fit to support the development of the industrial robot. (This may be a legacy of the council's experience with the more controversial science of "artificial intelligence" in the early Seventies, when its investment bore little fruit.) University research relating to robots in Britain "contrasts starkly with that in West Germany," laments the ACARD report.

Yet for the production engineer, robotics offers the same kind of excitement and hope for the future as synthetic fuels and nuclear power in the energy sector, and supersonics and vertical take-off in aviation. What is more, ACARD believes that Britain has all the ingredients needed for a successful effort to exploit the coming of robots.

In welding technology it is second-to-none with the Welding Institute and its [illegible] providing the bedrock. In adhesives technology it pioneered with the wartime production of the Mosquito bomber and has remained in the vanguard.

In the Sixties Mr. Theo Williamson, then technical director of Molins, attempted in the System 24 automated machine shop to implement what to this day is one of the most ambitious schemes for factory automation ever attempted anywhere. Other British technology highly relevant to robotics includes long experience of romote handling and repair techniques in the nuclear industry, involving major surgery deep inside reactors and other highly radio-active plant. In addition, Britain is skilled in "software" — programming. Cunningly-programmed microprocessors, together with miniature TV systems to provide the robots with vision, and other advanced sensors, will be the technological base of the new generation of robots of the Eighties.

The excitement of Concorde

ACARD is urging the Government to knit all this skill and experience into one programme, with the objective of revolutionising Britain's manufacturing methods. As a national objective, directed and managed by users—the leading manufacturing firms—such a venture could have all the excitement of a Concorde project and a far better chance of a national payoff.

We will know it has worked when we watch TV advertisements showing robots laughing at people who still try to assemble things by hand.

**Joining and assembly: the impact of robots and automation, pp 44, HMSO, £1.75.*

ADVISORY COUNCIL FOR APPLIED RESEARCH AND DEVELOPMENT

COMPUTER AIDED DESIGN AND MANUFACTURE

October 1979

ADVISORY COUNCIL FOR APPLIED RESEARCH AND DEVELOPMENT

COMPUTER AIDED DESIGN AND MANUFACTURE

FOREWORD

In its first report, "The Applications of Semiconductor Technology", published in September 1978, the Advisory Council for Applied Research and Development (ACARD) listed among the probable consequences of the widespread introduction of microelectronics the changes in design procedures and manufacturing methods that would result from the use of computer aids. It noted that these were being increasingly used in the mechanical, electronic and electrical engineering industries.

Because of the likely importance of these changes to all sectors of industry, the Council decided in January 1979 to set up a Working Group on Computer Aided Design and Computer Aided Manufacture (CAD/CAM) with the following terms of reference:-

i. to review the potential benefits from the use of CAD/CAM:

ii. to determine the extent to which British industry is obtaining these benefits, making comparisons with other countries;

iii. to identify and assess the need for measures to promote the use of CAD/CAM, and to make recommendations.

The members of the Working Group were:

*Mr R J Clayton (Chairman)	Technical Director, GEC Ltd
*Sir Ieuan Maddock FRS	Secretary, British Association for the Advancement of Science
Mr J W Nichols	formerly Director, National Maritime Institute, Department of Industry
Mr D H Roberts	Research Director, GEC Ltd (formerly Managing Director, Plessey Microelectronics Division)
Dr R B Sims	Group Technical Director, Delta Metal Co Ltd

* ACARD member

The report of the Working Group was considered and endorsed by the Council in October 1979. Like previous reports, including "The Applications of Semiconductor Technology", it makes recommendations which the Council believe will improve the competitiveness of British industry. The report does not, however, aim to provide a full technical exposition of computer aided design and manufacturing techniques.

The Council are grateful to the Working Group for their report. They also wish to acknowledge the support given by the Central Policy Review Staff and the ACARD Secretariat at the Cabinet Office.

CONTENTS

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1. INTRODUCTION

1.1 In the interests of an early and concise report, we decided to follow the generally understood meanings of CAD and CAM and to concentrate on the use of computers in the design and manufacture of discrete products. We therefore omitted from our review the optimisation or control of continuous processes, as well as the use of computers in inventory control, programmable handling systems ("robots") or scientific research.

1.2 Having defined the scope of our study, we produced working definitions for some CAD/CAM terms -

Computer Aided Draughting The use of a computer based system for translating concepts or sketches into drawings suitable for use in manufacture, or for storing drawings or parts of drawings in a data bank to be available on call for modification, incorporation into a revised drawing, or as input to a subsequent manufacturing process.

Computer Aided Design The use of a computer based system to assist in translating a requirement or concept into an engineered design, utilising a data bank of design principles and information on such matters as properties of materials, followed by production of information (which may be in the form of drawings) for manufacture. Such design may include "simulation" - the modelling of a design and calculation of performance, for example to reduce the need to build experimental equipment. This may be extended to "optimisation" - the search for the most suitable design to meet the requirement.

Computer Aided Manufacture The use of information from Computer Aided Design and Draughting as a direct input to control manufacturing plant (such as numerically controlled machine tools) or inspection and test equipment.

Integrated Business System (or Linked Business System) A CAD/CAM* system coupled to marketing, buying, production planning and control, and financial systems in the company or factory. A full Integrated Business System would include a data bank of customer requirements, product design information, manufacturing plant status etc, and a computer would be used to plan and control manufacture.

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* For brevity we refer in this report to the total field that we have surveyed as CAD/CAM.

1.3 Our enquiries covered users and manufactures of CAD/CAM systems, consultants, research organisations, professional institutions and government departments and we wish to express here our appreciation of those (listed in the Annex) who contributed to our work. We sought information on -

i. the extent to which CAD/CAM techniques were used in British industry as compared with overseas; the benefits that had been obtained from CAD or CAM, both quantifiable and non-quantifiable; the extent to which information derived from CAD can be directly input to CAM systems; and the relevance of current CAD/CAM systems to small companies or to industries not employing "high technology".

ii. the current R and D activity on CAD/CAM in universities, Research Associations and government establishments;

iii. the likely future developments in CAD/CAM systems and the potential for United Kingdom firms in the supplying industry.

iv. the need for Government to assist the introduction of CAD/CAM systems, for example through information services, education and training or financial measures.

1.4 The information obtained is presented according to the type of engineering or technology involved (eg mechanical, electrical, electronic). This approach simplified the analysis but we accept that in some cases it fails to illustrate the extent of interest in CAD throughout some sectors of the economy. For example, the transport sector is an extensive user of CAD because of the complex problems posed by the interaction between the moving structure and its environment, whether in the design of aircraft, aeroengines, ships, road vehicles or high speed trains.

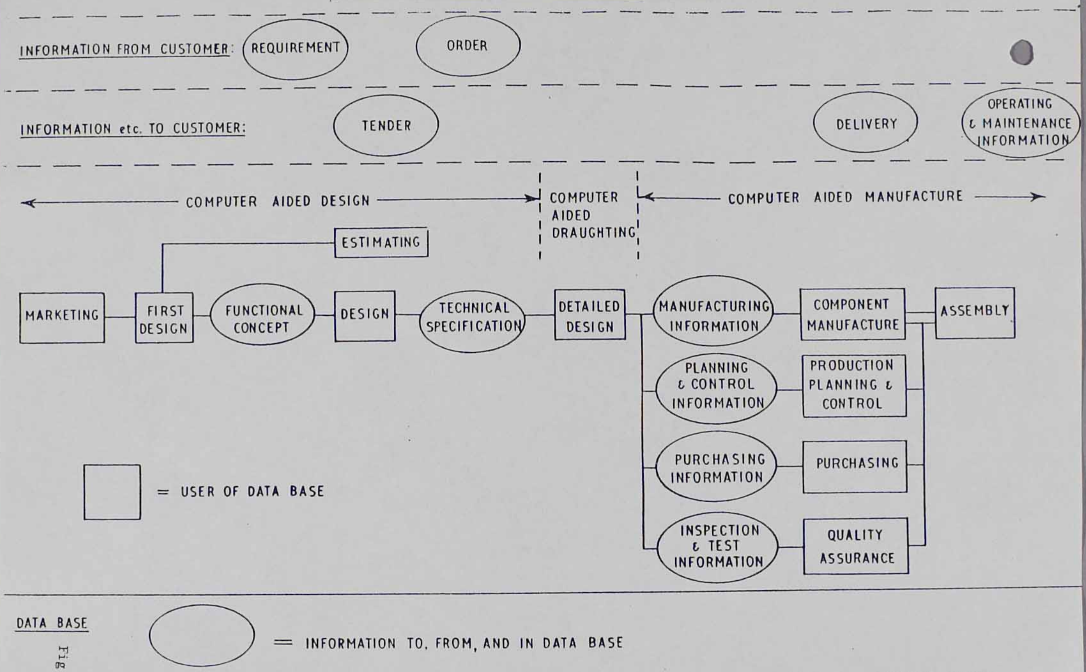
The following chapters present our findings.

2. THE USE AND BENEFITS OF CAD/CAM

Introduction

2.1 The operations of a business may be considered as a number of linked processes, shown diagramatically in Fig 1. This chapter describes how computer assistance has been adopted in these processes in various sectors of industry and the factors which have influenced its spread.

AN INTEGRATED BUSINESS SYSTEM



ALSO: STANDARDS, PREVIOUS DESIGNS, DESIGNS IN PROGRESS & MANUFACTURE, PAYMENT SYSTEM, CODES OF PRACTICE, MATERIALS & COMPONENTS, PRODUCT PLANT STATUS, MANAGEMENT ACCOUNTS & INFORMATION

Fig 1

Computer aided design and draughting

2.2 Computers have for some years been used for design calculations in industry, but initially they provided information for a design process which relied on designers and draughtsmen for the production of drawings.

2.3 Since the early 1970s, however, there have been rapid developments in the application of computers to design and manufacture. In industries such as the manufacture of semiconductor devices and telecommunication switching systems the design process has become so complex that computers now carry out as many as possible of the steps between the initial statement of the customer's requirement and the preparation of manufacturing and testing information. Other industries - for example aircraft and vehicle manufacture - use the computer's ability to store common information to improve communication between members of design teams working on different aspects of an overall design.

2.4 The computer has thus become far more than a rapid calculator. Through it, the designer can sketch, visualise and modify his design. Provided the cost of preparing the problem for the computer and the development of appropriate programs is less than that of alternative methods, such as hand calculations or - where possible - making experimental physical models, its use will make economic sense. It is most likely to be attractive where the design problem is complex, or repetitive.

2.5 Further incentive for the use of computer aids in design and draughting has come from the shortage of skilled drawing office staff. Many of the firms that we contacted mentioned the difficulty of recruiting staff as a reason for the installation of a CAD system. A widely accepted measure of staff shortage is the ratio between the number of vacancies and those unemployed with the particular skill. In June 1979 this stood at 1.26 for engineering draughtsmen over the country, and was nearly 1.5 in the South East. The increased design output obtainable through CAD enables work to be taken on which would otherwise be refused owing to shortage of design capacity. The cost of the system may thus be justified in terms of the overall operations of the firm even when its cost-effectiveness in relation to the design department is more difficult to prove.

2.6 As well as drawings, computer aided design or draughting systems can produce other manufacturing information such as part lists, material requirements, cabling schedules and information for inspection and testing. In some cases they can produce information for tenders rapidly and cheaply; this is important in the capital goods industry and other sectors where equipment is built to customer specifications.

2.7 At the moment, the cost of installing a computer aided draughting system is such that, in the absence of special factors, present systems are probably only economic if they are capable of being used by several draughtsmen simultaneously with many more draughtsmen participating on a rota basis. Extension of computer aided draughting to smaller organisations will depend on the availability of smaller, cheaper systems.

Computer aided manufacture

2.8 Another area of development has been in the control of numerical machine tools by computer. The output from computer aided design and draughting can be used, often without the need for production of drawings, for control of manufacturing machinery where the product has essentially two dimensional geometry ("2D"), for example a panel or printed circuit board, or to a limited extent two dimensional geometry with relatively simple step changes of profile in the third dimension ("2½D). It has, though, sometimes been the practice first to produce a drawing and then to convert the information from the drawing into a program for the machine tool. Work is in hand in this country to reduce the need for the intermediate drawing and to extend such integrated CAD/CAM to full three dimensional ("3D") machining (see Chapter 4).

2.9 Computer aided manufacture is particularly attractive where parts are complex and call for high accuracy (eg dies, moulds and prototypes). In such cases it can make up for shortages of skilled toolmakers and tool setters, and can produce the parts quicker than conventional machine tools and hand methods. It can improve the quality of the product, allows replication to close tolerances, and may assist automatic inspection.

2.10 Looking ahead, CAM techniques will be crucial to the development of machining "cells" in which groups of machine tools operate together under the control of a supervisory computer. This has already started, both in the United Kingdom and overseas. A major project along these lines by the Automated Small Batch Production Committee, under the aegis of the Mechanical Engineering and Machine Tools Requirements Board of the Department of Industry, is well advanced. Through such cells, productivity may be raised markedly and their development is essential if the United Kingdom is to maintain a competitive position in international markets for engineering products.

Other areas of computer assistance

2.11 There has for some time been widespread use of computers for production planning and control and business data processing, but links between these applications of computer and CAD are only just being established. Elements of computer aided design, draughting and manufacture have already been linked with some parts of factory production planning and control and company business systems. Examples exist in the aero-engine industry in the USA and in the telecommunications industry in the United Kingdom. Fully integrated systems (or "Linked Business Systems") will, however, be neither technologically nor economically feasible in many industries for some years. In the meantime, the dangers inherent in introducing individual elements piecemeal, with the possibility of subsequent incompatibility between elements, need to be recognised. Each step in the use of computers in design, draughting and manufacture should generate a store of information or "database" which ought to be usable in any other part of the design and manufacturing process. The danger is that each step will store its information in a form which is either inaccessible to other processes or can be used only with difficulty.

Benefits of CAD/CAM

2.12 Many of the benefits to be derived from CAD/CAM systems have been touched upon above. Undoubtedly the major benefit from CAD is the improvement in the productivity of designers and draughtsmen that can be achieved. Indices of improvement of between 2 and 30 have been quoted, but the most commonly accepted figure overall is around 3½. This means that a CAD system is likely to increase substantially the output of skilled staff who are in short supply, thus either freeing staff for other projects, or enabling expansion to take place without constraints caused by bottlenecks in the design department. As an example, one firm with a drawing office of 36 told us that they had cleared a backlog of 30 man years of work within a year of the introduction of a CAD system and were now competing for tenders that otherwise would have been missed. By the end of that first year, about half the drawing office staff were trained to use the CAD system and the time taken to produce a drawing had fallen by a factor between $2\frac{1}{2}$ and 25, depending on the proportion of "thinking time" to actual drawing required. The average was around 4.

2.13 The productivity of designers is raised not only by their own use of CAD, but also because a CAD system, by relieving draughtsmen of much routine manual drawing and facilitating access to essential engineering data, enables them to spend more time on tasks of a higher intellectual level. Further, shortages of draughtsmen can lead to designers spending time on their own detailed drawing, and this can be avoided through CAD.

2.14 The creation of a central store of product information (dimensions, material etc) drawn on by all concerned with design or manufacture, in itself brings many advantages. These include -

i. uniform design standards and specifications throughout a complete design;

ii. consistent specification of components;

iii. elimination of inaccuracies caused by hand copying of drawings and of inconsistencies between drawings;

iv. easier up-dating of designs, with the introduction of new components and the deletion of obsolete parts throughout a complete set of drawings being readily achieved;

v. ready checks on component usage, with easy links to production and ordering schedules, and consequent savings on inventory costs.

2.15 Drawings produced by a CAD system will be of high quality, without the errors that are inevitable with manual drawing. Further, once the basic program for a particular part is written, variations may be made quickly. A few parameters may suffice to define the complete design, and the drawing - required perhaps for tender purposes - may then be produced in hours rather than days. Indeed, we came across one medium-sized firm (450 employees) with a CAD system which provided immediate quotations for their salesforce, who could gain access to the system by telephone from customers' offices. This created a highly favourable impression with potential customers. The financial benefits that come from the ability of a CAD system rapidly to produce high quality drawings are not easy to quantify, but it is noticeable that once some firms have this ability, purchasers take advantage of it by shortening their tender invitation periods, and firms without CAD may find themselves unable to compete for tenders.

2.16 Different national markets often require a product to have slightly different specifications; international harmonization of standards and regulations has not yet come about and the pace of progress is slow. A CAD system enables different legal requirements easily to be incorporated in a product, reducing the penalty that non-standardisation brings, while CAM enables the variants to be more economically manufactured. It is also possible through CAD to anticipate future legal requirements, and perhaps save expensive testing and redesign at a later stage.

2.17 A CAD system can improve the quality of design because it aids the designer in visualising the final product and in seeing the effect of modifications. In addition the discipline that has to be established in a design office if optimum use is to be made of the CAD system, in other words the control required over the input of design details to the computer and their subsequent modification, itself brings about a reduction in errors and a general tightening up of design standards.

2.18 The principal benefit of CAM, as with CAD, is the improvement in productivity that can be achieved. This is particularly important when the staff concerned - skilled toolmakers, tool setters and machine operators, for example - are in short supply. At present, few CAM systems are operating in the United Kingdom and no generally accepted figure for productivity improvement is available, although experience in the USA suggests that an increase by a factor of three or so may be expected with current equipment. This figure will though be much greater when grouped machine tools are introduced with both transfers of parts between machines and machine setting being largely automatic.

2.19 By shortening the time taken in manufacture, capital requirements for both machinery and stock can be decreased. Identical parts can be reproduced at any time if the manufacturing instructions are retained and stocks of spares may thus be reduced. Optimum batch sizes may be reduced and product lines changed rapidly. These are direct financial benefits, which will improve a firm's cash flow.

2.20 Less quantifiable but nevertheless real is the improvement in quality and consistency of product that can be achieved through CAM. The inspection of manufactured products is also easier, since if the characteristics of a product are defined in the computer, automatic gauging and testing can be employed to check that it is up to specification.

3. CAD/CAM IN BRITISH INDUSTRY

3.1 The previous chapter described the development of CAD/CAM generally. Here we assess developments in the United Kingdom. Members of the Group undertook studies of CAD/CAM applications in seven sectors of British industry, with the following main findings -

Mechanical engineering

3.2 The mechanical engineering sector, which covers the manufacture of components for the whole range of mechanical, electrical and chemical industries, faces difficulties in producing drawings by traditional methods because of a shortage of designers and draughtsmen. The obvious advantage of the use of computers is in relieving staff shortages by increasing productivity of designers and draughtsmen. At present, however, CAD systems applicable to general engineering offices are seldom economic in drawing offices employing fewer than 20 draughtsmen (which accounts for the majority of firms in the industry) and are unsuitable for use on a bureau basis because the users' equipment must for technical reasons be close to the computer. Further development to overcome these problems is clearly required. Another feature of the present generation of computer aided draughting systems is that they have been developed primarily for the production of engineering drawings, with too little emphasis placed on application to manufacturing, either on the shop floor or for production control.

3.3 The incidence of CAD/CAM systems in this sector appears lower in the United Kingdom than in other countries, notably America and Japan. The cost of labour relative to that of CAD/CAM systems has been lower in the United Kingdom. However, it is more than probable that the constraints imposed on British mechnical engineering by lack of skilled manpower in the drawing office and in the machine shop will require CAD/CAM to be widely applied eventually.

Electrical Engineering

3.4 Proprietary American CAD systems have been coming into use in large companies in the electrical industry in recent years and now some smaller companies or manufacturing units are planning to introduce them. As with the mechanical engineering sector, the principal incentive for the introduction of CAD is shortage of skilled staff. Computer aided draughting has led to increased output, reduced costs and earlier issue of manufacturing information. In the electrical industry many drawings are produced by modification of existing drawings or generated from a set of standards and if stored information can quickly be amended, dimensions can easily be changed. The ability to use a database of existing information is therefore an important advantage in this sector.

3.5 There are few examples where the output of CAD is used for the control of manufacturing machinery but some drilling, punching and wiring machines are controlled in this way. The extension of CAD into an integrated business system is beginning to be studied in some companies.

Electronics

3.6 The whole electronics industry - including telecommunications and computers - is becoming more homogenous in its design and manufacturing methods, because of the increasing use of silicon integrated circuits (including microprocessors) in its products and of computer aids in design and in parts of the manufacturing process.

3.7 Both CAD and CAM in electronics have made their penetration because they offer the only practical way of dealing with increased product complexity and performance; they have not had to be justified on the basis of short-term financial savings in labour costs. A further benefit of CAD/CAM is beginning to emerge, namely that CAD/CAM systems reduce the cost and gestation periods of products and design modifications in existing products. As in other sectors, they improve the economics of small production runs and enable more effective use to be made of the available professional engineering resources.

3.8 With one possible exception, the United Kingdom is not lagging behind the USA, Japan or West Germany in the exploitation of CAD/CAM in electronics manufacture. The possible exception occurs in small companies where adoption is inhibited by the high cost of systems and by the shortage of CAD/CAM bureaux in the United Kingdom which could offer first-time users and small companies the opportunity of using CAD/CAM with a minimum of investment and risk.

Aerospace

3.9 The principal stimulus to the development of CAD/CAM techniques came from the American aerospace industry which now makes extensive use of CAD/CAM. Computer aided draughting is not, however, used extensively in the United Kingdom industry other than for avionics but computers are of course essential for modelling the aerodynamic and thermodynamic properties of aircraft and missiles. The major aircraft production sites in the United Kingdom employ CAM systems for the manufacture of components and, in some cases, for describing surface geometry also. European aerospace firms co-operate closely on CAD/CAM and United Kingdom practice appears to be in advance of the general level elsewhere in Europe, but behind that in the USA and the small but growing Japanese industry.

Chemical Industry

3.10 Major chemical companies make extensive use of CAD for the design of process plant; indeed the Computer Aided Design Centre - who have made important contributions to CAD in this section of industry - estimate that about half the process design work carried out involves CAD. Applications in project engineering appear to be not as widespread but computers offer in this field the possibility of significant productivity gains during construction, as well as more accurate specification of material requirements. One firm informed us that, prior to the introduction of CAD, they used to order 10 per cent extra valves for a new plant to allow for errors in estimation. This was now unnecessary since the CAD system provided a precise schedule of all components.

3.11 Several features of CAD make computer techniques particularly advantageous in the process plant industry, notably the ready availability from a data bank of physical and chemical data on the many products required in chemical processes and the easy access to design calculations required for safety and reliability purposes. These are in addition to the usual benefits of shortening of design time, ease of modification etc. The general picture is that the larger firms in the industry are well up with world practice but the implementation of CAD in the smaller firms is not as far advanced.

Construction Industry

3.12 The use of computers in the construction industry is related in general to one of three types of work: major civil and structural engineering projects (dams, bridges, roads, etc); public utilities (water distribution networks, etc); and modular buildings. Computers are now indispensible in the analysis of major structures and civil works with the use of finite element analysis being universal. There appear, however, to be few CAD systems that include the preparation of bills of quantities and of other production information. Computer graphics systems are used to provide visual impressions of different road alignments. One difficulty which affects planning of roads and other services by computer is the absence of a common database for describing locations. This could be derived on a national basis from Ordnance Survey data. Computer aided draughting systems can clearly remove much of the tedium of drawing modular buildings and computers can aid the analysis of the performance of such buildings - heat loss characteristics, illumination etc - and programmes to do this have been developed, but we were not able to judge the extent of their use.

Marine Engineering

3.13 We covered in this sector the design and construction of ships and offshore structures, such as oil and gas rigs, which might be expected to be built in shipyards. Conceptual design in marine engineering is based on centuries of tradition and experience, much being enshrined in Codes of Practice capable of mathematical definition. Computers are widely used at this stage of design. Stress analysis by finite element methods is widely used, particularly in the design of offshore structures. Hydrodynamic loads are similarly calculable by computer methods, although because of limitations on mathematical models of hydrodynamic behaviour, calculation is still not a complete replacement for traditional model testing which is still used in virtually all novel ship design.

3.14 Detailed design in this industry does not at present make much use of computer graphics and automated drawing systems. But in the construction of ships from steel plate, computer methods are extensively used to plan the cutting of the plates by flame cutters and to control their subsequent welding into sub-assemblies. This arises from the early introduction of programmed machine tools for both these functions.

3.15 An extended use of graphics in detailed design can be expected in the future, as well as improvement in mathematical modelling of the hydrodynamics of ships and structures, which may well permit improved methods of design optimisation.

General Comments on the use of CAD/CAM in the United Kingdom

3.16 Our investigations showed that some companies in the United Kingdom, particularly those engaged in "high technology", have used computers for design analysis for a number of years and are increasingly using CAD as defined in this report. They are in touch with similar companies overseas and are well aware of the potential uses of the techniques and the advances which are being made worldwide. Large companies not engaged in "high technology" fields also appear to be becoming more aware of the possibilities of CAD/CAM and a number are installing systems, particularly for computer aided draughting. However, use of CAD/CAM is very patchy.

3.17 By contrast, there seems to be a general lack of awareness of CAD/CAM among other companies, perhaps because they assume that CAD systems are still too expensive to be cost effective. In the experience of the Design Council's Design Advisory Service, CAD/CAM is not widely used in medium-sized or small engineering companies, although there has recently been some change and a few such companies are now exploring CAD systems, in particular, computer aided draughting equipment. We have to accept, though, that the systems presently available are too expensive for smaller companies. We have found that even where there is interest there can be ignorance about published information on CAD/CAM developments. The capabilities of some commercially available systems appear to be not fully appreciated with the result that some companies are trying to build similar systems for themselves.

3.18 One company contacted said that they had no experience of computer aided design and believed that they were typical of the majority of small to medium sized British engineering companies making traditional products. They suggested that such companies tend to be frightened of the more advanced computer applications (other than those for well established system routines such as sales ledger and inventory control). They thought that applications such as CAD/CAM looked expensive to such companies and potentially difficult, because they did not have the staff with the appropriate education and experience, particularly to handle the software.

3.19 The same company suggested, however, that if the problems could be overcome, it would be in companies such as their own that some big benefits of CAD/CAM could be realised. They were involved in batch production of products, frequently having to make small modifications or variations to a basic theme. This involved not only scarce drawing office staff but often even scarcer toolmakers. It seemed to the company that the computer could be an ideal tool to make frequent small changes in their products quickly and cheaply - and this is, of course the case. They felt, however, that, while the concept was easy, they needed information on how to achieve it. We believe this problem to be general.

3.20 Output from computer aided design or draughting systems is being used directly as input to manufacturing equipment for two dimensional and to a limited extent for simple "2½D" components. For three dimensional products, however, there is very little experience in manufacturing industry in this country or elsewhere in the generation and use of design information for direct input to manufacturing machinery. Although claims are made for some of the systems being purchased from America, there is still very little practical evidence of their successful use in this way.

3.21 Machined part manufacture at present usually entails the production of a conventional drawing, followed by the generation of a program for a numerically controlled machine tool. The Delta Metal Company, in co-operation with the Computer Aided Design Centre and partially supported by Department of Industry, have now developed a system for the generation of information for a numerically controlled (NC) machine directly from the designer's input, without intermediate drawings. Drawings to British Standards are also produced, as a by-product of the computer program on paper or on a visual display unit. This work could be of particular interest to toolmakers and mould and pattern makers. The system will be suited to the production of small quantities of prototypes and to batch manufacture using machine tools fitted with computer numerical control (CNC) systems. The results of the work should be available for information and instruction, and as a bureau service; and therefore should be of interest to the many small firms in this field.

3.22 From what has been said already in this report it will be apparent that CAD/CAM techniques already exist to help such companies with their manufacturing problems. Any difficulties in implementation concern not the inherent technical capabilities of the systems, but rather their overall cost-effectiveness; the information gap that has to be bridged in order to make companies aware of what CAD/CAM systems can offer, and the effort required to tailor commercial systems to firms' individual requirements.

4. ACTIVITY IN RESEARCH ASSOCIATIONS, GOVERNMENT RESEARCH ESTABLISHMENTS AND UNIVERSITIES

4.1 Of the 155 academic institutions listed in the Register of British Universities and Technical Colleges, about 60 have entries relevant to CAD/CAM. Of these, more than half have entries from more than one department, and in total over 100 departments have CAD/CAM interests. These tend in general to be isolated small projects, but some departments have more extensive programmes of research.

4.2 As examples, Strathclyde and Edinburgh Universities applied CAD techniques to architecture and building design and the resulting software from Edinburgh has been used in the construction industry. Both Edinburgh and Brunel Universities have worked on computer aids to integrated circuit design. The mechanical engineering sector has also received attention. One of the most difficult problems is three-dimensional or geometric modelling. The universities of East Anglia and Leeds have been active in this field, while several programs have been developed at Cambridge for the definition and machining of two and three dimensional surfaces, the DUCTS system is now being used in industry. Glasgow, Salford and Birmingham Universities have carried out work in production engineering and Imperial College has specialised in the study of draughting methods. Newcastle University and Liverpool Polytechnic have together produced CAD packages for designing mechanisms, linkages and cams for various types of machinery. Leicester University have also undertaken work on interactive CAD for engineering structures and components.

4.3 The National Engineering Laboratory (NEL) is a source of CAM programs (or "software") adapted from the basic American software APT. The Computer Aided Design Centre (CADC) at Cambridge, also a Government-sponsored establishment, works on CAD and increasingly on CAM. Both organisations have a major element of industrial collaboration in their work. The CADC has produced some notable software, in particular the GNC and POLYSURF programs for surface definition and machining, and more specialist software ranging from textile design in full colour to design and manufacturing drawings for pressure vessels and pipework layout. NEL is now co-ordinating the Department of Industry's Advanced Small Batch Production project, as well as being involved in CAM and robotics.

4.4 Of the Research Associations, only the Production Engineering RA has developed a CAM system (PADDS) capable of commercial exploitation, but this has been restricted to programs for turned parts and mainly 2D surfaces. The remaining Research Associations have concentrated their attentions on CAD, with software suited to the sectors of industry which they serve. For example, the Machine Tool Industry Research Association has programmes for gear design and the design of forming rolls; the Spring Research Association is collecting spring design. programmes and BNF Research Ltd has a suite of programs for extrusion die design. The software arising from these projects is made available primarily to the members of the various Research Associations. Typically each would have only two or three staff, not necessarily full-time, working on such projects.

4.5 Government support for development of CAD/CAM has included Science Research Council grants for the work in universities, and Department of Industry support for the CADC, Research Associations, NEL and projects in individual firms. For mechanical engineering, this support is co-ordinated through the Computer Aided Engineering Panel, a joint committee of the Mechanical Engineering and Machine Tool Requirements Board and the Science Research Council, now responsible for expenditure of about £2 million annually. The Panel has identified the need to catalogue the large quantity of software now available, starting with that produced in universities and extending in time to industrial software. This will enable the greatest benefit to be derived from existing programs.

4.6 Our survey showed us that while research activity in CAD/CAM is extensive, most projects are small and the research effort appears to lack overall direction and purpose. We return to this theme in our conclusions.

5. OVERSEAS DEVELOPMENTS

5.1 We made enquiries through Science Counsellors in United Kingdom embassies and from other sources about current applications of CAD and CAM in other countries. While our survey was not exhaustive it is clear that at least some of this country's major competitors in export markets - notably West Germany, Japan and the USA - have substantial government-supported research, development and application programmes already in existence.

United States

5.1 In 1976 a General Accounting Office (GAO) report drew attention to the failure of the USA in post-war years to match the increases in manufacturing productivity of its major competitors. A National Centre for Productivity with, as part of its aim, the sponsorship of CAM and CAD demonstration projects, was set up for a short period. The Centre commissioned a report on the use of numerically controlled (NC) tools in manufacturing industry and a study of the barriers to their use. Perhaps the most significant finding of this survey was that firms not using NC tools considered that the establishment of centres where they could obtain "hand-on" experience in such tools would be the best way of enabling them to see their potential. The firms that had installed NC tools supported this view and the relevance of this finding to the introduction of CAD and CAM systems in the United Kingdom is clear.

5.3 Partly as a result of the GAO report, two major federal programmes of support for CAD/CAM applications have been established. The first, sponsored by the US Air Force, is ICAM. This has a budget of $100 million over five years and is officially described as providing "seed money" to advance the application of CAD and CAM in firms that supply the aerospace industry. Computer aids - including design, manufacture and inventory control - are being introduced in the different "modules" of the manufacturing process of aircraft following an analysis and structuring of that process. Particular emphasis is being placed on the application of computers to sheet metal working.

5.4 More academically oriented is the National Science Foundation programme (running at approximately $3 million annually) on production research and technology. This includes CAD and CAM amongst a wider range of technologies for which research grants are available. The work is in general being carried out by universities or contract research organisations in close association with industrial "affiliates", the results being freely available. There would be no bar to United Kingdom firms associating themselves with relevant projects in the programme.

.5 It is clear that the number of CAD and CAM systems in use in the USA far exceeds that in the United Kingdom, but this is partly a reflection of the relative size of the countries, partly of the importance of high technology industries - notably aerospace and electronics - to the United States' manufacturing sector and partly of higher labour costs. It does not seem to us that the technology of CAD and CAM in general mechanical engineering is very different in the two countries - indeed, in some aspects of the subject, the United Kingdom would appear to be ahead. The result of the demand from high technology industry has been, however, the development of commercial CAD systems incorporating both hardware and software. The USA now dominates the world market for such systems.

Japan

5.6 Japanese industry is said to be introducing CAD/CAM extensively. Some 20 to 30 'cells' of NC machine tools with automatic transfer of pieces between them already exist while perhaps 100 examples of computer control of tools can be found. In particular, the motor industry is a major user. As with the USA, this is partially a reflection of the higher cost of labour relative to equipment in Japan compared with the United Kingdom. It may also be connected with the different financing arrangements that apply to Japanese firms, who can take a longer view of investment returns than the average British company. Most development work is carried out in industry but universities also contribute significantly. Much work was carried out on a "unmanned factory project" financed by the Ministry of Industry and International Trade (MITI). Although this work has now stopped, it has been followed by a major project, budgeted at £25 million over 7 years, to produce a Flexible Manufacturing System incorporating CAM, NC machine tools and automatic transfer equipment. This project is similar in objectives and scope to the Automated Small Batch Production project of the Department of Industry referred to previously.

West Germany

5.7 CAD/CAM systems are principally to be found in the high technology aerospace and semiconductor industries although efforts are now being made to widen the range of application. In the Third Data Processing Programme of the West German Government, £16 million has been allocated over 3 years for promotion of CAD/CAM and the expenditure is expected to be approximately equally split between applications in the electrical engineering, mechanical engineering and construction industries. Government support for CAD in the machine tool industry is extensive. One object of the Third Data Processing

Programme is to promote the use of CAD/CAM in medium-size firms. This is being tackled through project groups in which joint development work is carried out by users, consultants and universities. The university input to CAD/CAM development is significant with programmes at the major industrial institutes such as Aachen and Stuttgart.

6.8 We gained the general impression from suppliers and multinational firms that German industry was more receptive to the introduction of CAD/CAM than British industry. As with Japan, higher labour costs will be an important factor. While the United Kingdom does not appear to be too far behind in applications at the moment, the gap could rapidly increase.

France

5.9 Applications of CAD/CAM in France do not appear to be as numerous as in West Germany although again high technology firms in the aerospace and electronics industries and vehicle manufacturers have working systems. CAD systems are also in use in the public sector, eg in the design of railways and motorways. However the French government are making a major effort, under the Ministry of Industry, to create awareness of computer systems in general in industry and a principal aim is to encourage small and medium-size firms to use CAD. Short courses in CAD are to be provided for the managers of such companies. At present, though, there is very little government-sponsored research.

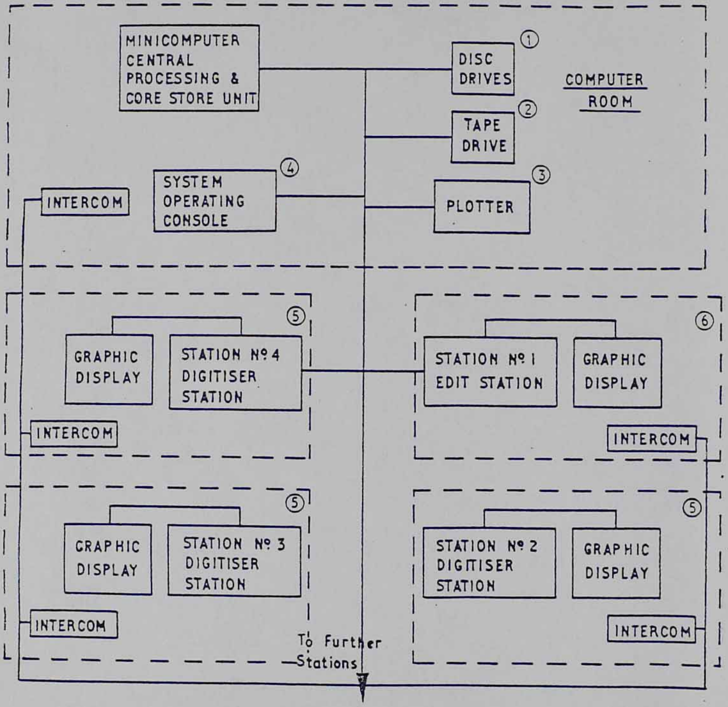
THE SUPPLY OF CAD/CAM EQUIPMENT

6.1 CAD/CAM systems employ machines ("hardware") and computer programs ("software"). Hardware is of two types: specialised devices such as graphics display systems which have been developed primarily for CAD/CAM applications, and general purpose computers, the most common examples of the latter being the minicomputers on which CAD/CAM programs run. Similarly, software may be designed for specialised purposes (eg a computer manufacturer's system for designing its own semiconductor devices) or relatively general use (eg a stress analysis package). Fig 2 shows the components of a typical computer aided draughting and design system.

6.2 A firm wishing to use CAD/CAM is faced with an initial choice of whether to build its own system (probably from available sub-units), or to buy one 'off the shelf'. The extent of the choice depends on the application. Where CAD/CAM systems of fairly wide applicability can be employed, the equipment supply industry can in general provide them, in the form of packaged systems and generalised software packages. This applies especially in the case of computer aided draughting, where systems running on mainframe and minicomputers are available together with generalised software packages. Such systems often originated as in-house developments by American aerospace companies. Hence most hardware and software is of American origin, though one British company is offering a CAD/CAM system and there are some minicomputer based systems for particular purposes such as printed circuit board design and circuit analysis.

6.3 Many draughting systems have provision for preparing the tapes required by numerically controlled tools; in addition such facilities are available on a bureau basis, as discussed earlier. But when considering CAD/CAM systems of a more fully integrated form, using a central production database, it is clear that the needs of individual firms can vary greatly and are unlikely to be fulfilled solely by an off the shelf system. Several of the firms that we consulted were in the process of comprehensive analysis of their CAD/CAM needs. It was clear that availability of software was thought to be a much bigger problem than availability of hardware, and that there was a general difficulty in obtaining advice on the selection of systems.

COMPUTER AIDED DRAUGHTING & DESIGN SYSTEM



①	DISC STORES:	for current drawings and component information
②	TAPE STORES:	for completed drawing information
③	DRUM PLOTTER:	for production of physical drawings
④	OPERATING CONSOLE:	including line printer for programs etc.
⑤	WORK STATIONS:	digitiser board for new drawings; graphical display of drawings, alphanumeric display of systems commands etc.
⑥	EDIT STATION:	for program development; graphical and alphanumeric displays, and electronic keyboard.

Fig 2

7. CONCLUSIONS AND RECOMMENDATIONS

General

7.1 Our first broad conclusion is that CAD and CAM are already benefitting parts of United Kingdom industry but that greater economic advantage could be obtained from wider adoption of these technologies. We have found clear evidence that the productivity of drawing office staff and skilled industrial workers can be enhanced considerably by the introduction of CAD or CAM systems. The major users in this country tend to be large firms in relatively 'high technology' industries.. Systems have up to now been too expensive, for medium-sized and small firms, but the declining cost of equipment, as a result of microelectronics technology, now brings the advantages of CAD/CAM to a wider range of firms. We expect this trend to continue.

7.2 The potential benefits of CAD/CAM to mechanical engineering are at least as great as in other sectors. Most systems, however, are sold to the electronics and aerospace industries. We believe that many firms outside high technology are insufficiently aware of the potential benefits of CAD/CAM. The United Kingdom is noticeably but not irrevocably behind a few countries in some areas of application, and the gap will increase if CAD/CAM plans overseas (particularly in the USA, Japan, West Germany and France) are successfully implemented and not matched by comparable United Kingdom progress. In the following sections we identify a number of obstacles to the use of CAD/CAM in the United Kingdom industry and recommend action by Government and others aimed at reducing them.

7.3 Our second broad conclusion is that although the importance of CAD/CAM has been recognised in government and elsewhere for some time, efforts to develop and promote it have been fragmented. Hence a theme in our recommendations is the need for increased co-ordination of research and for a focus for activities designed to promote the wider adoption of CAD/CAM. We believe that this will result in more effective use of the manpower and financial resources now employed.

Increasing general awareness of CAD/CAM

7.4 We have concluded that more effort should be directed to acquainting industry with the potential of CAD/CAM.

> We recommend that the Department of Industry should take responsibility for producing and disseminating (through courses and seminars) information on typical costs of installation and on the training needed for using CAD/CAM systems effectively. Case histories of successful installations showing how pitfalls can be avoided should be included.
> As with the current microelectronics awareness programme, all levels of management need to be informed of CAD/CAM. The Department should seek the assistance of professional institutions in their task.

ACARD made a similar recommendation in respect of microelectronics, which potentially affects the products of working methods of every firm. The impact of CAD/CAM will be more limited and we would judge the required expenditure to be considerably less than for promoting awareness of microelectronics applications. We suggest that an initial budget of the order of £1.5 million to be spent over, say, 3 years should be provided.

> We also recommend that in order to keep its advice up-to-date the Department of Industry should maintain close watch on developments overseas, if necessary by retaining specialist consultants for the task.

7.5 There is no substitute for first-hand experience if people are to become aware of the potential of any new technology.

> We therefore recommend that the Government should sponsor able young people to work for a period overseas to learn about and participate in developments in CAD/CAM. We suggest that this might be conveniently arranged through awards by the Fellowship of Engineering and an initial budget of about £100,000 annually might be appropriate.

Provision of advice on CAD/CAM

7.6 Companies in sectors where CAD/CAM can be cost-effective but is not yet a commercial necessity need a source of accurate and impartial information to help them in evaluating their CAD/CAM requirements and choosing and installing CAD/CAM systems. Many rely on the system suppliers for such advice. In time, no doubt, such companies will turn naturally to specialist independent consultants but at this early stage in the development of CAD/CAM technology, where rapid developments are taking place which require the provider of advice to be closely linked with current R and D activity, we consider that the Government's own establishments should play a significant role. Both the CADC and NEL already offer advice and undertake development work on contract. We see advantage from industry's point of view if their activities were linked more closely with the creation of a single nationally recognised organisation for advice and development work on CAD/CAM, even if, at least initially, the work continues in its present two locations. For convenience, we refer to this below as an Institute for Computer Aided Engineering. We emphasise this would not be a totally new body but a more effective way of organising the work now in progress. We judge the level of effort now devoted to R and D in CAD/CAM to be not inappropriate to the needs of the subject. Naturally we would be pleased to see greater resources given to CAD/CAM but we think the first priority is to make the best use of the resources now available.

> We recommend that the Department of Industry should arrange for the advisory and bureau services already provided by the National Engineering Laboratory and the work on software development of the Computer Aided Design Centre to be co-ordinated so that they form a single organisation (or Institute) for Computer Aided Engineering, with a single Director responsible to a Board of Management whose non-executive Chairman and at least half its non-executive members should be drawn from industry. The work of the new Institute should include -
>
> i. evaluation of available CAD/CAM systems through close links with user companies;
>
> ii. provision of advice on the economics and technical suitability of systems;
>
> iii. supporting government departments with advice on CAD/CAM matters such as investment in R and D, educational requirements and training, and standards.

7.7 The existence of such an organisation would provide the focus referred to in paragraph 7.3 and might well be the appropriate channel for the work we recommend in 7.4.

7.8 The Institute should charge for its services at market rates to meet part of its operating costs, but the Government should recognise its role of making industry more aware of the advantages of CAD/CAM, and allow it adequate financial support. In particular, it should not be limited in its repayment work for industry by any restrictions on public service manpower. The Institute will not however be able to finance its activities as a centre of excellence entirely from charges for its services. If attempted, this would create a conflict of objectives and detract from its role in developing the use of CAD and CAM in industry.

7.9 While considering the future role of the CADC and NEL in CAD/CAM, we are bound to comment that both institutions seem at the moment to be wrongly located, far removed from the main areas of industry that they serve. From comments that we received, it is clear that the inconvenience of getting to either Cambridge or East Kilbride is one deterrent to firms from making proper use of the expertise available.

> We recommend that eventually the Institute should be located on one or more sites nearer the main manufacturing centres of the United Kingdom.

7.10 Whilst we do not believe that the initial creation of the Institute need involve expenditure, we recognise that significant costs will be incurred if physical relocation takes place. The rapid and effective adoption of CAD/CAM by United Kingdom industry is, however, crucial to its future international competitiveness. Modest Government expenditure to provide firms with impartial advice and assistance with the development or adoption of software for their own use will bring large economic benefits. This expenditure will be made most efficiently if a single organisation is responsible for it, and the effectiveness of that organisation will be further enhanced by its ready access to potential users of CAD/CAM systems. In national terms, the cost is small; but the influence of the new Institute should be felt throughout United Kingdom industry.

Assistance with the installation of CAD/CAM systems

7.11 The proposed Institute should undertake on repayment terms preparation of software systems for general use in industry, and the modification of available software to the needs of individual companies, thus continuing the current activities of NEL and the CADC.

> We recommend in addition that the Government should consider how it might further assist companies, particularly those of small or medium size, to adopt appropriate CAD/CAM systems by, for example -
>
> a. supporting demonstration systems in user companies in exchange for availability of information on performance; this would allow companies to gain practical experience in use on their own problems of draughting and manufacture.
>
> b. initial leasing of equipment to companies until they have sufficient experience to show whether purchase is justified.

7.12 We doubt, though, whether any special financial incentives for the purchase of CAD/CAM equipment, other than those relating to all capital investments, are required.

Government use

7.13 The Government can help further by making available the experience of Departments (eg any Ministry of Defence use of CAD/CAM in its own organisation). It could also use public purchasing to encourage the effective use of CAD/CAM by contractors. Further impetus in the use of CAD/CAM can come from nationalised industries through similar measures.

> We recommend that Departments should consider how they can promote economic applications of CAD/CAM through their purchases, and those of the public sector organisations for which they are responsible.

Supply of equipment

7.14 At present most of the CAD systems used in this country are imported, mainly from the USA, but this ought not to be a major inhibition to the introduction of CAD/CAM. There is likely, though, to be a need for smaller, cheaper, systems for use in small companies and in education. This could provide an opportunity for a British company.

> We recommend that the National Economic Development Council, through relevant Sector Working Parties and Economic Development Committees, should consider how these market opportunities can best be tackled.

Linked Business Systems

7.15 The greatest benefits from CAD/CAM may come when systems are integrated with other business activities, as illustrated in Fig 1. These could, however, be lost entirely if CAD/CAM systems develop features that are incompatible with other computer aids to business. Some work aimed at providing more comprehensive computer assistance to manufacturing, aimed particularly at the mechanical engineering sector, is being supported by the Department of Industry. We would like to see further projects oriented towards other sectors of industry.

> We recommend that the Department of Industry should undertake a study of Linked Business Systems to review the present state of availability of such systems and their application outside high technology and large companies. It should decide whether results of any work in high technology industry in this country could profitably be transferred to or adapted for more general use in different sectors of industry and it should identify any work on standards, languages or interfaces which needs to be done to make intelligible, practical systems available.

Co-ordination of research

7.16 We have earlier commented on the fragmentation of research in support of CAD/CAM. The Computer Aided Engineering (CAE) Panel of the Department of Industry and the Science Research Council (SRC) has countered this in part of the field, particularly mechanical engineering, but CAD/CAM (like microelectronics on which it is based) is a technology which can affect all sectors of industry and draws on a number of disciplines. There is an optimum between projects going on in isolation, leading to duplication and lack of application, and over co-ordination, which could be bureaucratic and stifle initiative. Our discussions have convinced us that at the present time, research effort in this country is less than sufficiently co-ordinated and we are paying a penalty for this. We would like to see a strategy developed for each industrial sector in order that the R and D carried out might be related to an overall aim. This would imply also a more active role for the funding agencies in stimulating relevant R and D. At present they largely confine their work to assessing the requests for funding that come from R and D organisations.

> We recommend that the Department of Industry should take the lead in improving co-ordination (if necessary by creating new machinery for the purpose) involving the SRC, Research Associations, sectors of industry liable to use CAD/CAM, and organisations supplying equipment and software, as well as their own and other government establishments concerned. This work would take in the activities of the current CAE Panel and in it the proposed Institute would play a major role. The effort for this co-ordination would not be large and should not, we think, require extra staff.

Industrial collaboration

7.17 Currently there is a lack of cross-fertilisation of ideas between companies. We believe that, even allowing for the need to maintain competition, there are benefits to be derived by companies in the exchange of ideas and experience. The potential benefits to be gained from an increase in communication between companies have been illustrated by the amount of useful cross-fertilisation produced as a result of our own visits and discussions.

> We recommend, therefore, that the Department of Industry, probably through the new Institute, should promote the use of CAD bureaux, user clubs for groups of users of the same systems (in which they could exchange experience) and clubs for development of an exchange experience on common applications software.

Education and training

7.18 Changes in education and training will be necessary if CAD/CAM systems are to be introduced widely and effectively. These need to be aimed at (i) the public at large, particularly through schools but also through retraining schemes for existing staff; (ii) potential users of CAD/CAM who need to appreciate the capabilities of current and future systems; and (iii) potential programmers for CAD/CAM systems.

7.19 We would particularly stress the importance of introducing computing principles in schools. School-leavers must expect when they take up apprenticeships or otherwise enter industry that they will be in regular contact with computers. CAD can also provide a ready entry for girls into engineering and we would wish to encourage this.

7.20 Some experience of CAD should be provided in engineering courses in colleges and universities. This would give all students an appreciation of the subject. But further than this, we consider those now leaving higher and further education are inadequately trained for writing software for computerised engineering systems and more specialised courses are required. In addition, many companies will require assistance from educational establishments in retraining their established staff experienced in the older methods of drawing and manufacture.

<u>We recommend</u> that -

a. more emphasis should be given to computing principles in schools;

b. undergraduate engineering courses should include use of a CAD system for drawing and design, as a logical extension of manual methods;

c. courses should be established for re-education and retraining of existing staff (draughtsmen, designers, engineers, managers) and these should include practical experience with CAD/CAM systems;

d. Universities should prepare post-graduate courses on programming to train students capable of writing major software programmes and of modifying existing software;

e. increased awareness of CAD/CAM should be encouraged, for example by discussions between managements and employees and by meetings promoted by the professional engineering institutions.

Industrial Organisation

7.21 The first ACARD report 'The Applications of Semiconductor Technology' referred to the need to fuse marketing and development capability to deal with the rapid changes expected in product specifications, and the necessity of an inter-disciplinary approach in design. The introduction of CAD/CAM techniques provides both a need and an opportunity for changes in the relationship between different parts of an organisation. If maximum benefits are to be obtained from CAD/CAM, an analysis of these needs and opportunities is necessary and a commitment to implement necessary changes.

7.22 One aspect of such changes will concern what is conventionally understood by 'industrial relations'. The possibility that problems in industrial relations could arise from the introduction of CAD or CAM systems was mentioned frequently by those whom we consulted. We have however come to the opinion after studying the few case histories available, that any problems - which arise from genuine fears and uncertainties - are not insuperable if there are discussions between managements and workpeople at all levels, well in advance of introduction, and there is maximum co-operation in implementation.

7.23 CAD/CAM techniques can be regarded by some as a threat. We think it would be wrong to dwell on the possibility that they may lead to unemployment. Rather we would stress opportunities provided by CAD/CAM for freeing people from routine and boring tasks. Further CAD/CAM can, if properly implemented, give a firm a more competitive position and consequently provide a more secure future for its work force. As a nation we shall be successful in world markets only be increasing the productivity of industry. Increasing market share, obtained through intelligent application of CAD/CAM techniques, can help keep both skilled and unskilled workers in employment.

> <u>We recommend</u> that, in addition to the educational and training measures set out in the previous section, those offering education in management should include in their courses consideration of the need and opportunity for structural changes that can come with the introduction of CAD/CAM, and the means whereby such changes can be managed without unnecessary friction

Concluding comments

7.24 We return to our two main themes. Awareness of CAD/CAM in UK industry needs to be increased, particularly amongst small and medium-sized firms. That should be the first priority of government policy towards CAD/CAM. Secondly the R and D supported from public funds needs to be more co-ordinated, and focussed on clearer targets. We consider that the creation of a single organisation for advice and development work on CAD/CAM, covering the existing work at the CADC and NEL, would help to achieve these aims. The extra measures to increase awareness might cost in the region of £2 million over about three years. The total cost of our other recommendations, with the exception of any physical relocation of CADC and NEL work (7.10) or any schemes for assisting the adoption of CAD/CAM systems (7.11), is likely to be similar.

7.25 We believe that the changes we have proposed will both improve the competitive position of UK industry and enable more effective use to be made of the public resources now deployed on CAD/CAM. The extra expenditure implied on improving awareness is small, but failure of UK firms to adopt CAD/CAM through lack of appreciation of its advantages will make it that much harder for them to withstand foreign competition.

ANNEX

ORGANISATIONS CONSULTED BY ACARD WORKING GROUP ON COMPUTER AIDED DESIGN AND MANUFACTURE

A. INDUSTRY

B. RESEARCH ASSOCIATIONS

C. NATIONAL CORPORATIONS

D. ACADEMIC INSTITUTIONS

E. PROFESSIONAL INSTITUTIONS

F. CONSULTANTS AND CONTRACT RESEARCH ORGANISATIONS

G. GOVERNMENT DEPARTMENTS AND ESTABLISHMENTS

H. CAD/CAM EQUIPMENT SUPPLIERS

I. OTHERS

A. INDUSTRY

- *APV
- BAKER PERKINS
- *BICC
- BP
- BRITISH AEROSPACE
- BL CARS
- BRITISH SHIPBUILDERS
- DELTA METAL CO
- FERRANTI
- *FORD MOTOR CO.
- GEC
- GKN
- HAWKER SIDDELEY GROUP
- IMPERIAL CHEMICAL INDUSTRIES
- INTERNATIONAL COMPUTERS
- LUCAS GROUP
- SIR ROBERT McALPINE AND SONS
- NEI PARSONS
- PERKINS ENGINES
- PHILIPS INDUSTRIES
- PLESSEY
- RACAL ELECTRONICS
- ROLLS ROYCE
- STANDARD TELEPHONES AND CABLES

*No substantive response received

B. RESEARCH ASSOCIATIONS

BRITISH INTERNAL COMBUSTION RESEARCH INSTITUTE

ELECTRICAL RESEARCH ASSOCIATION

FABRIC CARE RESEARCH ASSOCIATION

FURNITURE INDUSTRY RESEARCH ASSOCIATION

MACHINE TOOL INDUSTRY RESEARCH ASSOCIATION

PRODUCTION ENGINEERING RESEARCH ASSOCIATION

RUBBER AND PLASTICS RESEARCH ASSOCIATION

SHOE AND ALLIED TRADES RESEARCH ASSOCIATION

SHIRLEY INSTITUTE

SIRA INSTITUTE

WOOL AND TEXTILE INDUSTRIES RESEARCH ASSOCIATION

C. NATIONAL CORPORATIONS

BRITISH GAS CORPORATION

CEGB

* POST OFFICE

D. ACADEMIC INSTITUTIONS

CAMBRIDGE UNIVERSITY ENGINEERING DEPARTMENT

SCIENCE RESEARCH COUNCIL

WOLFSON CAMBRIDGE INDUSTRIAL UNIT

E. PROFESSIONAL INSTITUTIONS

*BRITISH NUMERICAL CONTROL SOCIETY

CRANFIELD INSTITUTE OF TECHNOLOGY

INSTITUTION OF ELECTRICAL ENGINEERS

INSTITUTION OF MECHANICAL ENGINEERS

INSTITUTION OF PRODUCTION ENGINEERS

F. CONSULTANTS AND CONTRACT RESEARCH ORGANISATIONS

ARTHUR D. LITTLE INC.

ASSOCIATION OF INDEPENDENT CONTRACT RESEARCH ORGANISATIONS

COMPUTER AIDED MANUFACTURING INTERNATIONAL INC.

COOPERS AND LYBRAND ASSOCIATES

FREEMAN, FOX AND PARTNERS
INGERSOLL MANUFACTURING CONSULTANTS
OVE ARUP PARTNERSHIP

RICARDO CONSULTING ENGINEERS
SYSTEC

W S ATKINS AND PARTNERS

G. GOVERNMENT DEPARTMENTS AND ESTABLISHMENTS

UNITED KINGDOM EMBASSY, BONN

UNITED KINGDOM EMBASSY, PARIS

UNITED KINGDON EMBASSY, TOKYO

UNITED KINGDON EMBASSY, WASHINGTON

DEPARTMENT OF EMPLOYMENT

DEPARTMENT OF THE ENVIRONMENT

DEPARTMENT OF INDUSTRY (COMPUTER AIDED DESIGN CENTRE AND NATIONAL ENGINEERING LABORATORY)

DEPARTMENT OF TRANSPORT

MINISTRY OF DEFENCE (ROYAL ORDNANCE FACTORIES)

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

H. CAD/CAM EQUIPMENT SUPPLIERS

APPLICON

CALCOMP

CALMA

COMPUTERVISION

DAVY COMPUTING

FERRANTI CETEC

TEKTRONIC

UNIGRAPHICS

I. OTHERS

AMALGAMATED UNION OF ENGINEERING WORKERS (TASS)

CBI

DESIGN COUNCIL

ENGINEERING INDUSTRY TRAINING BOARD

LANIGAN, PROFESSOR M J - UNIVERSITY OF KENT (CHAIRMAN OF JOINT D OF I/ELECTRONIC ENGINEERING ASSOCIATION STUDY ON CAD/CAM)

NATIONAL COMPUTING CENTRE

ASTMS

TUC

WEST GERMAN EMBASSY

CABINET OFFICE

ADVISORY COUNCIL FOR APPLIED RESEARCH AND DEVELOPMENT

TECHNOLOGICAL CHANGE: THREATS AND OPPORTUNITIES FOR THE UNITED KINGDOM

November 1979

ADVISORY COUNCIL FOR APPLIED RESEARCH AND DEVELOPMENT

TECHNOLOGICAL CHANGE: THREATS AND OPPORTUNITIES FOR THE UNITED KINGDOM

FOREWORD

Previous ACARD reports have considered specific technologies ("The Applications of Semi-Conductor Technology", September 1978 and "Joining and Assembly", October 1979) or relatively narrowly defined institutional arrangements ("Industrial Innovation" February 1979). This report deals with a wider subject - technological change and the threats and opportunities for United Kingdom arising from technological change over the next ten to fiteen years.

The Council believe that excellence in technology and its applications is critical to the prosperity of an international trading nation such as the United Kingdom. We wish the Government to be fully aware of the opportunities that new technologies offer for improving the country's general standard of living. But at the same time we are aware of widespread concern about existing and potential levels of unemployment - concern which is deepended by a prospective growth in the labour force of 2 million people by 1991 - and uncertainty about the extent to which technological change will reduce overall requirements for labour or make traditional skills out-moded. It is not ACARD's function to propose employment or social policies to accommodate these changes, but we recognise that a strategy for applied research and development, which must be one component of the Government's overall approach to industry, cannot be formulated in isolation from its social and economic context. This report seeks to highlight the main threats and opportunities provided by new technologies that must be taken fully into account by the Government in the development of broader social and economic policies.

Like previous ACARD publications, this report is the outcome of a working party study. The terms of reference of the Council's working group were -

i. to project the impact of technological change on employment opportunities in the United Kingdom and

ii. to report on implications for applied R & D strategy.

Its membership was:

Sir James Menter FRS (Chairman)

Sir John Atwell

Mr J Lyons

Sir Ieuan Maddock FRS

Mr G H Wright

The Council received and endorsed the Working Group's report in October 1979. [It is now published as a contribution to the current debate on the implications of technological change.]

The Council wish to thank the members of the Working Group for tackling such a wide-ranging subject and to acknowledge the support provided for the study by the Central Policy Review Staff and the ACARD Secretariat.

CONTENTS

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

1. The rate of technological innovation in United Kingdom industry will need to increase if its products and manufacturing processes are to match those of our major competitors. This is a necessary condition of our future survival as a trading nation.

2. We have not been able to quantify the likely effects of technological changes on overall employment levels. Employment in many of our existing manufacturing enterprises will undoubtedly fall if their productivity is raised to meet that of our competitors. But more unemployment results from loss of market share following a failure to innovate than from the introduction of new technology. Conversely, if new technology leads to an increase in market share there is generally an increase in employment opportunities.

3. Industries capable of generating substantial new employment should be identified and fostered. Different sectors of industry require different forms of technological innovation; each sector should have a strategy to establish technological goals. The employment consequences of technological change will vary between sectors; reduction in employment in one will provide the labour resource required by another. Technological strategies therefore need to be developed in an institutional framework structured by sectors but covering all of industry. The National Economic Development Council and its supporting organisation seems the most suitable body for this purpose, both for these reasons and because it is able to provide continunity of purpose over the long periods that often separate new ideas from marketable products or processes.

4. There are many areas where United Kingdom technology is internationally competitive and where our scientific effort remains outstanding. But in recent years R and D expenditure by United Kingdom industry has declined disturbingly compared with that of other countries. This trend needs to be reversed, while at the same time industry should be encouraged to acquire already proven technology from abroad.

5. New and small firms utilising high technology are important as creators of new manufacturing employment opportunities. Their expansion may be limited by insufficient cash flow in early years to support necessary R and D programmes.

6. The service sector of industry, both in traditional services and in the service occupations associated with manufacturing activities, has substantial potential for employment. These should be enhanced. More R and D (for example in information processing and distribution, software services, computer aided design, etc) could accelerate the potential of service sector employment without necessarily imposing a further overhead charge on the manufacturing sector.

7. New technologies can provide new opportunities for employment as well as threats to existing jobs. But these opportunities will only occur if as a country we are willing to accept the changes in work organisation associated with them. New technology means new products and new working methods. Old organisations and their now obsolete working methods will have to be discarded.

8. Principal recommendations, concerned essentially with R and D strategy, are as follows -

i. The development of technology strategies for different industrial sectors should form an integral part of the NEDC Economic Development Committee (EDC) and Sector Working Party (SWP) studies. The R and D programmes of the Department of Industry's Requirements Boards and of Research Associations, and the relevant parts of Research Council programmes, should be aligned with these strategies.

ii. In this work the EDCs and SWPs should pay particular attention to the interfaces between industrial sectors and the potential industries that might be created by the combination of technologies from different sectors.

iii. The Department of Industry should study how Government can foster the rapid development of new industries based on emergent technologies, in particular information technology and biotechnology, and of industries with high growth potential arising from the increasing need to conserve energy and materials.

iv. The Department of Industry should examine how the transfer of technology into the United Kingdom can be facilitated and in particular the case for establishing a new agency (or inviting an existing institution in the public or private sector to extend its role) for this purpose.

v. The Department of Industry and the Foreign and Commonwealth Office should review staffing policies in both technical and commercial sections of major overseas posts to see whether more engineers should be appointed to them.

vi. Government should examine how industrial enterprises can be encouraged to strengthen their R and D capabilities.

vii. Government should pay greater attention to the technological needs of small firms, in particular -

a. The Department of Industry should consider measures Government might take to help small businesses to overcome obstacles to long term viability and growth arising from inadequate technological resources. ?

b. Large companies with R and D results that they do not intend to exploit commercially should be encouraged perhaps through fiscal means to set up or seek out small firms better able to utilize such results. ?

c. Government and industry should consider whether small firms could benefit more from consultancy services in technology such as the Manufacturing Advisory Service of the Department of Industry and the Design Council's Design Advisory Service and should in particular consider the role that experienced executives from larger companies may play in such consultancies.

d. Provision of information on foreign technology through the Research Associations should be strengthened.

viii. The Department of Industry should examine the scope for more R and D directed towards enhancing employment opportunities in service industries, particularly those with export potential, eg information processing and distribution, software and systems design and CAD.

Additional comments of a more general nature that may call for action are as follows -

ix. It would be prudent for government to maintain a close watch on the availability of key materials and support R and D which may enable more widely available materials to be used. (3.8)

x. Government should examine the machinery by which the United Kingdom tenders for large overseas projects and consider whether in certain industries closer relationship should exist between the public and private sectors. (4.3)

xi. The public sector's purchasing power should be used to improve our competitiveness in overseas trade. The Government should consider whether analogues of the Defence Sales Organisation of the Ministry of Defence Procurement Executive are required. (4.14)

xii. Studies to investigate the role of small firms in job creation should be initiated. (5.2)

xiii. The balance between public and private funding of training requires attention and the case for an earnings related "training-benefit" entitlement, which could be earned through a certain number of years in employment, should be examined. (5.6)

xiv. The Government and the higher education institutions should consider the present mismatch between the supply and demand of graduates for industry and in particular the number of places in undergraduate courses in electronic engineering, computer science and information technology. (5.7)

xv. Industry needs more stability in fiscal and economic matters in order to cope with the greater uncertainties now inherent in technological advance; politicians must recognise that the successful adoption of new technology demands a greater consensus about policies that affect industry than has been the case in the past. (2.4)

ADVISORY COUNCIL FOR APPLIED RESEARCH AND DEVELOPMENT

TECHNOLOGICAL CHANGE: THREAT AND OPPORTUNITIES FOR THE UNITED KINGDOM

1. Introduction

1.1. The two basic questions faced by the Working Party as we began our study were:

i. What are the technological changes likely to have a significant impact on employment, either in terms of numbers employed, or in terms of the type of job required, in the next ten to fifteen years?

ii. What are the consequences for employment of these changes?

1.2. To answer the first, we invited submissions from many organisations, including Government Departments, Research Associations, trades unions, universities and industrial bodies. We would like here to acknowledge the help that we obtained from them. Chapter 3 of this report draws extensively on the evidence that we received.

1.3. As a guide to the second, we examined the literature on the relationship between technological change and employment.* We found two basic positions. The first focusses on the potential for displacing labour through automation or by radical redesign of the product (or by a combination of the two). Proponents of this, microeconomic, viewpoint concentrate their attention on those industries with the greatest potential for substitution of labour by machines and sometimes appear to overestimate the influence of technology on manning levels. Moreover, new technologies are often adopted at a slower rate than is forecast in their early stages.

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* A useful summary can be found in "Technical Change and Employment" a report prepared for the Six Countries Programme by the Science Policy Research Unit, University of Sussex.

Thus although this approach can produce illuminating results for individual developments or sectors of the economy, it does not provide a satisfactory framework for determining the impact on the economy as a whole.

1.4. The other point of view is that higher productivity, resulting from technological change in particular sectors of an economy, is likely to lead in the long term to an increase in employment in those and related sectors because of increased demand for their products. The typewriter is often quoted as an example of an innovation that was expected to reduce the demand for labour, but in fact contributed to a considerable increase in demand. The rate of technological change is not, according to this view, a major determinant of the level of employment. In each sector of the economy, this level will largely be determined by domestic demand and the sector's share of world trade, while slow productivity growth results in lower relative incomes, rather than higher unemployment. A recent cross-sectoral study of the United Kingdom economy[1] provides some support for this view.

1.5. We formed the view that the second of these approaches provides a more balanced framework for any consideration of the impact of technological change on employment. We are certain that the share of world trade held by the United Kingdom in any particular industrial sector is a crucial factor in determining both the general employment level and the security of employment in that sector. But as we continued with our study, we realised that a comprehensive examination of the effects of technological changes on

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[1] Post War Trends in Employment, Productivity and Output in the United Kingdom: Department of Employment Working Paper No.4.

employment on future levels of employment was beyond the resources of ACARD. Indeed we wonder whether the uncertainties that must inevitably surround such an examination - over the level of world trade, the pace of introduction of innovations and the prospects for energy supplies, for example - are not so great as to render precise numerical predictions impossible.

1.6. Further, we came to question the view that the worst that the United Kingdom has to fear from a failure to adopt new technology is a slower growth in real incomes. The large changes in productivity which our competitors could achieve from some of the technologies discussed later in this report, and the growing importance of the low wage newly industrialised countries pose severe threats to this country's present markets. New production methods also lead to products of higher and more consistent quality; if we retain outdated methods, we shall lose markets because of the inferior quality of our goods. If we are to continue to be a trading nation (and our requirements for food and raw materials from overseas give us no option) these threats must be overcome. We have no option but to attempt to match the productivity and product quality of our overseas competitors, to concentrate our efforts on those industries where we have most chance of success, and to adopt as fast as possible technical innovations from abroad, as well as those developed at home, which will enable us to do this.

1.7 The problems posed by new technology were amply illustrated when automation first started to make an impact on production processes in the early 1950s. This did not have the dire effects on employment that were forecast at the time, partly because the 1950s and 1960s saw a great expansion in world trade and parlty because automated methods of production never became as widespread as some had predicted. Nevertheless, the United Kingdom's share of the world market for manufactured goods has more than halved in that time, from more than 20 per cent to around 8 per cent.

There are important lessons to be learned from the debate on automation of the 1950s and our failure to make a sustained effort over the following decades to reap the advantages that others, notably Japan and Germany, have gained. In our view, these are -

a. that certainly in the long term, but often in the short term also, more unemployment results from loss of market share following a failure to innovate than from the introduction of new technology;

b. that, conversely, if the introduction of new technology by a firm leads to an increase in its market share, then there is almost invariably an increase in employment opportunities in the firm that introduces the new technology;

c. that introduction of improved technology can not only raise material comforts and increase leisure but can provide in addition more interesting jobs and better working conditions;

d. that an increase in productivity in service industries often leads to greater variety or quality in the service provided rather than to a reduction in numbers employed;

e. that changes to systems, as opposed to isolated products, always occur more slowly than is theoretically possible or predicted by specialist commentators, and that therefore large-scale changes in employment are unlikely to occur rapidly;

f. that the introduction of new technology is likely to reduce demand for skilled but routine jobs while increasing the number of mentally demanding jobs. (There is a corresponding need for more retraining measures, particularly for the unskilled and those with obsolete skills.)

g. that attempts by firms or industries in the United Kingdom to avoid competition from technologically more adept foreign competitors by specialising in certain (usually high-priced) sectors of the market (eg the motor cycle industry), by continuing to accept lower real wage rates and higher manning levels (eg the motor car industry) or by adopting restrictive trading practices (eg the textiles industry) are ultimately doomed to fail. At best such strategies buy time and preserve some of the existing employment opportunities for a limited period.

1.8. Failure to note these lessons, when faced with future technological challenges, could result in our rapid decline. Our report focusses on the ways in which we may as a nation meet these effectively. It remains therefore a report on "the impact of technological change on employment opportunities", to quote our terms of reference, for there will be few worthwhile employment opportunities in this country if we do not successfully meet the competition ahead. But we do not attempt to quantify the impact of individual innovations on job numbers, instead we deal broadly with the response that the United Kingdom should make to the technological developments that will come over the next few years, and the consequences for applied R and D.

2. The Social, Economic and Political Environment

2.1 The relationship between technological change and social change is complex. Causes and effects are not easily distinguished and there is growing debate about the extent to which the one is driven by, or responds to, the other. There is little doubt, however, that many desirable social changes can only be achieved by generating additional wealth. Technological innovation can help to create that wealth but over the last fifteen to twenty years, the competitiveness, and therefore the wealth creating power, of United Kingdom industry has diminished because as a nation we have failed to take maximum advantage of technological developments.

2.2 The Council's earlier report "Industrial Innovation" listed (p 11) some of the factors which have hindered the application of technological resources for the improvement of the competitiveness of the United Kingdom industry. These factors, and others such as the decline in the proportion of our GNP devoted to civil R and D, particularly in mechanical engineering, in combination have led to an environment in the United Kingdom which is less receptive to industrial change than in many other countries. We have never been a "fast growth economy" (even in the 19th century) in the way Japan, France or West Germany have been in the last two decades. By comparison with our own past, our performance in recent years has not been bad. But to keep pace in the modern world our standard of comparison must not be our own industrial history but the present industrial performance of our competitors.

2.3 There are signs of change in some areas. The "swing from science" and more particularly from engineering amongst the young seems to have halted. There is growing awareness of the need to concentrate, not only on the number of engineers we produce, but also on their quality and deployment. Detailed proposals on this and many other aspects of the use of engineering resources in manufacturing industry will come from the enquiry into the engineering profession under Sir Monty Finniston. The importance of adequate incentives both for individual entrepreneurs and employees in innovative industries is becoming more widely recognised. Successive governments have taken steps to improve these, and also to alleviate legislative and fiscal burdens on companies, particularly the smaller firms which frequently create new jobs through technological advances.

2.4 These changes are welcome but affect only a few of the attitudes and policies - on, for example, labour relations and the work environment, housing, pensions and education - that bear on our ability to adapt to technological change. We do not comment further on these, but we wish to stress the importance for technological advance of stability in economic policies. "Industrial Innovation" drew attention to the long time, perhaps ten or fifteen years, that could elapse between the initial investment in a major industrial project and the point at which it became profitable. In that time, a competitor's new product or process can render the investment unprofitable. Technological change therefore implies risk and uncertainty; government policies should not add to this unnecessarily. Industry needs more stability in fiscal and economic policies in order to cope with the greater uncertainties now inherent in technological advance. Politicians must recognise that the successful adoption of new technology on a large scale demands a greater consensus about policies that affect industry than has been the case in the past. Our major competitors have found that concensus; we still need to find it.

2.5 Some sectors of United Kingdom industry would no doubt wish that the rate of technological change could slow. But we see no reason to expect this and no possibility either of shielding our industries from the consequences of rapid advance elsewhere. The United Kingdom market is less than 10 per cent of the total world market for manufactured goods. We will therefore have to move at the pace set by international competition, and domestic pressures will act to reinforce the need for technological advance. On the international scene, developing countries will increasingly wish to transform their raw materials into finished products themselves, thus removing some of our traditional markets for products with a low technological content. This process is aided by the ready availability of the skills and technology needed for certain "basic" industries, notably steel-making, vehicle assembly and shipbuilding, where countries such as Brazil, South Korea and Taiwan have invested in plants designed for world markets and incorporating the latest technology. If we are to compete, we must accelerate the adoption of cost-reducing technologies in our own plants, a policy recognised by many employers and acknowledged in the TUC report "Employment and Technology". But there will also be new markets in these countries for products with advanced technological features. To identify and meet the market opportunities thus presented will be a major problem in the coming decades.

2.6 Domestic pressures for technological advance will come from the increasing real cost of energy and raw materials and the desire for a cleaner and safer environment, both at work and more generally. Technologies which allow recycling and re-use will be encouraged, as pointed out in the ACARD report "Joining and Assembly", as will those that reduce waste in manufacture and increase product life. These technologies are already encouraged by most governments in advanced industrial countries.

2.7 The high and increasing "entrance fees" now required before a research advance can be turned into a marketable product further reduce the United Kingdom's ability to influence the rate of adoption of technology since they lead to international collaboration in development and marketing, either by governments or multinational corporations.

2.8 It follows that (a) we can expect no reduction in the rate of technological advance and (b) that the United Kingdom will need to adopt new technology more rapidly than in the past simply to keep up with the competition. We discuss in the next chapter, by way of illustration only, likely changes over the next decade in some selected areas of technology.

3. SOME MAJOR TECHNOLOGICAL CHANGES LIKELY IN THE NEXT DECADE

Microelectronics

3.1. The Council's first report drew attention to the importance for United Kingdom industry of this technology and we will not therefore discuss its implications for products and services further here. We note with satisfaction that nearly all the recommendations of that report were adopted. Microelectronics, of all the new technologies, carries the largest potential for destroying or transferring existing jobs, and also for creating new ones. We have not been convinced by the widely-publicised estimates that have been made that microelectronics may cause unemployment to rise to 5 million or more. It is relatively easy to estimate the number of jobs likely to be displaced in different industrial sectors; the Six Countries report "Technical Change and Employment", to which we have referred previously, usefully discusses the potential impact of microelectronics on certain sectors of both manufacturing and service industry. But we have seen no reliable estimate of the number of jobs that will be created through the introduction of new products and services and the improvement of existing ones. Indeed, this number is so dependent on the vigour with which United Kingdom industry adopts microelectronics that we consider it essentially unpredictable. The net effect on employment is therefore unknown. We are sure, however, that the improvement in the quality and reliability of United Kingdom products that microelectronics can bring about will do much to ensure secure jobs in the United Kindom manufacturing sector.

3.2. As a further note on this topic we refer back to the lessons from automation that we listed in paragraph 1.6. It may well appear in the future that the rate of introduction of microelectronics around the world is slower than its enthusiastic advocates presently predict. United Kingdom industry thought the same of automation, and as a consequence failed to pursue it with sufficient vigour. Microelectronic technology affords us a similar opportunity to improve our industrial performance; we must not let it pass in the same way.

Information Technology

3.3. Among the many potential uses of microelectronics, we wish particularly to highlight the emergent field of information technology where sequences of logical operations are performed on data of all kinds, including textual material. Input keyboards and output visual display units, information processing microelectronics and appropriate communication links (which we expect will increasingly employ optical fibres), form the essential "hardware" ingredients of information technology, for which we envisage great market opportunities in the next decade. However, the "software" aspects of information technology offer equally exciting opportunities. Microprocessor programming is a highly skilled, labour-intensive activity in which this country has, partly as a result of the international use of the English language, certain competitive advantages. The United Kingdom should seize these advantages by putting together our existing skills in service industries (such as consultancies and financial services generally) and our acknowledged expertise in software writing to devise new exportable services. While software services can be marketed independently of specific hardware, the marketability of both can be substantially enhanced by their combination.

Energy Technologies

3.4. Beyond 1985 it is likely that fuels other than oil will have to meet any increase in world energy demand. They will in addition have to compensate for a slowly falling oil supply. It will become increasingly important to use oil preferentially for petrochemical feedstocks and those forms of transport where it has an overwhelming advantage. This will require implementation of extensive R and D for the development of novel sources of energy, the exploitation of established sources of fuel such as coal, and for new conservation techniques. Together, conservation measures and the development of alternative energy sources should ensure that oil will be available for these two essential sectors well beyond 2000.

3.5. Savings in space and process heat can be made by a combination of improved design, insulation and control, with consequent opportunities for innovation. A substantial demand for insulation products and services in the home should provide increased employment opportunities in a relatively labour intensive industry. With final energy supply increasingly dominated by electric power, the heat pump is likely to find widespread use for space heating. The world market for improved control systems for space heating - again no doubt employing microelectronics - is bound to grow. Our traditional strength in coal production and utilisation should be a major national advantage as other countries turn increasingly to coal for their energy supplies. Similarly, our experience in nuclear power, if effectively organised, should be of considerable commercial value.

3.6. But if we are to take full advantage of future opportunities, our energy supply industries must provide a steady flow of orders so that their United Kingdom suppliers can, in turn, maintain the necessary intensity of R and D effort. Further, our own industries should, in their specifications and ordering patterns, bear in mind the needs and standards of international markets. Those responsible for setting standards for energy conservation devices and heating control systems should similarly take into account the need to comply with foreign standards and building codes. The general relationship between R and D carried out in support of public sector purchasing and the international competitiveness of the United Kingdom based supplying industries is being studied by another ACARD work group.

Materials Technology

3.7. Shortages of key elements through exhaustion of natural resources other than oil and natural gas are unlikely to be a serious world problem in the next 10-15 years although they may become an important constraint on industrial activity in the next century. However, within the shorter time scale, shortages resulting from political actions are a distinct possibility. Whether or not these occur, the inevitable increase in the energy cost of extraction and processing of all materials will cause pressures for substitution by other, cheaper materials.

3.8. High technology products are likely to form an increasing proportion of our industrial output and the rarer elements, albeit in relatively small quantities, are frequently essential to the design and performance of these products. Special steels and catalysts are examples. It would be prudent for the government to maintain a close watch on the availability of key materials and to support R and D which may enable more widely available materials to be used. We welcome the initiative of several scientific and engineering professional institutions in proposing to establish a forum for examining this problem. The lead time to effective solutions may well be long. If shortages do occur, the United Kingdom, with its negligible indigeous resources, will be particularly disadvantaged against some international competitors.

3.9. New opportunities in material design have resulted from substantial research in the post war years on composite materials. Glass reinforced plastic is perhaps the most common example but there are many others, including glass reinforced cement and carbon fibre composites. The use of such materials and the development of new ones based on similar principles is likely to expand over the next decade as their advantages are established, as engineers become familiar with them and as production technologies are improved for manufacture and assembly.

3.10. There will in addition be increasing emphasis on economy in the transformation of raw materials into semi-finished articles and final products. This will be achieved both by shortening the production route from raw material to finished component and by greater economy in design. Thus continuous casting, with "straight through" secondary processing, will be widely used in the metal industries. More metal components will be formed directly from powders and by improved casting methods, more accurate forming processes will minimise the need to remove metal, and new shaping technologies will displace elaborate fabrication procedures in sheet forming (a change already seen in the introduction of "superplastic" metals). New fastening technologies will affect the ease with which components are recycled. Computer aided design and manufacture will become widespread.

Biotechnology

3.11. Existing industrial technology is based largely on the exploitation of mineral (ie non-renewable) resources using knowledge largely derived from the study of physical and engineering sciences. At some future time we will need an industrial system more dependent on technologies based on the exploitation of biological (ie renewable) resources and biological systems. The transition will be long, and is unlikely to occur as quickly as is currently predicted by the propagandists for "alternative technologies" or "ecological solutions". However, it is possible to see in the present research activities of biologists themes which must form part of any biologically based industrial system:

new techniques of genetic engineering;

enzyme catalysts derived from biological sources;

novel methods for growing cells of all kinds in culture.

These come within the scope of a joint study of biotechnology set up by ACARD, the Royal Society and the Advisory Board for the Research Councils. Without seeking to anticipate the detailed conclusions of our colleagues, we express the view here that new industries, providing new employment opportunities, will emerge from current advances in biotechnology.

3.12. The considerations of this chapter illustrate the two major driving forces for technological change - market pull, eg rising energy costs and technology push, eg microelectronics. Behind both forces there is another of special significance for the United Kingdom - international competition. The relative strength of these driving forces varies from one type of industry to another with correspondingly varied R and D needs. The next chapter deals with the differential impact of these forces and the appropriate R and D response.

4. IMPACTS ON INDUSTRY AND R AND D STRATEGY

Mature Industries

4.1 These industries produce large volumes of essentially uniform products and rely for their competitiveness on low unit cost from economies of scale. Their technology is well established and widely installed internationally. A number of these industries are crucially important to the United Kingdom for strategic reasons (eg steel-making) or for their contribution to the balance of payments (eg vehicle assembly).

4.2 The United Kingdom competes in the world market for the products of those industries not only with advanced industrial nations but also with low wage developing countries, some of whom have substantial export capacity. Their plants, moreover, utilise the latest production technology. Our competitive position in these industries is in general poor, since our labour productivity is relatively low. The use of new technology by our competitors will make it still worse. Future success will depend upon our adopting more efficient manufacturing methods which minimise both the use of labour and the waste of material and energy inputs. R and D priorities must clearly include greater automation of production and the development of more cost-effective designs as well as raising standards of reliability in both manufacturing processes and final products. The quickest results may well require the importation of foreign technology. The Council has already made recommendations on what needs to be done in some relevant fields, e.g. micro-electronics, joining, assembly and robots and has completed a further study on computer aided design and manufacture.

4.3 Even if our productivity improves, however, we must expect to lose traditional export markets in developing countries to new domestic industries. But establishing those industries requires "know-how" and advanced equipment. The resulting opportunities for the United Kingdom to secure large export orders are sometimes lost through insufficient co-ordination between different private and public sector (ie nationalised industry) interests. The Government should examine the machinery by which the United Kingdom tenders for large overseas projects and consider whether in certain industries closer relationships should exist between the public and private sectors.

Small Enterprises

4.4 In 1975, 86 per cent of the total R and D manpower in United Kingdom industry was employed by enterprises with a total employment of 5,000 or more persons, and such firms account for 87 per cent of the total R and D expenditure by industry. They also received more than 90 per cent of the total Government financing of industrial R and D. These figures imply that small businesses spend relatively little on R and D. Indeed, they usually get the knowledge they need from the experience and contacts of their founders than from a formal R and D organisation. Inevitably this experience is going to be limited and there is need for more and better consultancy services in order that small firms can keep up with technological developments. These could be provided by the contract research organisations, Research Associations, Government and industry itself. The CBI stressed to us the key role which older men, with experience in large companies, might play in this context, and we would like to see this idea developed not only by Government (who have already established a Small Firms Counselling Service) but also by the other types of organisations mentioned.

4.5 Small enterprises are sometimes better able to take up and develop new technological advances. The United Kingdom has through small firms maintained its competitive position in some high quality consumer goods such as certain types of textiles and foodstuffs. Technical developments in these areas are, however, more likely to come from high volume mass market producers who can afford the necessary R and D. Their exploitation by smaller firms should be encouraged. Further, not all of a large company's research output will be translated into production. It may be, for example, that the likely volume of sales is small compared with the company's normal lines, or perhaps the requisite manufacturing expertise is not available. Larger companies should be encouraged, perhaps through fiscal measures, to license such developments to companies better suited to undertake their exploitation, or to set up small firms themselves for the purpose.

4.6 Some small firms rely on craft skills which may become scarce and expensive. These would benefit from R and D to enable less skilled workers to undertake some of the tasks now carried out by skilled personnel.

Industries where we have lost competitiveness

4.7 In recent years, United Kingdom imports of finished goods - eg domestic appliances, consumer electronics and office machinery - have increased substantially. It is possible to detect a common sequence of events which has led to a crisis in industries as diverse as cutlery and consumer electronics. In the first stage goods from EEC countries, Japan or from newly-industrialised countries undercut domestic products and secure a significant market share. The home industry's defensive response is to reduce prices, make losses and then retreat into the higher price (and usually more labour intensive) end of the market. In order to maintain its traditional place in the market, it may additionally import and market some of the foreign products under a UK brand name. Overseas firms will then start to compete in this higher price bracket. The UK manufacturer may try to respond at this late stage with plans to increase productivity in those market areas to which withdrawal has taken place. But because the initial withdrawal was purely defensive , the market in that segment is unlikely to be large enough to justify the large scale investment in new equipment and product redesign which is necessary for effective competition. As a result recovery of the lost market is impossible. This kind of pressure is likely to be applied across an increasingly wide range of products over the next fifteen years as Japan and the newly-industrialised countries which have adopted "Japenese" tactics reach the limits of existing markets.

4.8 The Japanese approach investment decisions on the assumption that they will capture a large percentage of the relevant world market. UK manufacturers need to take the same view. The cost advantage of production on a very large scale can at present be great but developments in programmable manufacturing equipment capable of dealing with a variety of products now enable some of the advantages of large-scale automation to be achieved in batch production. More R and D to improve the efficiency of batch production processes typical of United Kingdom manufacturing is required.

4.9 Companies in this category clearly have a strong need to monitor their overseas competitors' design and production technology in order to anticipate attacks on their established markets. Because many of them will be small in relation to their competitors, and also smaller than the enterprises in our first category, they may lack the resources for "technological intelligence" work. One way of meeting this challenge would be to strenthen the capability of the Research Associations for this purpose.

Service Industries

4.10 It is clear that the future success of much of the UK manufacturing sector depends on improving productivity and reducing manning levels. By contrast the UK service sector, despite a post-war growth of productivity lower than in manufacturing, uses labour relatively efficiently by international standards. In deployment of labour, the UK stands at the opposite extreme from Japan, where manufacturing industry has a positive commitment to reducing its labour force but where for example distribution, a major service industry, absorbs 22 per cent of the national labour force. This is almost double the percentage in the UK, and almost as much as the Japanese manufacturing sector.

4.11 The Japanese appear to reap two important benefits from this aspect of their employment policies. First, because the majority of manufactures are traded internationally and the majority of services are not, overmanning in the service sector does very much less harm to the overseas competitiveness of the Japanese economy than overmanning in UK manufacturing does to our own. Secondly, there is much greater benefit in terms of the quality of the product from increased employment in service occupations than in production. Modern technology makes possible substantial reductions in the number of people involved in production and will usually improve the quality of the product. By contrast, almost every kind of service would be improved if there were two people working for every one currently employed - shorter queues at retail check-outs, more rapid attention to customers' queries by sales departments, more personal service in hotels and restaurants etc. Services would cost more - and they are relatively expensive in Japan - but manufactured goods would be cheaper both absolutely and by comparison with imported goods. Home and overseas sales of manufactures expand and the dearer services can be afforded.

4.12 Thus higher productivity in manufacturing through the adoption of new technology should lead to more employment in the traditional service industries for some of the displaced unskilled or semi-skilled workers. Internationally competitive manufacturing processes and the lack of international competitive pressure on these industries will permit them to adopt innovations at a rate appropriate to their own needs and the state of the labour market, rather than at a forced pace. The benefits will often be taken up in providing more or improved services rather than in reduced employment.

4.13 We see additionally the probable expansion of the service side of the manufacturing industries themselves - in the design and maintenance of increasingly complex production plant or in the provision of improved after-sales service. The employment potential of such activities is substantial, although we do not underestimate the problems of getting people to accept change in the nature of their work and to undertake education and training in new skills.

4.14 It follows therefore that R and D which led to new forms of service - which might also generate a market for new types of equipment - would benefit the employment potential of both service and manufacturing sectors. But the detailed specifications that follow from a decision to introduce new technology into offices, shops or schools can determine whether the demand is met from the UK or abroad. This kind of issue has not often arisen before because of the very low level of capital employed in most service industries. Few service providers even in the public services seem to have grasped its implications, and there is need for urgent consideration of how service sector purchasing power can be used most effectively in the interests of UK manufacturers. This may require the creation of special units in major purchasers, possibly modelled on the Defence Sales Organisation of the Ministry of Defence Procurement Executive. The Government, local authority associations and relevant commercial sectors should take steps to examine the problem.

New Industries

4.15 New technologies will create employment opportunities, both in entirely new industries and in industries whose products become relatively more attractive as a result of innovations. Among those, we have already identified the information industry as most likely to mature over the next fifteen years into a high volume industry offering substantial new employment opportunities. This new industry is emerging from the conjunction of several technologies up to now embodied in a number of disparate industries and services in both public and private sectors. A closely related field which we expect to expand substantially is the provision of "processed" information at various levels of sophistication, ranging from simple presentation of information on prices in the shops and on the Stock Exchange to complex bibliographical data banks. The United Kingdom can potentially secure a significant international market share in this major growth industry. But it will require a co-ordinated national strategy if we are to meet international competition, particularly from the USA. Public communications sytems, private equipment suppliers, software houses and service-providing organisations in both public and private sectors will all need to collaborate to ensure the compatability and international acceptability of their products. While Government may not wish to take the lead in developing the necessary overall strategy, we consider that it should initiate and oversee its development; major market opportunities will otherwise be lost.

5. WIDER EMPLOYMENT CONSEQUENCES OF NEW TECHNOLOGY

5.1 Although the number employed in manufacturing in the United Kingdom has fallen from 8.5 million in 1966 to nearer 7 million in 1979, we still have a greater proportion of our labour force engaged in manufacturing than do most of our competitors. There is no doubt that the latter figure would be still lower if United Kingdom manning levels were closer to those overseas. It seems likely that the decline of the last few years will continue. Indeed the argument outlined in the previous chapter leads to the conclusion that only by increasing output per head through the application of labour-saving technology (which with stagnant output implies a reduction in the number employed by those industries) can any employment at all be guaranteed in mature industries in ten years' time. To a lesser extent, because unit labour costs are a smaller factor in our competitive performance, the same holds good even in those industries where our position is at present more secure.

5.2 A further conclusion from the previous chapter is that expansion of employment opportunities must come on the one hand from services of all types and on the other from small firms and new industries. Evidence of the importance of the small business sector in job creation comes from the work of Birch of MIT ("The Job Generation Process") which shows that in the USA -

business firms die or contract at a rate which is high and remarkably constant in different geographical regions;

areas or times of high economic growth and considerable job creation are characterised by a high rate of birth of new firms and an expansion of old ones, rather than a diminution in the rate of death or contraction;

small firms (fewer than 20 employees) were responsible for generating two thirds of all the new jobs in the USA between 1960 and 1976;

of small firms, new ones were the best generators of employment;

the chances of a small, new firm dying soon after birth were also high but for those who survived, the chances of continuing expansion were high.

The pattern in the United States is thus clear - the job-generating firm tends to be small; it is dynamic (or unstable - the kind of firm banks feel nervous about); it tends to be young and it is difficult to reach through conventional Government policy initiatives. We suspect that the situation is similar in the United Kingdom and we would like to see a study similar to Birch's carried out here. If his findings are also true here, the encouragement of new small businesses should feature prominently in job creating initiatives. We have expressed the view previously that small firms tend to be more effective in taking up and developing new technological advances on which expansion and new industries can be based. We recognise that Governments have done much in the past two years to encourage small firms. We ask it to continue to favour this part of our industrial structure and to consider whether initiatives aimed to encouraging small businesses are indeed reaching them.

5.3 Even though we cannot be certain about the net effect on the level of employment of changes in technology, it is clear that the quickening pace of technological change which we predict will cause the nature of many jobs to change more often, leading to greater need for retraining of staff. Evolving products and production processes will require changed skills, but so also will new technologies in service industries. The optimal scale and location of industrial plant may also change. A further consequence may be an acceleration in the rate at which enterprises enter and leave particular markets. As a result, the manufacturing labour force of the future will have to be both more flexible and more mobile. It is not ACARD's role to comment on the current barriers to flexibility and mobility; we merely note that every effort should be made, in the interests of our future industrial performance, to remove them.

5.4 Technological change has considerable implications for the organisation of education and training. The demand for unskilled labour is likely to decrease, while the number of mentally demanding jobs will rise. The unskilled traditionally receive very little training after leaving school. The introduction of labour displacing technology would be eased if access to existing training programmes were easier for the unskilled, but "speculative training" without a clear prospect of employment will have little attraction. The need is therefore for more retraining "on-the-job" or at least within the enterprise.

5.5 The problems that currently exist in the provision of skilled technicians and supporting staff of every kind will become more acute as industry adapts to a faster rate of technological change. HNC, HND and some of the existing City and Guilds courses are being reorganised under the aegis of the Technician Education Council into a more coherent scheme. It is crucially important that this reorganisation be completed as speedily as possible and that a stable structure be devised whereby skilled workers and line supervisors can receive appropriate training and education. What is meant by "appropriate" will almost certainly change at a different rate in different industries as new technologies enter. This will place a great responsibility not only on the Technician Education Council, who will have to react quickly to the changing needs for suitable courses, but also on employers and trades unions who will have to recognise in good time the way "skills" are being redefined.

5.6 The balance between public and private funding of training may need to be reconsidered. Paradoxically, when skills are very scarce - and skills appropriate to new technologies will undoubtedly be scarce initially - employers may be less prepared to fund "off-job" training because of the difficulty of ensuring that the individual returns to work with their previous employer. Recruiting trained people from other firms is more obviously cost-effective. In these circumstances the public sector should accept much greater responsibility for training despite the harmful consequences this will have for the private sector's general willingness to pay for training. The case for an earnings-related "training benefit" entitlement which could be earned through a certain number of years in employment should also be examined by Government. This would again ease the transition between different types of employment, by allowing those under training to receive an income close to their previous wage or salary.

5.7 Universities and polytechnics will need to respond quickly to changing demands. There is already evidence of shortages of graduate level staff in electronics engineering, computer science and information technology. There is a severe shortage of software specialists at all levels, particularly at the highest levels of systems analysis. Higher education institutions can respond fairly quickly by mounting short courses to meet new demands, but current financial restrictions severely restrict their ability to switch resources to provide full undergraduate courses in subjects of high demand. The minimum lead time inherent in the educational process means that students, starting today, will not be effectively employed before the mid-80s. Government cannot afford to delay in making resources available to produce more graduates with the skills required to take advantage of the market opportunities we foresee. Higher education institutions for their part should be more responsive to national needs for vocational education in applied science and technology and will need to develop close relationships with the engineering profession. They should design curricula in these subjects which will prepare students for a working lifetime of accelerating change and enhance the ability of such students to communicate with non technical people.

5.8 Finally, we note that most of the current debate on new technology and employment has been, quite rightly, conducted in terms of the needs of manufacturing industry for better trained workers and managers. But we hope that those in other occupations, particularly the traditional professions, will respond to the new opportunities opened up for them by information and related technologies. Part of the stock-in-trade of a teacher, doctor, lawyer or administrator consists of the ability to manipulate a specialised set of data according to logical rules. Since this is just what the new generation of microprocessors are designed to do there will be considerable changes in the work of these professions in future. The research on computer-aided diagnosis of medical complaints, for example, has shown how this can benefit both patient and doctor. The professions, like manufacturing industry, will have to abandon present training methods and work procedures when they have outlived their usefulness.

CONCLUSIONS AND RECOMMENDATIONS

6.1 We have attempted in this report to review the causes and consequences of technological change and to indicate the principal directions in which such change will take place. We believe that the general rate of technological innovation in the world will increase. If the United Kingdom is to catch up in its products and manufacturing processes with its major competitors, innovation in United Kingdom industry must therefore come even faster. This is a necessary condition of our future survival as a trading nation.

6.2 We have not been able to quantify the likely effects of these changes on overall employment levels. As we said in our opening chapter, we doubt whether such quantification can produce estimates of value in policy formation. Employment in our existing manufacturing enterprises will undoubtedly fall if their productivity is raised to meet that of our competitors. This decline will probably be most marked in what we have termed mature industries although in these and elsewhere it may be mitigated by an increase in market share. Some of our traditional industries will continue to decline and may even disappear as developing countries with their natural resources, cheap labour and modern plant take over world markets for low-technology goods.

6.3 It is crucial, therefore, that those industries capable of generating substantial new employment should be identified and fostered. Some of these have been discussed in earlier chapters. Their successful development is vital not only for the employment they can provide, but also for our balance of trade. We will need the high-technology products of, for example, the information industry or of biotechnology. If we cannot produce them ourselves, not only will we be losing exports, we will be adding to our import bill. Improvement in the competitive position of our existing industries will bring the same dual benefit.

6.4 These new industries will not, however, appear from a vacuum. They will grow out of existing industries, often out of the conjunction of different technologies and industrial sectors. The process of identifying these and arranging for suitable stimulus to their development therefore starts in existing industries. We have shown previously that different industries require different forms of technological innovation; in some, for example, R and D priorities will relate to production methods while others need to take advantage of new materials and design procedures. We consider that each sector of industry should have a strategy for technology which establishes technological goals, and set out policies for attaining these with the aid of suitably co-ordinated R and D programmes. It seems to us that the effectiveness of the industrial R and D carried out at present suffers through the lack of such goals and co-ordination.

6.5 The labour resources made available by reductions in employment in some manufacturing sectors will provide the opportunity for rapid expansion in quite different sectors. National policies towards technological innovation should therefore be formed within an institutional framework that allows the employment consequences in different sectors to be reconciled. Moreover, this framework should be able to provide the continuity of purpose demanded by the long lead times frequently needed before a new idea can be turned into an industrial product or process. The National Economic Development Council seems the most suitable of our national institutions for the task of developing technological strategies based on different industrial sectors. Inevitably, its work will be limited by commercial considerations, but it can provide the continuity of purpose required and its supporting organisation is already structured according to industry sectors.

> We recommend therefore that the development of technology strategies for different industrial sectors should form an integral part of the NEDC Economic Development Committee and Sector Working Party studies. The R and D programmes of the Department of Industry's Requirements Boards and of Research Associations, and the relevant parts of Research Council programmes, should be aligned with these strategies.

We recommend further that in this work the EDC's and SWPs should pay particular attention to the interfaces between industrial sectors and the potential industries that might be created by the combination of technologies from different sectors.

6.6 Our discussion of major new technologies has not been exhaustive. There will be more to be identified through the measures suggested above. But we are sufficiently certain of the importance of those discussed in Chapter 3 - and sufficiently uncertain, because of this country's recent industrial performance, of the ability of United Kingdom industry to exploit them fast enough unaided - to seek Government action on them.

We recommend, therefore, that the Department of Industry should study how Government can foster the rapid development of new industries based on emergent technologies, in particular information technology and biotechnology, and of industries with high growth potential arising from the increasing need to conserve energy and materials.

6.7 At various points in our report we have suggested that overseas technology suitable for United Kingdom industrial needs may already exist. We have already stated our conclusion that the rate of technological change in this country must be faster than that of our competitors if we are not to fall further behind. We doubt the nation's ability to provide new technology at the required rate from its indigenous R and D resources. This potential shortfall can be overcome by a greater readiness to acquire already proven technology from abroad. The relatively small number of foreign licences taken by United Kingdom industry has been judged by some to indicate the excellence of British science and engineering. We regard it rather as evidence of a worrying complacency and parochialism amongst sections of British industry.

6.8 We see, therefore, a need to increase the flow of foreign technology into the United Kingdom. Private organisations who act as brokers for licences and patents can at present only bring together an active United Kingdom buyer and an active foreign seller. We believe that there is much foreign technology which is not actively offered for sale but which could be purchased. Any agency appointed to undertake this task should have a budget large enough to allow it to purchase goods which embody new technology as well as to obtain documentation and specifications. It should be able to let research contracts for the evaluation of foreign technologies. The results would be offered to specific firms or generally to the relevant United Kingdom industry. We have an open mind on whether an existing institution in the public or private sector should be asked to take this on or whether a new agency is needed.

> We recommend, therefore, that the Department of Industry should examine how the transfer of technology into the United Kingdom can be facilitated and in particular the case for establishing a new agency (or inviting an existing institution in the public or private sector to extend its role) for this purpose.

6.9 The agency would be greatly assisted if the staff in key embassies and British Council posts were strengthened to include more engineers, preferably with some working experience of United Kingdom industry.

> We recommend that the Department of Industry and the Foreign and Commonwealth Office should review staffing policies in both technical and commercial sections of major overseas posts to see whether more engineers should be appointed to them.

6.10 There are of course many areas still where United Kingdom technology is internationally competitive and where our scientific effort remains outstanding. We cannot afford, even if we make more use of foreign technology, to make less than optimum use of our own scientific and technological expertise. We emphasise here the importance of deploying R and D resources as close as possible to the markets served. In recent years, R and D expenditure by United Kingdom industry has declined disturbingly compared with that of other countries. The usual pressures to reduce costs in times of falling profitability have no doubt accounted for a substantial part of this decline. A market-oriented R and D capability within an industrial enterprise is essential for the effective and rapid transfer into production of both its own output and of new technology from external sources. In view of the special significance we attach to technological development in restoring this country's competitiveness,

> <u>we recommend</u> that Government should examine how industrial enterprises can be encouraged to strengthen their R and D capabilities.

6.11 The importance of new and small firms utilising high technology as creators of new manufacturing employment opportunities suggests that Government should give greater attention to their technological base. Often founded on a single product or idea originating as spin-off from elsewhere, such firms in many cases lack the cash flow resources to support R and D programmes. Their future expansion, and indeed existence, is thus threatened. We indicated in Chapter 4 the kinds of measures that we thought appropriate. In summary, <u>we recommend</u> that

i) The Department of Industry should consider measures that Government might take to help small businesses to overcome obstacles to long term viability and growth arising from inadequate technological resources.

ii) Large companies with R and D results that they do not intend to exploit commercially should be encouraged perhaps through fiscal means to set up or seek out small firms better able to utilize such results.

iii) Government and industry should consider how small firms benefit more from consultancy services in technology such as the Manufacturing Advisory Service of the Department of Industry and the Design Council's Design Advisory Service and should in particular consider the role that experienced executives from larger companies may play in such consultancies.

iv) Provision of information on foreign technology through the Research Associations should be strenthened.

6.12 We discussed in Chapter 4 the prospects of new employment opportunities in the service sector both in traditional services and in the service occupations associated with manufacturing activities and contrasted the structure of employment in the UK and Japan. There appears to be a natural tendency for R and D to be dominated by considerations of hardware, whether of products or processes.

In view of the employment potential of the service sector, we wonder whether more R and D resources could with advantage be allocated to enhancing this employment potential. We are not suggesting that R and D should be directed towards increasing the labour intensity of this sector but rather that more R and D, related for example to information processing and distribution, software systems, computer-aided design etc, could accelerate the availability of service sector employment, without necessarily imposing this as a further overhead burden on the manufacturing sector.

> We recommend that the Department of Industry should examine the scope for more R and D directed towards enhancing employment opportunities in service industries, particularly those with export potential, e.g. information processing and distribution, software and systems design and CAD.

6.13 The emphasis of our report has been on the "technological imperatives" of the age in which we live, enforced on the United Kingdom by its dependence on international trade in competition with some nations also driven by these same imperatives and others increasingly able to exploit them. We do not underestimate the social changes that will flow from technological changes likely in the next 10-15 years nor the difficulties of making these changes smoothly. We have sought to show that new technologies can provide new opportunities for employment as well as threats to existing jobs. But those opportunities will only occur if we are willing to accept the changes in work organisation associated with them.

6.14 The concept of a "learning-curve" for new technological processes is well established. As a nation we have a number of technological learning curves to climb up. In a mature industrial society such as the United Kingdom, however, technological learning curves often need to be accompanied by social and organisational "forgetting" curves. New technology means new products and new processes, and, almost invariably, new organisations and new working methods. This means that old organisations and their now obsolete working methods, together with the conflicts they give rise to (or were designed to manage), have to be discarded at the same time.

6.15 Many of the technological developments we foresee are suited to our industrial and intellectual strengths. Many desirable changes in industrial practice and social environment will be facilitated by the newer electronic technologies now being introduced. Our capital equipment, being older than that of our competitors, may be more easily discarded when new plant, incorporating new technology, is required. We must build on these advantages and utilise the time given us by the windfall of North Sea oil to create a coherent and internationally competitive manufacturing base by the turn of the century. Recommendations relevant to the use of new technology in manufacturing industry will be included in the report of the Finniston enquiry. We urge Government and other interested parties to respond speedily and positively to these.

6.16 We believe that this country is capable of securing sufficient shares of the world market in goods and services to ensure an acceptable level of employment, but only if we are prepared as a nation to seize the opportunities offered by technological change. Our recommendations, which we have confined essentially to R and D matters, will we believe help UK industry to improve its competitive position. We have offered views on other matters elsewhere in the report and we commend these for consideration by Government and others.

Top Copy.

Govt Machinery, July 1979

appointment of Leo Pliatzky to consider Quangos

Govt Machinery

10 DOWNING STREET

From the Private Secretary

<u>MR VILE</u>

The Prime Minister has considered Sir Leo Pliatzky's report on the non-departmental bodies for which the Cabinet Office is responsible.

In respect of the Advisory Council for Applied Research and Development, the Prime Minister agrees with Sir Leo's recommendation. She is content that ACARD should continue for a further two years, and she would like Sir Robert Armstrong to report to her on its current performance, and the case for continuing it or bringing it to an end, within that time scale. I suggest that Sir Robert should aim to report to the Prime Minister before the end of the 1981 summer recess.

The Prime Minister looks forward to receiving Lady Young's proposals on the future of the Women's National Commission. As you know, the Prime Minister takes the view that for political reasons a "leave well alone" policy will prove most appropriate. She has it in mind that half an extra secretary should be provided. She recalls that, in her time as co-chairman, there was some part-time help in addition to the two secretaries.

I am sending copies of this minute to Alex Stewart (Department of Education and Science), Sir Leo Pliatzky and to David Laughrin (Civil Service Department).

<u>29 October 1979</u>

M. A. PATTISON

Top copy: Govt Mach, Pt 3, Quangos.

PRIME MINISTER 1.

1. On WNC, agree to await Lady Young's paper, which will take account of Sir Leo's comments?

2. On ACARD, agree to maintain for 2 years and then review, as in para 12?

MAP 24/x

On W.N.C. – leave well alone. – provide – half an extra secretary. We need to have some part-time help on addition to the [illegible] Sec. other sec. M.T.

FROM SIR LEO PLIATZKY

CONFIDENTIAL

MR PATTISON

NON-DEPARTMENTAL PUBLIC BODIES: WOMEN'S NATIONAL COMMISSION AND ACARD

1. This is to let you have my comments on the two bodies for which the Cabinet Office is responsible - the Women's National Commission and the Advisory Council for Applied Research and Development.

Women's National Commission

2. This body was set up in 1969 and has the following terms of reference.

> "To ensure by all possible means that the informed opinion of women is given its due weight in the deliberation of Government on both national and international affairs."

3. The Commission comprises 47 representatives of national organisations, who provide one of its two Co-Chairmen; the other is Baroness Young, Minister of State at the Department of Education and Science.

4. The Commission are serviced by one Principal and one Clerical Officer, who last year cost the Cabinet Office about £26,000. The travelling and subsistence expenses of the Commission's members cost £7,000.

5. The Commission's terms of reference are extraordinarily vague and it appears to be an ineffective body.which does not satisfy most of the criteria adopted in the exercise on public bodies generally. I understand that Baroness Young agrees with this assessment as regards the Commission in its present form, but she considers that it is politically out of the question to abolish it, and that it should be given different and more specific terms of reference and increased staff support. She shares, I believe, the view of officials that this could not take the form of a link with the Secretariat of the Equal Opportunities Commission, which has a different remit and is located in Manchester. This need not in itself rule out some other arrangement for closer links between the two organisations.

Agreed

Not a lot.

6. Without making excessively heavy weather of this issue, it would be helpful to be as clear as possible about the objective. Is it to give due weight to the informed opinion of women on both national and international affairs, when there must be many subjects on which there is no opinion of women as such? Or is it to safeguard the interests of women in particular spheres where these certainly do exist? If so, is this really best achieved by the present kind of arrangement involving a great number of women's organisations?

7. The answer may be that it is politically too difficult to disengage from this arrangement and, even if there is no positive value in continuing it, there would in this sense be disadvantage in terminating it. In that case it is not clear that matters would be much improved purely by a change in the terms of reference and an increase in staff support. The Cabinet Office would naturally not welcome having to provide this within their staff ceiling as adjusted by recent cuts, and the question might arise whether this role should remain with them.

8. The Prime Minister may wish to discuss these matters with Baroness Young and the Secretary to the Cabinet. If the Commission is given new terms of reference and an enhanced staff, I suggest that on this basis it should be given a limited lease of life, say three years, after which a fresh decision would be needed to continue it. I am likely to put forward in my report a suggestion on these lines with regard to advisory committees generally.

Advisory Council for Applied Research and Development (ACARD)

9. ACARD was set up in 1976 to advise the Government on applied research and development and technological development. Its membership was chosen so as to make it industrial and engineering in outlook rather than theoretical and scientific. Last year it cost the Cabinet Office about £42,000 to service it, and travel and subsistence expenses were a little over £1,000.

10. It is clearly not an essential body, but it has some general value as a forum for both outsiders and Government Chief Scientists in an otherwise highly decentralised governmental system in relation to science and technology; and its work has some practical value in promoting awareness of technological possibilities, a contribution which some people would rate fairly highly and others less so.

11. ACARD is said to have got off to a poor start but to be doing better now. The tenor of the views which I had from Sir John Hunt and Sir Kenneth Berrill was that the abolition

of ACARD would leave something of a gap and would lead to pressure from a number of interests; some, such as the Royal Society, would want to revive the old Council for Science Policy, while others would want to replace ACARD by a more expensive arrangement following the publication of the report of the Finniston Committee of Inquiry into the Engineering Profession. A move to combine ACARD and the Advisory Board for the Research Councils is conceivable but the outcome would be uncertain and might save no money, and the change would certainly take a great deal of negotiation.

Agreed MT

12. My advice is to give ACARD a further lease of life of up to two years, before the end of which Sir Robert Armstrong should report to you on its current performance and the case for continuing it or bringing it to an end. During this period further thought could be given to the idea of a new arrangement involving the Advisory Board for the Research Councils.

13. I am sending copies of this to the Private Secretary to Baroness Young, to Sir Ian Bancroft and to Sir John Hunt.

L.P.

LEO PLIATZKY

23 October 1979

Govt, Machinery

10 DOWNING STREET

From the Private Secretary

copy on: Sci and Tech,
Aug 79,
ACARD - Joining Rpt

MR VILE

The Prime Minister has seen Sir John Hunt's minute, reference A0122, of 10 August about the Advisory Council for Applied Research and Development.

The Prime Minister accepts Sir John's recommendations with respect to the handling of the ACARD report on the Working Party under Sir Henry Chilver on Joining and Assembly.

In respect of the future of ACARD, the Prime Minister has commented that the point is not how many interesting reports ACARD produces but whether those reports have practical effect. For her part, she doubts this. But she would nevertheless be content to see ACARD added to the list of bodies to be considered by Sir Leo Pliatzky. The Prime Minister has it in mind that Sir Leo might identify scope for compressing several pure and applied science quangos into one.

M. A. PATTISON

KRB

13 August 1979

PRIME MINISTER

Earlier, you reserved judgement on ACARD but privately thought it unnecessary. Sir J Hunt puts the case for retention, and offers ways of proceeding in para 7. MAP 10/viii

copy on: Sci and Tech, Aug 79, ACARD-Joining Rpt.

Ref: A0122

PRIME MINISTER

Advisory Council for Applied Research and Development (ACARD)

I promised you a further submission about the future of ACARD: but before dealing with the arguments for and against abolition I would be grateful for your instructions on one immediate point.

2. ACARD have just produced a report on a Working Party under Sir Henry Chilver on Joining and Assembly which they wished to see published. I enclose a copy which has a convenient summary of conclusions and recommendations at the beginning: the list of the authors is on page 6. As you will see, the report warns of a serious situation developing in British industry through the failure to adopt robots when our major competitors are doing so, and it argues that there is a role for Government working in close collaboration with industry. Whatever the decision on the future of ACARD I do not think we can suppress this report. Printing will take about 2 months and the choice of publication date is in our hands. In the meantime, I think the Secretary of State for Industry should be asked to consider what response the Government should make to the report in due course and to let you have his views, copied to the other Ministers concerned, in the autumn. Do you agree?

Agreed

3. Turning now to the future of ACARD, I attach its composition and terms of reference, and also copies of its earlier reports.

4. The arguments for abolition can be simply stated. It is a Quango and, although its financial cost is minimal (the members give their time free) there is always an economic cost in people sitting around on Working Parties. It is also arguable that it is not the Government's business, through the medium of a Quango, to try and influence R & D decisions in the private sector although, as you will see, this is only one part of ACARD's remit. Finally, some would argue that ACARD itself has not achieved any dramatic results.

5. Against this, it can be argued that, after the slow start, ACARD has published several good reports. Its forward programme includes ones on the employment implications of technological change (due in the autumn); computer-aided design and manufacture (also nearing completion); and the implications for the private sector of our large public sector capability for Research and Development (expected late this year or early next). There is also a joint group with the Royal Society and the Advisory Board for the Research Councils (ABRC) studying biotechnology, another field where our industry has rewards to gain or opportunities to lose. ACARD's reports are also commendably short and clearly written, focussing attention on areas where R & D effort is needed to secure industrial and economic advantage. There is also the point, to which Sir Kenneth Berrill attaches particular importance, that the Government is keen to get its message across in many areas from pay claims to productivity. ACARD reports have gained useful publicity, at low expense, for certain supply side problems and they have stimulated useful discussion amongst the technological and industrial communities. There has been a gratifyingly high demand for the Council's reports so far published: "The Applications of Semi-Conductor Technology" is now being reprinted for the third time, and a second reprint of "Industrial Innovation" will be needed any time now.

Action ?

6. Finally, I think it is only right to remind you of the circumstances in which ACARD was set up. It followed persistent criticism from the Select Committee on Science and Technology, two successive Presidents of the Royal Society (Hodgkin and Todd) and many other outside scientists that there was insufficient effort directed towards co-ordination of science and technology matters, and that the Government had no forum of outside advice here in parallel to the ABRC. No-one expected miracles of ACARD, but you will clearly wish to weigh the probability that its abolition would lead to considerable outside criticism on the grounds that the Government is discounting the importance of science in general and the relevance of applied science and technology to industry in particular. All in all, I incline to the view that even if ACARD does no more than keep these important interests happy at a very small cost it is worth its keep.

7. As for settling the matter, you could decide it outright yourself. Otherwise, you could ask for a second opinion from Sir Keith Joseph, since ACARD is of most relevance to his area of responsibilities; or you could ask Sir Leo Pliatzky to include it in his review of Quangos.

(John Hunt)

10th August, 1979

The point is not how many stimulating reports ACARD produces but whether those reports have practical effect. I doubt it. But add ACARD to Leo Pliatzky's list. We might be able to telescope several more applied science Quango's into one.

MT.

ADVISORY COUNCIL FOR APPLIED RESEARCH AND DEVELOPMENT

TERMS OF REFERENCE

"To advise Ministers and to publish reports as necessary on -

i. applied R & D in the United Kingdom and its deployment in both the public and private sectors in accordance with national needs;

ii. the articulation of this R & D with scientific research supported through the Department of Education and Science;

iii. the future development and application of technology;

iv. the role of the United Kingdom in international collaboration in the field of applied R & D."

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Mr G H Wright	Regional Secretary for Wales, Transport and General Workers' Union

FILE

DS.

Govt. Machinery

10 DOWNING STREET

From the Private Secretary

MR. VILE,
CABINET OFFICE.

The Prime Minister has seen Sir John Hunt's minute of 16 May about handling of science matters.

Taking account of the fact that the Prime Minister appointed Mr. Neil Macfarlane to handle the science side at the Department of Education and Science, she is herself prepared to answer questions on science if need be.

The Prime Minister wishes to reserve judgement on the Advisory Council for Applied Research and Development. She remains to be convinced that this is a necessary body.

M. A. PATTISON

21 May 1979

520

PRIME MINISTER

At present, Neil Macfarlane's responsibilities are as in (i) below.

Agree A, B & C? (subject to quango review)

MAP 18/v

Ref. A09575

PRIME MINISTER

Science

You have not appointed a Minister for Science or made any change in the responsibilities of the DES. I assume therefore that you wish to continue the arrangements of recent years (under both Conservative and Labour Governments) whereby:-

Neil Macfarlane was appointed to the Science side of the Ministry.

(i) DES is responsible for the Research Councils and for the Science Budget.

(ii) Each major Department is responsible for determining and financing its own R and D programme broadly on the "customer/contractor" principle.

(iii) There is no "scientific overlord" who tries to run science and R and D from the centre, but a Cabinet Minister is given a general co-ordinating role and acts as the Government's spokesman on general scientific affairs.

A / Agreed

2. If you agree thus far, the next question is which member of the Government should take on this co-ordinating role. Lord Peart did it in the last Government and there is some advantage in having a Peer because the House of Lords is particularly interested in and knowledgeable about scientific matters. Similarly it ought not to be someone with too much of a vested interest. I rather doubt however whether it is Lord Soames' cup of tea, and I wondered whether you would like to ask the Lord Chancellor to take on the job. If he felt able to, I believe his appointment would be very well received. Not a great deal of work would be involved and he would be supported by the Cabinet Office (there is a small section of the economic Secretariat concerned with scientific affairs).

B /

C /

3. Finally, do you also agree that the Advisory Council for Applied Research and Development (ACARD), which was set up by the last Government, should continue? After a shaky start ACARD now seems to be doing a useful job. Its first two reports, on micro-electronics and on the encouragement of innovation, were well received. It has four more now in progress on the employment implications of technological change; joining and assembly techniques; computer-aided design and manufacture; and the implications for the private sector of the

public sector's R and D capacity: and they are also doing a joint study with the Royal Society and the ABRC studying biotechnology. The "co-ordinating" Minister chairs ACARD (the scientific community have welcomed this as a visible token that Government takes the applied end of civil science seriously): but there are two working Deputy Chairmen (Dr. Alfred Spinks and Sir James Menter): all the other members are outsiders but Sir Kenneth Berrill and some Departmental Chief Scientists attend as assessors; and some support (minimal in terms of staff time) is provided by the Chief Scientist in the CPRS (John Ashworth) and the Cabinet Secretariat.

John

JOHN HUNT

16th May, 1979

① Neil Macfarlane was appointed to "do" the science side of the Ministry

② I will answer questions on science if possible.

③ Reserve judgement on ACARD) It seems to me totally unnecessary

MT