

“Machines and People” - The evolution of industrial ergonomics in the mid- twentieth century.

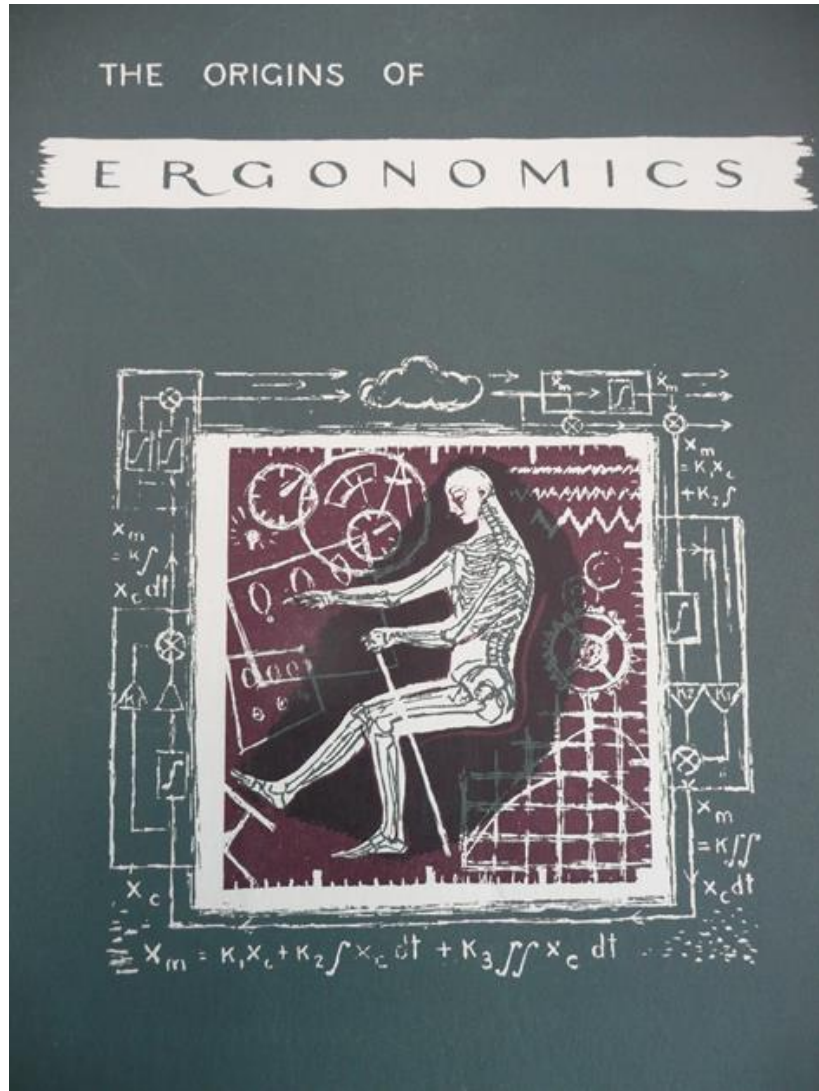
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Front Cover of Origins of Ergonomics published in 1964.

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Abbreviations.

AACP	Anglo-American Council on Productivity.
ACSP	Advisory Council on Scientific Policy.
AM	Air Ministry.
APU	Applied Psychology Unit.
ARC	Agricultural Research Council.
BISRA	British Iron and Steel Research Association.
BMC	British Motor Corporation.
BPC	British Productivity Council.
BRS	Building Research Station.
BS	British Standards.
BSc	Bachelor of Science
BTech	Bachelor of Technology.
CATs	Colleges of Advanced Technology.
CIP	The Committee for Industrial Productivity.
CIP (HF)	The Committee for Industrial Productivity Human Factors Sub-Committee.
CRP	Committee on Research into Productivity.
DPRC	Defence Research Policy Committee.
DSIR	Department of Science and Industrial Research.
DSIR RC	Department of Science and Industrial Research Research Council
ERS	Ergonomics Research Society.

EPA	European Productivity Agency.
FBI	Federation of British Industries.
FPRC	Flying Personnel Research Council.
FY	Financial Year.
HRIC	Human Relations in Industry Committee.
HSC	Human Sciences Committee.
HSE	Health and Safety Executive.
ID	Information Department.
IEA	International Ergonomics Association.
IEC	Individual Efficiency Committee.
IHRB	Industrial Health Research Board.
JTUAC	Joint Trade Union Advisory Council.
LSE	London School of Economics.
MA	Master of Arts.
MAP	Ministry of Aircraft Production.
Min Tech	Ministry of Technology.
MoS	Ministry of Supply.
MRC	Medical Research Council.
MRC OHC	Medical Research Council Occupational Health Committee.
NIIP	National Institute of Industrial Psychology.
NMSU	Naval Motion Study Unit.
NUBSO	National Union of Boot and Shoe Operatives.
OEEC	Organisation for European Economic Co-operation.

OR	Operational Research.
ORS	Operational Research Society.
PPC	Procurement Policy Committee.
RA	Research Association.
SAC	Scientific Advisory Council.
SATRA	Shoe and Allied Trades Research Association.
SPSO	Senior Principal Scientific Officer.
SRC	Science Research Council.
SSRC	Social Science Research Council.
TI	Tube Investments.
ToR	Terms of Reference.
TUAC	Trades Union Advisory Council.
TUC	Trades Union Congress.
TUCPD	Trades Union Congress Production Department.
TUCSAC	Trades Union Congress Scientific Advisory Council.
UCL	University College, London.
UGC	University Grants Committee.
UWIST	University of Wales Institute of Science and Technology.
WP4	Working Party 4.
WSL	Warren Springs Laboratory.

Abstract.

The severe balance of payments crisis of 1947 threatened the Labour administration's ability to fund the totality of its post-war reconstruction programmes. The government's solution was to call for an increase in individual and collective industrial productivity to boost exports and increase income. One of their initiatives was the launch of an industrial human science research programme. The expectation was that this would yield information and techniques which would increase human efficiency and, hence, productivity, on the shop floor and in management.

The human science research programme, which comprised both ergonomics and human relations studies, was of low financial value and produced knowledge and techniques that were capable of supporting an array of non-human science technologies. This thesis examines the derivation and management of the human science research programme and how this contributed to the emergence, growth and shaping of ergonomics, the study of the worker in their working environment.

By tracing the development and growth of the human science research programme, I show how the learned society for ergonomics, the Ergonomics Research Society (ERS), played a marginal role in promoting the science. Instead, it was the actions of engineers in academia, and organisations such as the Department of Science and Industrial Research (DSIR), Medical Research Council (MRC) and the Trades Union Congress (TUC), that were responsible for the institutionalisation and professionalisation of ergonomics in the middle years of the twentieth century. This study also throws new light on the management of a low-value research programme during this period by showing how the level of responsibility was delegated down from central government to committees which comprised academics, industrialists and union officials only. I argue that this resulted in a flexible and agile research programme which addressed important issues of productivity and shaped the science of ergonomics.

Key Words: Ergonomics, Human Science Research, institutionalisation of science, DSIR, TUC.

Declaration.

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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Acknowledgements.

A part time PhD is a challenge, even the second time around, which makes demands on time and eventually takes over your life. It can also be slightly embarrassing when people constantly ask, “Have you finished yet?” and look mildly surprised to learn that you are still working. It is a difficult path to choose and follow and is critically dependent on the support, patience, encouragement and help of those around you.

There are many people who helped me in producing this thesis and the first to be thanked is my supervisor Dr Jeff Hughes. From the outset he cheerfully and enthusiastically guided me towards thinking and writing like an historian, even during the very darkest days. His continual support, encouragement and constructive criticism, at times of great stress and uncertainty, made producing this thesis a far more pleasurable process than I could have hoped. By the end he was a valuable friend rather than a supervisor. I also thank Dr Carsten Timmerman who was my second supervisor and always provided helpful comments and insights and on a notable occasion provided support and help over and beyond the call of duty. I must also thank Dr James Sumner for his thoughtful comments and observations on the arguments within my thesis. These added to, and significantly strengthened the narrative

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Finally, I must thank my wife, Dawn, who had to put up with me hunched over my computer with my office looking like a tip, and my rants when PCs died or did not do

what I required, or when a scaffolding pole was put through my office roof! It was only through her love and belief in what I was doing that I completed this thesis. The villain of the piece is our son, Owen. During his graduation ceremony from Manchester in 2007 someone received a Master's in the History of Science Technology and Medicine. I thought that when I retired I wouldn't mind studying that topic, little thinking that within 5 years that is what I would do. So, for giving me the idea to go back to university I wish to thank Owen our son. Finally, I thought undertaking another PhD would be fun. It was.

Chapter 1: Introduction.

1.1: Overview.

This thesis focuses on the political and economic factors which stimulated the emergence and institutionalisation of industrial ergonomics - the study of the human in their working environment - in the UK during the mid- twentieth century. Despite being a wide ranging and ubiquitous science, and which has everyday applications, the emergence and institutionalisation of industrial ergonomics has not, to date, been subjected to academic scrutiny by historians. This is all the more surprising, given that the UK government supported research in the field of industrial ergonomics over two decades as part of politically significant productivity programmes.

I will trace the emergence and institutionalisation of industrial ergonomics through lens of the formation, growth and management of the government-funded industrial human sciences research programme: which sought to generate knowledge which could sustain or improve human performance at the work place. There have been many previous studies of UK government research funding during the mid-twentieth century, for example Jon Agar's study of the development of Jodrell Bank.¹ Such studies, however, focus on high financial value, technology programmes which usually, but not exclusively, support a single large installation, such as a radio telescope. Here, I will be examining a low-value, non-medical human science research programme which supported industrial efficiency and productivity, and which also contributed to other technology programmes.

“Low-value” indicates that the financial value of the human science research programme was £60,000 per annum or less. Technology programmes tended to be managed by ministries which had deep experience in that domain. Military aircraft research, for example, was managed by the Ministry of Supply (MoS) and its successor department the Ministry of Technology (Min Tech).² The human science research programme was managed by the Department of Science and Industrial Research (DSIR), who had no previous experience in managing human science

¹ J. Agar, *Science and Spectacle. The Work of Jodrell Bank in Post-War British Culture*. Amsterdam, Harwood Academic Press, 1998.

² D. Edgerton, *Warfare State: Britain, 1920 - 1970*. Cambridge, Cambridge University Press, 2006.

research. How DSIR managed the research programme, and how this shaped industrial ergonomics is a key theme in this thesis.

A central, and major theme, which runs through this narrative will be the marginal role played by the ergonomists' professional society – the Ergonomics Research Society (ERS) - in the institutionalisation of the science. Instead, growth and institutionalisation were nurtured and shaped by a diverse group of actors and institutions with differing and, occasionally, conflicting expectations. Influential actors came from the DSIR and the Medical Research Council (MRC), who were involved in managing the research. The Trades Union Congress (TUC) sought to use ergonomics to support their political goals whilst certain universities were key in exploiting the research and training ergonomists to work with industry.

In this thesis, I will explain why the ERS played a marginal role in the institutionalisation of industrial ergonomics, and why individuals in DSIR, MRC, the TUC and academia nurtured and shaped the science. I will also address the management of the government funded human science research programme and how this, also, shaped industrial ergonomics. This will add to our understanding of the formation and growth of science and how human science research was managed and its output used by scientists, academics, TUC officials, designers and engineers in the mid-twentieth century.

The introduction to this thesis is in two distinct parts. Sections 1.2 to 1.6 will provide a review of the nature of ergonomics and the management and the funding of science in the immediate post-war years. This will also include a brief review of the Trades Union Congress's (TUC) scientific committees. The second part, Sections 1.7 to 1.12, will be a set of literature reviews which will be used to highlight the research questions addressed in this thesis. Before describing the management and nature of scientific endeavour in the UK in the post-war years it is necessary to provide some background information on ergonomics.

1.2. What Kind of Science was Ergonomics in the mid-twentieth Century?

The internationally agreed definition for ergonomics is “a science-based discipline that brings together knowledge from other subjects such as anatomy, physiology, psychology, engineering and statistics to ensure that designs complement the

strengths and abilities of people and minimise the effects of their limitations”.³ Ergonomics is an all-pervasive science: the British Standards (BS) for door and window heights and widths were established using ergonomics, whilst advertising agencies make a virtue of household items, such as the humble toothbrush, being designed using ergonomics principles.

Initially, ergonomics knowledge had been established from military based studies undertaken by physiologists and psychologists during World War 2.⁴ Their work aimed to understand and lessen the impact of the military working environment and new technology on human performance. In Chapter 2, I will briefly review the establishment of military research centres, but military ergonomics will not be further considered as the funding mechanisms, political and research imperatives differ markedly from industrial ergonomics.

Industrial ergonomics came to prominence in the post-war years as scientists, particularly those working in the MRC Applied Psychology Unit (APU), sought to civilianise their military human science knowledge to address physiological and psychological problems faced by workers in the working environment. In 1947 the government launched a human science research programme which sought to increase the individual and group efficiency of the workforce. This fanned the growing interest in the impact of the working environment on human performance and facilitated the formation of The Ergonomics Research Society (ERS) in 1949 as the learned society for ergonomics practitioners.

As Figure 1-1 shows, practitioners viewed ergonomics as a field of study and not a discipline. The ERS existed solely as a forum for information exchange with no political aspirations, and little desire to institutionalise or professionalise the science and its practitioners. As I will demonstrate, it was the actions of engineers and individual ergonomists in academia, and organisations such as DSIR and the TUC who promoted and shaped the science. The ERS council was to play a relatively

³ Chartered Institute of Ergonomics and Human Factors, What is Ergonomics? <http://www.ergonomics.org.uk/what-is-ergonomics> accessed 6 January 2016. This is the web presence of the Chartered Institute of Ergonomics and Human Factors which is the modern name for the Ergonomics Research Society.

⁴ For an account of the use of civilian scientists on military projects during World War 2 see M. Kirby, *Operational Research in War and Peace*, London, Imperial College Press, 2003

minor role in the process. The main reasons for this marginal role are identified and explained in the body of the thesis, particularly, Section 1.8, 3.6 and 4.7.

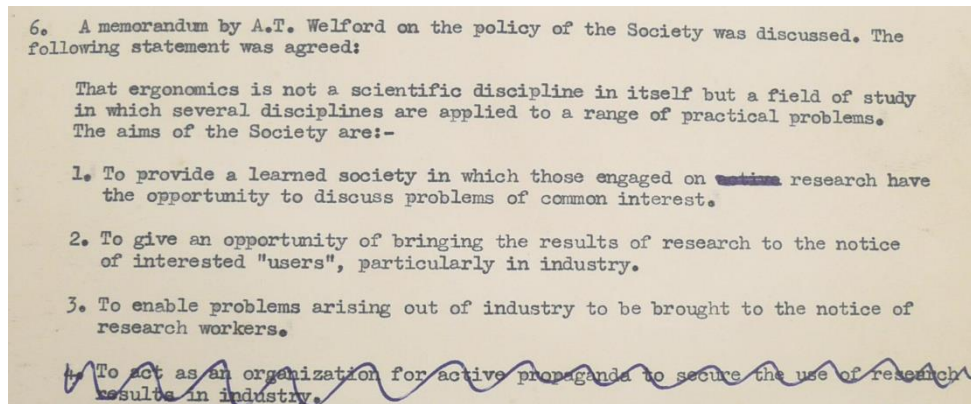


Figure 1-1. Extract from ERS Council Minutes April 1954.⁵

Up until the early 1960s practicing ergonomists were, generally, formally educated in physiology or psychology. Formal degree-awarding courses in ergonomics were established in 1962 at the University of Loughborough, with subsequent courses being offered at University College London and Brunel, Birmingham, Aston and Surrey Universities. Early ergonomics research was aimed at understanding the physiological, psychological and environmental impacts of work on human performance. This changed as the nature of work transitioned from heavy physical to lighter and sedentary, and with the introduction of automation and mechanisation at the workplace. The main research areas were now cognition and automation, human skill and error and training methodologies. This transition in the focus of ergonomics is charted through Chapters 2,3, and 4.

Early ergonomics practitioners were predominantly employed in physiology or psychology departments at the universities of Bristol, Cambridge, Oxford and Birmingham. There were individual practitioners employed by industrial concerns such as Tube Industries (TI), Metrovick, Pilkington and Electrical and Musical Industries Limited and DSIR Research Associations (RA). Whilst it has been relatively easy to chart the work and progress of practitioners working in academia, understanding the formation and work of the industrial units has proved problematic.

⁵ Taken from a loose leaf folder in the ERS Archive at Loughborough.

Many of these institutions employing ergonomists have left little or no archive material pertaining to the establishment of these units. The most complete record is a company note produced by EMI describing the work, and identifying the practitioners working in their Psychology Research Laboratory.⁶ This brief overview of ergonomics has provided a signpost to the institutions which will be examined in this thesis, the attitudes existing within the ERS and the role of ergonomics in academia.

It is necessary to provide some definition to the terminology that will be encountered in this thesis. Ergonomics has been defined, above, but the terms ‘human science’, ‘human relations’, ‘human factors’ and ‘human engineering’ also appear in the text. ‘Human science’ is used to collectively describe research undertaken into ergonomics and ‘human relations’. ‘Human relations’ refers to research into social aspects of work, such as the use of incentives or the impact of work on home life for female workers. The terms ‘ergonomics’ and ‘human factors’ are interchangeable, with the term ‘human factors’ generally, but not exclusively, preferentially used in the US. The International Ergonomics Association defines human factors as “the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.”⁷ ‘Human engineering’ was a term developed by Paul Fitts in the US during the war to describe his studies into the psychological aspects of military tasks.⁸ The use of these terms in this thesis will be a reflection of how they are employed in the primary source data. Finally, it should be noted that human relation practitioners in both the US and UK also used the term ‘human factors’ during the 1930s and up to the mid- to late 1950s to describe their work. The impact of the use of the term by ergonomists in the UK, and by US human scientists is revealed in Section 3.5.

⁶ Unattributed, The Psychological Research Laboratory 1954 to 1965. Now named EMI Ergonomics Laboratory. EMI Electronics CP.5518.

⁷ International Ergonomics Association, Definition and Domains of Ergonomics, (2017), <http://www.iea.cc/whats/index.html> accessed 25th July 2017.

⁸ P. M. Fitts, *Psychological Research on Equipment Design*. US Army Air Forces Aviation Psychology Programme Report No.19, 1947 is the key reference which draws together Fitts work.

1.3. The Management of Post-War Science in the UK.

In framing this thesis it is necessary to understand the political and economic factors which shaped the nature and requirements of the government funded human science research programme. Here I examine how science was managed in the immediate post-war years in the UK, and show that it was the emergence of empowered strategic bodies which provided the conditions in which a human science research programme could be launched. There will follow a review of the nature of large scale technological research in the UK and a brief review of the role and work of DSIR. This will highlight the gaps in our knowledge of the work of this department.

Prior to World War 2 the governance of UK scientific research resided with research councils such as the MRC, the Agricultural Research Council (ARC), DSIR and individual government departments, for example the Colonial Office.⁹ The three Research Councils operated under the supervision of the Lord President's Office, but there was no overarching body to set central government policy on scientific research. This resulted in a fragmented approach to setting priorities and funding. The rapid increase in scientific activity at the outset of the World War 2 necessitated central control to bring strategic coherence to government research. In 1940, following strong and repeated lobbying from the Royal Society, an overarching Scientific Advisory Council (SAC) was established.¹⁰ Chaired by Lord Hankey, with members including Sir William Bragg, the President of the Royal Society, the two secretaries, A.V. Hill and A.C.G. Egerton and the secretaries of DSIR, the MRC and the ARC, the SAC was to advise the Lord President's, and other government departments on scientific matters.¹¹ It was also to inform the Lord President's Office of new scientific discoveries which could be of significance to the war effort. The SAC was an advisory body and was not empowered to set strategies or manage the deployment and development of scientists.¹² It was, however, an initial move towards central governance of scientific research.

⁹ N. Vig, *Science and Technology in British Politics*. Oxford, Pergamon Press, 1968, pp 7 - 33. For a study on Colonial Office research see S. Clarke, A Technocratic Imperial State? The Colonial Office and Scientific Research, 1940–1960. *Twentieth Century British History*, (2007), 18, 453 - 480.

¹⁰ P. J. Gummatt, *Scientists in Whitehall*. Manchester, Manchester University Press, 1980, pp. 28 - 31.

¹¹ W. McGucken, The Central Organisation of Scientific and Technical Advice in the United Kingdom During the Second World War. *Minerva*, (1979), 17, 33 - 69.

¹² *Ibid.*

The Barlow Committee on Future Scientific Policy, established in 1944, considered possible mechanisms for the strategic research governance in the early post-war years.¹³ Barlow recommended that the SAC be replaced by the Advisory Council on Scientific Policy (ACSP) and the Defence Research Policy Committee (DRPC). The need for the DRPC had been championed by Henry Tizard, with the support of the Chiefs of Staff in the latter years of the war.¹⁴ Tizard had read chemistry at Oxford, joining DSIR after World War One as assistant secretary and becoming permanent secretary in 1927. He left DSIR in 1929 to become Rector of Imperial College, London, although he continued to chair scientific bodies such as the Aeronautical Research Committee. He also chaired what was colloquially known as the “Tizard committee” which fostered the development of both radar and operational research in the years leading to World War 2.¹⁵

The ACSP was formed in 1947 and was responsible for advising the Lord President on formulation and execution of scientific policy, reviewing scientific manpower, industrial research and productivity and government organisation for civil research.¹⁶ They also had influence over the appointment of departmental scientific advisors.¹⁷ The critical role of the ACSP in the development of industrial ergonomics was the formation of the Committee on Industrial Productivity (CRP), the first human science research committee (see Chapter 2). Up to its demise in 1964 the ACSP remained one of the key institutions in the management of British science. The problem it faced was that it was excluded from exerting authority in key areas, such as atomic power which meant that a pan-civil science policy could not be forged.¹⁸ On the recommendation of the Trend Report (see below) the ACSP was disbanded by the Wilson government to be replaced by a Ministry for Science.

¹³ *Scientific Manpower*: Report of a committee appointed by the Lord President of the Council. Cmnd. 6842. London: HMSO, 1946.

¹⁴ P. J. Gummatt and G. L. Price. An Approach to the Central Planning of British Science: The Formation of the Advisory Council on Scientific Policy, *Minerva*, (1997), 15, 119 - 143. This provides a detailed description of the discussions and decisions surrounding the formation of the ACSP. Vig, (1968) provides outline information on how the ACSP worked and interacted with successive governments.

¹⁵ R.V. Jones and W. S. Farren, Henry Thomas Tizard, 1885 – 1959, *Biographical Memoirs of Fellows of the Royal Society*, (1961), 7, 313 - 348.

¹⁶ Vig, (1968), p17.

¹⁷ Gummatt, (1980), pp. 35 - 36. For a discussion on the emergence and role of scientific advisors see Egerton, (2006), pp 145 - 190.

¹⁸ Vig, (1968), pp64 - 67.

The DRPC “acted as an intermediary policy-shaping body between the Chiefs of Staff and Defence Committees, and a range of specialist advisory committees and the research programmes at the various government establishments.”¹⁹ Effectively, it was a forum for the three services to argue the merits of their equipment programmes with the body which set post-war defence policy.²⁰ The DPRC was replaced in 1963 by the Defence Research Committee.

Following Treasury concerns over the cost and accountability of scientific research and development, the then Prime Minister, Harold MacMillan, tasked the Cabinet Secretary, Sir Burke Trend, in March 1962 to review the organisation of civil science.²¹ His brief was to consider if there should be changes in the functions of the agencies for which the Minister of Science (then Lord Hailsham) had responsibility. In addition, he should consider if new agencies should be formed, what was the best way to provide scientific advice to the government and whether changes in the ways agencies were funded, and held accountable, should be made.²²

Trend’s main recommendations were that DSIR be dissolved (see next section) and replaced by a Science Research Council (SRC) which would be responsible for postgraduate awards in science and technology. An Industrial Research and Development Authority would assume responsibility for industrial support.²³ Douglas-Home’s government announced that it would accept and implement the Trend Report, and disbanded the ACSP. The Labour manifesto promised a Ministry of Technology (Min Tech) and, on gaining office introduced a Science and Technology Bill which established the Min Tech to replace DSIR, but did not create the Industrial Research and Development Authority.²⁴

Whilst the ACSP was a strategic body it was not a grant awarding body. Before 1945 funding came from the research councils such as the ARC, MRC, DSIR, or from charitable bodies such as the Leverhulme or Nuffield Trusts. Funding for university courses, research and building programmes was either through institutional

¹⁹ Agar and Balmer, (1988), p. 246.

²⁰ Ibid, pp. 250 - 251.

²¹ Vig, (1968) pp. 50 - 52.

²² Gummett, (1980), p.42.

²³ Vig, (1968), pp. 51 - 52. He also recommended the formation of a Natural Resources Research Council.

²⁴ Ibid, p.53.

endowments or government grants administered through the University Grants Committee (UGC).²⁵ Strategic growth of the university sector was, however, inhibited by the relatively low levels of available funding. In the post-war years, Attlee's administration significantly increased research spending,²⁶ with one of the main beneficiaries being the UGC.

During planning for post-war reconstruction, it became clear to the Board of Trade that there was a chronic shortage of trained engineers to undertake and manage building projects. Hugh Dalton, President of the Board of Trade, instructed the UGC to present the Treasury with a plan which would identify required expenditure to meet the reconstruction of university campuses and the development of courses in scarce skills, such as engineering. The Treasury responded by doubling the block grant, with promises of further increases in later years, further directing that the UGC should be empowered to take strategic funding decisions. This would have enabled the UGC to create new academic courses and departments. After expenditure on building refurbishment and scarce skill courses there was little that could be directed towards other academic ventures.²⁷

Reconstruction also included wholesale reform of the education sector. The 1944 Education Act established secondary and grammar schools and technical colleges,²⁸ whilst higher education reform was addressed in three major reports spread over ten years. The 1945 Percy Report proposed that a limited number of technical colleges should be upgraded, in terms of status, course content and quality, to be comparable with universities,²⁹ a proposal that was fiercely criticised by the ACSP and shelved.³⁰ The 1946 Barlow Report called for an increase in university places to meet the projected skills gap in science and engineering,³¹ noting that bridging this skills gap

²⁵ M. Shattock and R. Berdahl, *The British University Grants Committee 1919-83: Changing Relationships With Government And The Universities*, *Higher Education*, (1984), 13, 471 - 499.

²⁶ Agar, (1998), pp. 9 - 11.

²⁷ *Ibid.*

²⁸ 1944 Education Act accessed from www.legislation.gov.uk/ukpga/Geo6/7-8/31/contents/enacted. 19 Jan 2014.

²⁹ Percy Report Ministry of Education *Higher Technological Education. Report of a Special Committee*. London, HMSO, 1945.

³⁰ J Boocock and K Taylor, *The Labour Party and Higher Education: 1945-51*. *Higher Education Quarterly*, (2003), 57, 249 - 265.

³¹ Barlow Report *Scientific Manpower: Report of a committee appointed by the Lord President of the Council*. Cmnd. 6842. London, HMSO, 1946.

would be critical in both post-war reconstruction and addressing the balance of payments crisis. This was partially addressed by the work of the UGC.

In 1956 the Conservative Minister for Education, David Eccles, produced the Technical Education Act, which proposed closing the perceived persistent skills gap in the engineering sciences by conferring enhanced status on leading technical colleges. Renamed as Colleges of Advanced Technology (CATs) they would be able to offer non-degree awarding courses in technology subjects.³² In addition, the government announced a major building programme to help accommodate an anticipated increase in student numbers at the CATs, and expand the number of technology based courses that were being offered.³³ Loughborough CAT, later Loughborough University, as part of its expansion plans, started the first academic courses in ergonomics. As I show in Chapter 6 this was a significant step in the institutionalisation of ergonomics.

The post-war changes in research governance had a major impact in shaping and developing research and, as discussed in Chapter 2, through their work on scientific manpower informed the debate on higher education for scientists and engineers. Both the ACSP and the DRPC provided strategic guidance on government science policy, backed up by scientific facts and observations, which had not been the case before World War 2. The ACSP, for example used statistical analysis to inform the debate on the supply and demand for scientists and engineers. They provided the necessary strategic advice and guidance to sub-ordinate committees which would manage and prioritise research. The increased UGC funding enabled the expansion of the university sector, which would contribute to the institutionalisation of ergonomics. In the next section I will briefly review the nature of post-war science.

1.4. The Nature of Post-War Science in the UK.

This thesis is concerned with low value, non-technology research. It is important, however, to situate this within the tapestry of the research and development programmes which were established in the UK in the post-war years. Such a review provides an important comparator for the management of the human science research

³² These were Aston, Battersea, Bradford, Bristol, Brunel, Cardiff, Chelsea, Loughborough, Northampton and Salford. The courses would be able to award Diploma of Education.

³³ Unattributed, Scientific, Technological and Technical Manpower, *Nature*, (1957), 179, 1 - 3.

programme. This section will also contain a short description of the formation and work of DSIR.

Agar has pointed out that in the immediate post-war years there was enthusiasm for the application of science to accelerate reconstruction.³⁴ Further, scientists and engineers returning from work on military programmes had significantly broadened horizons, networks and expectations and would seek to translate their military research and development knowledge for civilian use.³⁵ These observations in concert with the semi-formalisation of government science policy, and the need to reconstruct and grow the academic sector established the environment which saw the launch of a series of high value technology programmes.

As an example, in 1946 the Nuclear Physics Committee of the MoS issued an invitation for outline research programmes which would permit the construction by academic institutions, such as The University of Manchester, of nuclear physics research facilities.³⁶ Edgerton has drawn attention to the sustained high levels of funding for the construction of both civil and military aircraft production, pointing out that, certainly in the mid to late 1950s, new aircraft were imagined as a potent symbol of the science and technology and manufacturing prowess of the UK.³⁷ These examples, and other programmes, such as Jodrell Bank and the Blue Streak missile programme have been colloquially referred to as ‘Big Science.’ The sums of money supporting ‘Big Science’ were large in comparison for funding for human science research. As a comparator, in 1951 DSIR provided a single grant of £279,140 as a contribution towards Jodrell Bank. In 1959, DSIR provide £50,000 per annum for human science research.

‘Big Science’ was ‘coined’ by Alvin Weinberg in 1961 as a term to encapsulate what he saw as “the monuments of Big Science” such as particle accelerators and rockets and space vehicles.”³⁸ This also included the large sums of money and manpower which supported these monuments, and the military and political significance attached

³⁴ Agar, (1998), p.8

³⁵ Ibid. p.12.

³⁶ Ibid, p.12.

³⁷ D. Edgerton, *England and the Aeroplane. Militarism, Modernity and Machines*. London, Penguin Books, 2013, pp. 141 – 143.

³⁸ A. M. Weinberg, Impact of Large Scale Science on the United States, *Science*, (1961), 134, 161 - 164.

to these programmes and structures. Capshew and Rader have explored the notion of ‘Big Science’ and how it has been characterised and perceived by other authors.³⁹ Their exploration proposes that ‘Big Science’ can be viewed as the intersection of political, social, scientific and economic goals, and that it represents the ‘industrialisation’ of science. Their final, intriguing, observation is that ‘Big Science’ could be viewed as a mechanism for the institutionalisation of science. Using CERN as an example, they point out that the much of the early funding for ‘Big Science’ was directed towards constructing facilities rather than undertaking research. In Section 1.7 I discuss how research facilities are an important stimulus in the institutionalisation of science and disciplines

A key UK institution in the funding of ‘Big Science’, and in stimulating and sustaining the growth of industrial ergonomics, was DSIR. From 1951 until its closure in 1965, DSIR provided strong support for industrial ergonomics, ergonomists and the ERS. DSIR was established in 1916 with the aim of increasing the supply of trained research workers, expanding university research in science and technology, encouraging industrial research by the establishment of research associations (RA) and the creation of a network of state research establishments such as the National Physical Laboratory and the Building Research Establishment.⁴⁰ The RAs’ role was to contribute to the overarching goals of DSIR.⁴¹ This was achieved either by the consolidation of research undertaken by individual industrial concerns, or by providing the opportunity for them to participate in co-operative government funded research with academia.⁴²

Varcoe⁴³ and Melville⁴⁴ provide detailed accounts of the formation and work of DSIR, but both examine senior levels of management and, so, do not give an understanding of the bureaucratic processes within DSIR. Varcoe analyses the work

³⁹ J. H. Capshew and K.A. Rader, *Big Science: Price to the Present*, *Osiris*, (1992), 7, 2 - 25.

⁴⁰ Vig, (1968), p.10.

⁴¹ Vig, (1968), p. 10. For an analysis of the formation of DSIR see A. Hall, *War of Words: the Public Science and the British Scientific Community and the Origins of the Department of Scientific and Industrial Research*, *British Journal of the History of Science*, (1999), 32, 461 - 481.

⁴² I. Varcoe. *Co-operative Research Associations in British Industry, 1918 – 34*. *Minerva*, (1981), 19, 433 - 463.

⁴³ I. Varcoe, *Organising for Science in Britain. A Case Study*. Oxford, Oxford University Press, 1974.

⁴⁴ H. Melville, *The Department of Scientific and Industrial Research. The New Whitehall Series, No.9*. London, George Allen & Unwin Ltd. 1962.

of the RAs and their interactions with industry during the 1930s,⁴⁵ whilst Clarke has drawn attention to how, in the same era, DSIR used the term “fundamental research”⁴⁶ as rhetoric to defend and promote the legitimacy of the programmes that it funded and its right to remain as a funding body.⁴⁷ Whilst these papers provide an understanding of how DSIR operated before World War 2 we have a very hazy picture of how the department operated in the post-war years. The single piece of work which gives some insight is Agar’s study on the funding of Jodrell Bank. This discusses the work of the Strategic Grants Committee in deciding the level of DSIR’s funding for the project.⁴⁸ One of the purposes of this study will be to examine, at a greater level of granularity than that of Agar, the work of some of the management bodies in DSIR in the post-war era.

In this section I have briefly reviewed the emergence of the technology-heavy, high-value ‘Big Science’ research programmes in the post-war years, to provide a comparator for the low-value, technology-light human science research programme. The validity of this comparator is underlined by Capshew and Rader’s view that ‘Big Science’ was characterised by large-scale, expensive projects which had strong political, or military support. It was a centralised science that was directed at developing large scientific spaces, e.g. Jodrell Bank, or expressions of national prestige. In contrast ergonomics was a “distributed science” in that it was practised at widely dispersed academic and industrial sites. Additionally, it served to enable and enhance other scientific disciplines and their programmes, for example, engineering research programmes.

Why should ergonomics be considered as a “distributed science”? It has already been shown that ergonomics practitioners employed elements of physiology, psychology and anatomy to characterise the impact of the working environment on the worker. This thesis will show that the nature of ergonomics was influenced by the imagining of the science by different actors and institutions, most of whom were not human scientists. It will also show how the science was shaped and used to meet local

⁴⁵ Varcoe, (1981).

⁴⁶ DSIR and the scientists it funded recognised “fundamental research” as a contributor to scientific theory and the body of scientific knowledge. See S. Clarke. *Pure Science with a Practical Aim. The Meanings of Fundamental Research in Britain, circa 1916–1950.* *Isis*, (2010), 101, 285 - 311.

⁴⁶ Agar, (1998).

needs and requirements. It was a science that maintained a core characteristic – how to ameliorate the impact of the working environment on the worker – but was distributed across research centres, and had its own local characteristics at those centres. As appropriate, throughout this thesis these contrasts will be made to identify similarities and differences between the concepts of ‘Big Science’ and the ‘distributed science’ of ergonomics. Having examined research management it is necessary to turn attention to the industrial climate which pervaded during the period of this thesis, and examine the notions of productivity and the changing nature of work.

1.5: Post-War Productivity and the Changing Nature of Work.

There is a rich vein of scholarly studies on the issue of British post-war industrial productivity. These generally attempt to identify the political, economic and social reasons for the perceived decline, or otherwise in factory output and, hence, productivity⁴⁹. Other studies examine the establishment and work of government bodies which sought to help industry increase productivity. These included the Anglo-American Committee on Productivity (AACCP), the British Productivity Council (BPC) and the European Productivity Agency (EPA),⁵⁰ all of which are of relevance to this thesis. Each promoted productivity techniques and directly, or indirectly, supported and influenced the growth of industrial ergonomics. The formation and roles of the BPC and EPA will be described in later chapters of this thesis, here the causes of the balance of payments crisis, the nature of mechanisms put in place to stimulate productivity and the changing political perceptions of productivity by successive Conservative and Labour administrations will be described.

⁴⁹ Studies on the decline or otherwise of British post-war productivity include C. Barnett, *The Lost Victory: British Dreams, British Realities, 1945-50*, Basingstoke, Macmillan, 1996, W.D. Rubenstein, *Capitalism, Culture, and Decline in Britain, 1750-1990*, London, Routledge, 2015 and, perhaps most notably M. Shanks, *The Stagnant Society: a warning*, Baltimore, Penguin, 1961 which all argue that post-war Britain was in economic and industrial decline. Arguments against this position may be found in J. Tomlinson, *The Politics of Decline: Understanding Post-war Britain*, Harlow, Pearson Educational, 2000, D. Edgerton, 2006 and G. Ortolano, *The Two Cultures Controversy: Science, Literature and Cultural Politics in Postwar Britain*, Cambridge, Cambridge University Press, 2009.

⁵⁰ See A.Carew, The Anglo-American Council on Productivity: The Ideological Roots of the Post-War Debate on Productivity in Britain, *Journal of Contemporary History*, (1991), 26, 49 - 71, N.Tiratsoo and J. Tomlinson, *The Conservatives and Industrial Efficiency, 1951 – 1964. Thirteen Wasted Years?* London and New York, Routledge, 1998 and B. Boel, The European Productivity Agency and Transatlantic Relations 1953 – 1961 in M. Rudiger and M. Pelt (eds.). *Studies in 20th and 21st Century European History. Vol 4*. Copenhagen, Museum Tusulanum Press, 2003. These references cover the AACCP, all the mentioned institutions and the EPA respectively.

Productivity is commonly defined as a ratio between the output volume and the volume of inputs. It provides a measure of how efficiently production inputs, such as labour and capital, are being used in an economy to produce a given level of output⁵¹. The causes and consequences of the severe post-war balance of payments crisis, which was the trigger for Attlee's administrations pre-occupation with the productivity drive, have been well documented.⁵² Briefly, the cessation of Lend Lease prevented the UK from obtaining imports cheaply,⁵³ which obliged the government to borrow from the US to pay for imports and finance post-war reconstruction.⁵⁴ A condition of the loan was the requirement to relax the controls on pound to dollar convertibility after one year,⁵⁵ triggering an increased outflow of dollars which further weakened the economy, although the dollar drain had commenced well before this date.⁵⁶ The situation was further exacerbated by a severe shortage of coal, coupled with the bad winter weather of 1947 resulting in power cuts, lay-offs of workers and paralysis of the transport networks. Labour's immediate response was to further reduce imports, introduce a pay freeze and call for greater productivity in the workplace to boost exports.⁵⁷ Some relief came in late 1947 with the granting of financial aid under the Marshall Plan which provided Europe nations with funding over a two-year period to assist recovery from war damage.⁵⁸

Attlee's administration, under the aegis of the President of the Board of Trade, Sir Stafford Cripps, created a welter of official advisory bodies to help industry increase productivity. For example, the Productivity Efficiency Service aimed to "bring about an increase in the productivity of the individual firm or group of firms [and] ... aims at making industry aware of the possibility of increasing efficiency by the study of the

⁵¹ Unattributed, Defining and Measuring Productivity, www.oecd.org/std/productivity-stats/40526851.pdf accessed 6 Jan 2014.

⁵² Discussions on the causes and consequences of the balance of payments crisis may be found in J. Tomlinson's two books, *Government and the Enterprise Since 1900*, Oxford, Clarendon Press, 1994, and *Democratic Socialism and Economic Policy*, Cambridge, Cambridge University Press, 1997. M. Chick, *Industrial Policy in Britain 1945 – 1951*, Cambridge, Cambridge University Press, 1998 provides a perspective from the viewpoint of the industrialists.

⁵³ J. Tomlinson. "Reconstructing Britain – Labour in Power, 1945 – 1951" in N.Tiratsoo, (ed.), *From Blitz to Blair. A New History of Britain Since 1939*. London, Phoenix, 1998, pp. 77 - 101.

⁵⁴ C. Bryant, *Stafford Cripps First Modern Chancellor*, London, Sydney and Auckland, Hodder & Stoughton. 1997. p.364.

⁵⁵ Tomlinson, (1997), p.26.

⁵⁶ Chick, (1998), p.8.

⁵⁷ Tomlinson, (1998).

⁵⁸ J. B. De Long and B. Eishengreen, The Marshall Plan, History's Most Successful Adjustment Program. Working Paper, 91 – 184 (1991). Department of Economics, University of Berkeley and California.

application of up to date methods.”⁵⁹ Cripps also co-founded, with Paul Hoffman, the director of the US European Co-operation Administration, the AACP, an advisory forum for bringing US management practices into UK firms and the TUC.⁶⁰ The Board of Trade, under Harold Wilson, created the British Institute of Management for training and developing middle and senior managers in industry.⁶¹ The Ministry of Labour also formed the National Joint Advisory Council, which addressed wages and working conditions.⁶² A common feature of these bodies was that they included government, industrial and union representation, a structure which was to be replicated by the early management boards of the human science research programmes.

Cripps, in particular, sought to involve both private industry and the TUC in consensual management, believing that such involvement in decision making would result in policies which would be acceptable to all parties.⁶³ In truth such boards had lukewarm support from the Federation of British Industry (FBI) and other employer associations.⁶⁴ Indeed, as Tomlinson has pointed out, the Attlee administration’s attempts to boost post-war productivity were thwarted by the negative attitudes and behaviours of industry and their associations.⁶⁵ Bufton has suggested that senior management believed that productivity could be talked about but did not require action on their behalf,⁶⁶ whilst the leader of the Birmingham Local Productivity Council⁶⁷ stated that “top management had to be convinced of the need for productivity.”⁶⁸ Conversely, and for reasons which I will discuss in Chapter 5, the TUC strongly supported both Labour and Conservative efforts to increase productivity.

⁵⁹ TNA BT 64/2324 Board of Trade, “The Production Efficiency Service”, 30 Nov 1945 quoted by J. Tomlinson, Mr Attlee’s Supply –Side Socialism. *Economic History Review*, (1993), XLVI, pp 1 - 22.

⁶⁰ J. Tomlinson, The Failure of the Anglo-American Council on Productivity, *Business History*, (1991), 33, 82 - 92. The US European Co-operation Administration was the body which oversaw the administration of Marshall Aid.

⁶¹ Tiratsoo and Tomlinson (1998), pp. 41 - 42,

⁶² Tomlinson (1997), p. 85. The National Joint Advisory Council was to keep close relationships with all the government based committees which managed the funded human factors programmes.

⁶³ Bryant, (1997).

⁶⁴ Ibid, p.87.

⁶⁵ Tomlinson, (1993).

⁶⁶ M. W. Bufton, *Britain’s Productivity Problem, 1948 – 1990*. Basingstoke, Palgrave Macmillan, 2004, pp 143 - 146.

⁶⁷ The Government also established Local Productivity Councils in major industrial cities, see Chapter 6 for a discussion on the Birmingham council and its links to Birmingham University.

⁶⁸ Carew (1991).

In addition to establishing productivity agencies the Labour administration also took steps towards stimulating scientific research to support productivity. As described above, one of the first steps was to establish strategic science bodies which could set a coherent strategy for government research. The ACSP, established in 1947, provided impartial advice to the Lord President's Office on scientific policy and how science could be used to increase productivity.⁶⁹ As discussed in Chapter 2 the ACSP were instrumental in establishing the first human science research committee. In addition to centralising scientific advice the government also sought to increase funding for research. Grant providing bodies such as the National Research Development Council were formed to help develop inventions which could aid productivity. The government also modestly increased funding to DSIR to aid the formation of more RAs (see Chapter 2) and to concentrate research on short term investigations of economic importance.⁷⁰ What Attlee's administration had achieved was the establishment of a range of national and international bodies whose purpose was to assist industry in increasing productivity both on the shop floor and in management. It also took steps to develop a science base which could support government policy: this is further examined in Chapter 2.

The economic goals of Churchill's 1951 Conservative administration were to revive and encourage competition, so that with full employment and relatively high profits industry would be encouraged to re-invest and re-equip with new technology and undertake research and development.⁷¹ As Tomlinson points out, industrial efficiency was not central to the Conservatives' fiscal policy, mainly because the balance of payments deficits had eased significantly since the crisis of 1947. Output was now targeted towards sustaining the boom in national and international consumerism rather than alleviating financial crises.⁷² The Conservatives did not pursue Labour's interventionist policies because of an aversion to direct engagement with industry, a stance they maintained until leaving office in 1964.⁷³

Successive Conservative administrations were also somewhat cool towards bodies which were designed to help industry increase productivity. Thus, although the Board

⁶⁹ Gummett and Price (1997).

⁷⁰ Vig (1968), pp.17 - 18.

⁷¹ Tomlinson, (1994), pp.216 - 244.

⁷² Ibid.

⁷³ Ibid, p.226.

of Trade formed the British Productivity Council (BPC) in 1952 as a UK successor to the AACCP, it was granted little executive power.⁷⁴ Further, the UK's participation in the EPA was afforded some interest by central government, but was enthusiastically supported by the TUC.⁷⁵ The activities of the TUC in supporting industrial ergonomics, and their interactions with both the EPA and BPC are discussed in later chapters. Successive Conservative administrations, therefore afforded a lesser priority to institutions which sought to increase individual and group productivity. This thesis will demonstrate the impact that the Conservative's approach had on the level of management of the research programme and the opportunities it afforded the TUC to shape the science of industrial ergonomics.

Whilst stimulating productivity through direct intervention was not core to the Conservative industrial strategy, successive administrations actively supported and encouraged growth in training and education as a means of increasing the numbers of apprentices, engineers and scientists. As described in the previous section, the 1956 Technical Education Act⁷⁶ called, initially, for the establishment of 25 CATs, although only 10, at locations such as Loughborough, Salford and Bradford, were established. The CATs would be empowered to offer Diploma of Education courses in technical subjects such as engineering, and be funded to expand the size of their respective campuses. The Act also proposed a doubling of number of places on technical college courses.

The expectation, in the Department of Education and Science, was that these changes to further, and higher, education would result in an expansion in student numbers. This, in turn, would increase the numbers of workers trained, or qualified in disciplines which were important to stimulating and maintaining productivity, particularly engineering. These measures did not result in the anticipated increase in the skills base. It has been suggested that this was due to uncertainty regarding how this growth in student numbers and courses would fit into the prevailing higher education structures.⁷⁷ In summary, although successive Conservative administrations

⁷⁴ The British Productivity Agency also produced *The Target* which was a monthly newspaper distributed free to industry and which presented stories on how productivity had been improved by individual actions on the shop floor.

⁷⁵ Bufton, (2004).

⁷⁶ *Technical Education*, Cmd 9703, London: HMSO, 1956.

⁷⁷ M. Davis, *Technical Education 1944 – 1956*. In P. Summerfield and E.J. Evans, (eds.). *Technical Education and the State since 1850*. 1990, Manchester, Manchester University Press, pp. 120 - 144.

appreciated the importance of productivity they were less enthusiastic than the preceding Labour administration in putting in place structures and initiatives which would help increase productivity. The Conservatives' major effort was an attempt to increase the technical skills base through increased educational opportunities.

The election of the Labour government in 1964 heralded the return of the view that capitalism was marked by inefficiency, waste and uncontrolled economic processes, all of which precluded growth and a rise in the standard of living.⁷⁸ Much of this view may have been a result of impressions formed by Wilson during his period at the Board of Trade, and the influence of Stafford Cripps on his thinking (see also Chapter 2).⁷⁹ Wilson's *Labour's Plan for Science*,⁸⁰ colloquially known as the "White Heat" speech, proposed that emerging developments in science and technology would be introduced into industry in a rational fashion to ensure stimulation of productivity. There would be a new Ministry of Science, an elevation in the status of British scientists to reverse the 'brain drain' and the creation of state industries based on government research.⁸¹ In the 'White Heat' speech Wilson noted that, "What we need are new industries This means mobilising scientific research in this country in producing new technological breakthroughs."⁸² Horner points out that Labour's interest in science had stemmed from their election defeat in 1955. In the aftermath it was perceived that a strong science policy would be part of a suite of 'modern' Labour policies.⁸³ Labour went so far as to establish the "Gaitskell Club" as their own Scientific Advisory Committee, which developed the White Heat speech.⁸⁴

The proposal for a Ministry of Science floundered and, in its place Min Tech was formed as the successor department to DSIR, taking over much of this department's

⁷⁸ N. Thompson, "The Fabian Political Economy of Harold Wilson" in P. Dorey (ed.), *The Labour Government 1964 – 1970*. Hoboken, Taylor and Francis, 2004, pp 53 – 72.

⁷⁹ For a discussion on Wilson time at the Board of Trade and his political relationship with Stafford Cripps see B. Pimlott. *Harold Wilson*. Glasgow, Harper Collins, 1992, pp 102 – 105 and 108 – 132.

⁸⁰ H. Wilson, *Labours Plan for Science*, (1964), <http://nottspolitics.org/wp-content/uploads/2013/06/Labours-Plan-for-science.pdf> accessed 27th January 2016.

⁸¹ D. Horner, *The Road to Scarborough: Labour and the Scientific Revolution* in R. Coopey, S. Fielding and N. Tiratsoo (eds.), *The Wilson Governments, 1964 – 1970*. London and New York, Pinter, 1993, 48 - 71.

⁸² H. Wilson, *Labours Plan for Science*, (1964), <http://nottspolitics.org/wp-content/uploads/2013/06/Labours-Plan-for-science.pdf>, p.5.

⁸³ Horner, (1995), p.50.

⁸⁴ The 'Gaitskell Group' of scientific advisors which had been formed by Marcus Brumwell, a high-profile member of the Labour Party following the 1955 general election. This included P.M.S Blackett, Dr J.Bronowski, Sir Ben Lockspeiser, who had been secretary of DSIR and James Callaghan. The group was charged with developing a new science policy for the Labour Party.

roles and responsibilities.⁸⁵ Min Tech held a key sponsorship role in industries such as computing, electronics and machine tools: advances in these industries would all contribute to the changing nature of industrial work. How changes in the nature of work, and the introduction of new technologies affected the scientific content of the human science research programme and the shape and nature of industrial ergonomics is discussed throughout this thesis.

The measured introduction, from the mid-1950s onwards, of automation and mechanisation resulted in the diminution of the physical component of work. This, in turn sparked mounting union concerns over de-skilling of tasks and redundancies. Further, the restructuring of the economy resulted in a contraction in the numbers employed in the traditional heavy industries, such as agriculture and steel making, and an increase in employment in service industries.⁸⁶ Between 1951 and 1971 the numbers employed in extractive industries fell by 60% whilst those employed in commerce and finance rose by 30%.⁸⁷ This movement away from heavy to light service industries was matched by an increase in the number of women in the labour force from 29.5% in 1951 to 36.5% in 1971.⁸⁸ The productivity drive and the need for greater efficiencies, as voiced by the Attlee administration, and the subsequent changing nature of work produced challenges at the workplace which human science research could resolve. In this thesis, I will show how the human science research, particularly industrial ergonomics was shaped to meet these challenges and imperatives and how such research was implemented.

The section has framed the debate concerning successive government's views and responses to increasing industrial productivity. Each administration set in place strategies to stimulate productivity. Some, such as the Productivity Efficiency Service were short lived, whilst others, such as the BPC, survived changes in government and continued to support the scientific enhancement of productivity. As discussed later, the BPC ran courses in ergonomics which were targeted specifically at shop floor workers. In addition, they also produced the film, *Fitting the Job to the Worker*, which

⁸⁵ R. Coopey, Industrial policy in the white heat of the scientific revolution in R. Coopey, S. Fielding and N. Tiratsoo (eds). *The Wilson Governments, 1964 – 1970*. London and New York, Pinter, 1995, 102 - 122. This provides one of the more detailed discussions on the formation and purpose of Min Tech and explains why they absorbed the Ministry of Aviation.

⁸⁶ For an in-depth analysis of the changes in working practices see A. J. McIvor, 2013.

⁸⁷ *Ibid*, p. 12.

⁸⁸ *Ibid*, p. 23.

provided a visualisation of industrial ergonomics research and its benefits for the shop floor worker. The political meaning of productivity changed over time. For Attlee's administration, productivity was intimately linked to the balance of payments crisis. Successive Conservative administrations viewed productivity as a means of enabling industry to re-invest and to help fuel and sustain the consumer boom. The return of a Labour administration in 1964 saw productivity being linked to improvements in work place efficiency. How this change in the political context of productivity shaped the human science research programme, particularly industrial ergonomics, is a central issue in this thesis.

A consistent theme in the productivity debate was how to increase industrial output through human endeavour and efficiency, or, more bluntly, how to help the human to work harder. As discussed above, in 1947 the imperative was to raise productivity and efficiency at the workplace, increase exports and so relieve the balance of payments crisis. The response by the Lord President's Office was to launch the government-funded human science research programme. I now show why the Department undertook this action.

1.6: Why an Industrial Human Science Research Programme?

Successive governments from Attlee's to Wilson's perceived that research into the human sciences, which encompassed industrial ergonomics and human relations, would yield information which could be used to reduce worker fatigue, increase efficiency and productivity at the workplace. Government's interest in using human science research in such a purpose arose from the Attlee administration's ambitious attempt to make a wholesale reconstruction of the industrial and social landscape of the UK in the immediate post-war years. This encompassed rebuilding the housing and industrial stock, the modernisation of industry through re-equipping and nationalisation of certain industries, the establishment of the welfare state and revision of all levels of the education sector. Planning for post-war reconstruction had started in 1940 when the Ministry of Works and Buildings was established to identify long term needs for housing, industrial and academic building stock, new towns and

roads.⁸⁹ Concurrently plans were formulated for social and educational reconstruction, thus the Beveridge Report proposed the formation of what is commonly known as the Welfare State, whilst the 1944 Education Act and the 1945 Percy Report made proposals for the wholesale re-organisation of the educational system.⁹⁰

The success of reconstruction depended on an efficient industrial base to generate the funds to service these plans. In the face of limited resources and scarce skills, the wartime government had actively sought to maximise industrial efficiency and output to ensure the supply of critical wartime materials, such as advanced metal alloys. Attlee's administration understood that enhanced industrial efficiency and productivity would be just as critical in funding post-war reconstruction and that this could be achieved through the modernisation of the working environment and improvements in both union and management work practices.⁹¹

Reconstruction was compromised by a shortage of both manpower and fiscal resources. Physical reconstruction required a mass workforce equipped with appropriate industrial, constructional and planning skills, but the sluggish rate of demobilisation from the armed forces inhibited the release of skilled workers into the employment pool. This meant that, compared to 1939 the workforce in the immediate post-war years was relatively static in numbers, on average older and with a much greater proportion of women.⁹² The 1947 balance of payments crisis significantly threatened the pace of reconstruction.

The government's response was to call for an immediate increase in individual and collective industrial efficiency and productivity on the shop floor and in middle and senior management. With the long lead times associated with re-equipping industry with new machinery, a possible method for rapidly achieving the desired levels of efficiency would be through the application of science, including the human sciences to, in effect, help workers to work harder. Initiatives considered included the

⁸⁹ For an overview of the work of the Ministry of Works and Public Buildings, particularly on community planning see S. V. Ward, Gordon Stephenson and the 'Galaxy of Talent': Planning for Post-War Reconstruction in Britain 1942 - 1947. *The Town Planning Review*. (2012), 83, 279 - 296.

⁹⁰ *Higher Technological Education. Report of a Special Committee*. London, HMSO, 1945.

⁹¹ For a review of the government plans for industrial modernisation see J. Tomlinson, *Government and the Enterprise Since 1900*, Oxford, Clarendon Press, 1994, pp 139 - 160. Also see Carew (1987) for how the Labour administration worked within the constraints of the Marshall Plan.

⁹² A. J. McIvor, *Working Lives Work in Britain Since 1945*. Palgrave MacMillan, Basingstoke, 2013.

provision of incentives in the form of extra rations for key workers, such as miners,⁹³ and increasing the length of the working day.⁹⁴ E.M. Nicholson, Private Secretary to the Lord President, identified the lack of basic human science knowledge which could determine if such interventions were appropriate. This observation was the stimulus for the establishment of a research programme in industrial human sciences. The output, it was anticipated, would provide information and methodologies which would assist in increasing productivity. This programme was to be a major stimulus for the emergence and growth of industrial ergonomics.

The government funded human science research programme was low value. It did not seek to develop new technologies, but to produce knowledge which could be used to alleviate worker stress. Initially managed by the Lord President's Office, in time this passed to the joint control of the MRC and DSIR. It was managed solely by DSIR from 1957 until the Department was dissolved in 1965. DSIR's main expertise lay in managing and undertaking physical and chemical industrial research;⁹⁵ it had no previous experience of managing human science research. Indeed, it was the first civilian government department to manage the development of a human science research programme, although the MoS had managed military human science research since the war and would continue in this role until it was dissolved in 1959.⁹⁶ Upon the closure of DSIR the stewardship of the human science research programme was transferred to either the Social Science Research Council (SSRC) or the SRC. As discussed in Chapter 4, government funding for industrial ergonomics research ceased in the early 1970s.⁹⁷

The establishment and maintenance of the government funded industrial human science research programme is the central theme of this thesis. It is the vehicle which permitted the development of ergonomics as a science and, although outside the scope of this thesis also contributed to the growth of human relations research. The formation, growth and shape of the human science research programme were moulded by the post-war productivity drive, but it was the shop floor which would be most

⁹³ The National Archive (TNA) CAB 124/694. Incentives to Production. Gen 105/5. 3rd April 1946.

⁹⁴ TNA CAB 124/694. Scheme for Temporary Increase in Working Hours. J.C.C. 207 8th August 1947

⁹⁵ For an overview of the work of DSIR see Melville, 1962 and Varcoe, 1974.

⁹⁶ D. Edgerton, (2006). A sketchy account of how the MoS managed aviation human science research may be found in Gibson and Harrison, (1984).

⁹⁷ E. N. Corlett and C. Stapleton, The Ergonomics Society: 50 Years of Growth, *Ergonomics* (2001), 44, 1265 - 1277.

affected by, and would be expected to implement, the output of the research. I will now briefly review the TUC's executive bodies which set their scientific policies.

1.7: The TUC's Executive Science Bodies.

The TUC's interest in science and technology arose from the modernisation of the organisation after the 1926 general strike. Driven by Walter Citrine, the TUC General Secretary, the modernisation programme sought to move the organisation from an adversarial to a more conciliatory form of trade unionism.⁹⁸ Central to this was the expectation that a new industrial order would appear through planned reconstruction, advances in technology and management methods, the growth of scientific research and psychological investigation. If the TUC was to actively participate in this modernisation, which could result in higher efficiency, productivity and wages, then members needed to understand the scientific basis of this revolution.⁹⁹

Three bodies were responsible for setting and implementing strategic scientific policy for the TUC. These were the TUC Scientific Advisory Council (TUCSAC), the Production Committee and the TUC Production Department (TUCPD). The TUCSAC was formed in 1939 with assistance from the British Association for the Advancement of Science and comprised union officials and scientists, with initial membership including Citrine, Ernest Bevin, Blackett, Bernal and Winifred Cullis.¹⁰⁰ Its role was to provide strategic guidance and advice to the General Council on topics such as fatigue, nutrition, uses of coal and, later, policy on the use of atomic weapons.¹⁰¹ They also advised on scientific policy for planning and reorganisation of industry and facilitated representation on national research bodies.

The Production Committee was formed in 1941 and comprised senior union officials whose role was to develop an industrial production plan which could be offered up to the government.¹⁰² After the war the committee represented the TUC on the National

⁹⁸ R. Taylor, *From the General Strike to New Unionism*. Basingstoke, Palgrave, 2000, pp. 41 - 44.

⁹⁹ *Ibid.*

¹⁰⁰ TUC Library Online TUC Annual Report, 1939 pp. 259 - 260.

<http://www.unionhistory.info/britainatwork/emuweb/objects/nofdigi/tuc/imagdisplay.php?irn=6009478&reftable=ecatalogue&refirn=6009363>. Cullis was professor of physiology at University College.

¹⁰¹ For a discussion on how Bernal and Blackett attempted to use the TUCSAC and the TUC to influence the government policy on nuclear weapons see Greta Jones, *The Mushroom Shaped Cloud: British Scientists Opposition to Nuclear Policy, 1945 -57*, *Annals of Science*, (1986), 43, 1 - 26.

¹⁰² TUC Annual Report, 1941, pp.182 - 183.

<http://www.unionhistory.info/britainatwork/emuweb/objects/nofdigi/tuc/imagdisplay.php?irn=6009843&reftable=ecatalogue&refirn=6009942>.

Production Advisory Council on Industry¹⁰³ and liaised with other government departments on productivity issues.¹⁰⁴ The committee was supported by the TUCPD, which was formed in 1950 following a visit of senior TUC officials to the US to study American union attitudes to scientific management.¹⁰⁵ The Department's role was "to co-operate with unions to exert pressure towards increasing the pace of industrial development."¹⁰⁶ It led in lobbying central government and departments on science policy and arranging and developing internal symposia, seminars and training courses on topics such as work study, industrial relations and negotiation skills. It is not known if the department was staffed by TUC employees or if professionals were recruited to fill the posts.

The TUCSAC, the Production Committee and TUCPD provided the TUC with a set of executive groups which could set the strategic direction for engagement with government and industry and provide a training service. In the previous section I observed that little was known about how DSIR managed its science and technology in the 1960s. The same is true of the TUC. Although passing references are made to the work of the TUCSAC and the TUCPD¹⁰⁷ there appears to be, as yet, little published information on their workings. By examining how the TUC interacted with ergonomists and the ERS we may start to get an idea of the executive attitudes within the union movement to science and technology.

I now consider existing relevant literature which will frame this thesis. I will first review the literature pertaining to the development of ergonomics, its learned society, the ERS. The subsequent section on the formation and development of disciplines will frame the research questions to be addressed in the body of the thesis.

¹⁰³ The National Production Advisory Council on Industry was a tri-partite advisory committee which were established by Cripps in 1947. It was concerned with identifying methods of increasing productivity – see Chapter 1.

¹⁰⁴ TUC Annual Report, 1950, p. 216.

<http://www.unionhistory.info/britainatwork/emuweb/objects/nofdigi/tuc/imagedisplay.php?irn=6012381&reftable=ecatalogue&refirn=6012267>.

¹⁰⁵ Carew, (1991).

¹⁰⁶ E. Fletcher, Industrial Relations and the Production Engineer, *The Institution of Production Engineers Journal*. (1959), 38, 475 - 479.

¹⁰⁷ See, for example Carew (1987), pp. 153 -183. This describes the work of the Production Department.

1.8: The Ergonomics Research Society.

The ERS,¹⁰⁸ founded in 1949, is the UK's learned body for professional ergonomists and those, such as engineers or occupational health officers, who have a professional interest in the science. There are a few accounts of the history of the ERS and these are written exclusively by, and for, the practitioner. They do not analyse political influences or actions of external actors on the development of the society or the science. Their utility is that they establish the temporal development of ergonomics and identify what the authors, most of whom were involved in the early development of the society, consider to be 'key' moments or actors in the growth of the science. The major papers are those of Edholm and Murrell,¹⁰⁹ Waterson and Sell¹¹⁰ and Waterson.¹¹¹ Collectively they describe the formation and growth of the ERS up to 2005 and cover society foundation, development and growth, membership, foreign relations, journals and publications.



Figure 1-2 Hywel Murrell shortly before his death in 1984.¹¹²

Edholm and Murrell's *The Ergonomic Research Society, A History* was published in 1973. Edholm was the physiology secretary of the ERS until 1959 whilst Hywel Murrell (Figure 1-2) founded the ERS and was the psychology secretary. Their narrative is drawn from personal recollections and analysis of "a mass of paper and

¹⁰⁸ It is now called the Chartered Institute for Ergonomics and Human Factors.

¹⁰⁹ O. G. Edholm and K. F. H. Murrell, *The Ergonomic Research Society, A History*. London, Taylor and Francis, 1973.

¹¹⁰ P. Waterson and R. Sell, Recurrent Themes and Developments in the History of the Ergonomics Society. *Ergonomics*, (2006), 49, 743 - 799.

¹¹¹ P Waterson, World War II and Other Historical Influences on the Formation of the Ergonomics Research Society. *Ergonomics*, (2011), 54, 1111 - 1129.

¹¹² G.C. Simpson, An Appreciation. *Ergonomics*, (1984), 27, 239 - 241.

letters from members who have made their files available”,¹¹³ covering the period 1949 to 1960: it is unsupported by references. They state that it is not an objective history as “both of us were too involved in the foundation and running of the Society to be dispassionate.”¹¹⁴ The narrative addresses the formation of the society, the early annual conferences and the international relations, particularly the work of Murrell and others for the EPA. Edholm and Murrell write from an ERS-centric position and provide a rather glossy narrative of the societies activities in the 1950s. They provide little contextual information on the prevailing political, social or economic climates and how these might have shaped the development of the Society or the science of ergonomics. Much of the information is reproduced in other reviews.

Waterson and Sell¹¹⁵ start their narrative at 1959 and, using minute books, interviews with long serving ERS members and past copies of *Ergonomics* as their primary sources, review developments to 2005. They do not situate their narrative in the political, social and educational landscape of the time. Waterson and Sell’s aim was “to present neither an overly positive or critical account”,¹¹⁶ which they achieve. They extended the narrative of Edholm and Murrell on interactions with other learned bodies, government, industry and academia. The strengths of this paper are that it presents data on growth of membership, an analysis of the nature and types of papers published in the journal *Ergonomics* and tables noting the dates of key events, all of which will help to frame this thesis.

There are other deficiencies, for example they draw attention to a major schism between the physiological and psychological practitioners within the society in the early years, and the long running debate regarding the ERS being a research or a consultative body, but the identity of the key actors in these dramas, and the reasons for these differences are not revealed. Further research undertaken for this thesis has shed more light on the nature of this schism. Sections 3.6 and 4.7 discuss the implications of this schism on the ERS’s role in the institutionalisation of the science. In summary, the paper complements and extends Edholm and Murrell but, again provides little contextual detail. It is also notable that neither document makes any

¹¹³ Edholm and Murrell, p. 3.

¹¹⁴ Ibid.

¹¹⁵ Waterson and Sell, (2006).

¹¹⁶ Ibid, p. 744.

reference to the government funded human science research programme and the impact it had on the development of ergonomics.

Finally, Waterson's paper seeks to show how ergonomics developed during World War 2 and then transitioned into an industrial setting in the post-war years. It is the sole narrative concerned with the emergence of the science.¹¹⁷ Drawing heavily on scientific reports rather than primary source data to support his arguments, Waterson traces the development of the study of the worker in their working environment from the late seventeenth century to the start of the World War 2. He then reviews the work of the various military human science research establishments, such as the Royal Air Force Institute of Aviation Medicine (RAFIAM) at Farnborough. He does not demonstrate how the wartime research was exploited into the civilian industrial base, an area which I concentrate upon in Chapter 2.

Two other papers deserve mention. Corlett and Stapleton provide some details on the allocation of membership numbers into different disciplines,¹¹⁸ whilst Waterson and Eason show how research into particular topics, such as automation and systems ergonomics assumed increasing importance for ergonomics in the 1960s.¹¹⁹

In summary, the small body of published literature on the formation and growth of the ERS and ergonomics is largely practitioner based and provides little analysis of the political and social reasons for the emergence and growth of the science. Superficial attention is paid to the influence or nature of the interactions with government and non-government institutions or to other external factors. What this literature does, inadvertently, reveal is the existence of a small group of practitioners who dominated the science during its infancy. These include Murrell and Edholm, and others, such as Sir Frederic Bartlett and W.F. Floyd, who will be introduced in the main body of this thesis. The literature also shows that a thorough analysis of the political and social factors which underpinned the growth and institutionalisation of ergonomics has not been made.

¹¹⁷Waterson, (2011).

¹¹⁸ E. N. Corlett, and C. Stapleton, (2001).

¹¹⁹ P. Waterson and K. Eason, "1966 and all that": Trends and Developments in UK Ergonomics During the 1960s, *Ergonomics*, (2009), 52, 1323 - 1341.

1.9: The Characteristics of Scientific Disciplines.

Practitioner histories of the ERS relate that the society was formed by physiologists, psychologists and anatomists who had a deep interest in understanding and ameliorating stressors on the worker in their working environment. Initial membership was drawn from these disciplines with, in time, engineers, designers and occupational health professionals joining the society. Practitioners brought their own discipline specific norms, practices and methodologies which, as this thesis will highlight, contributed to the growth of ergonomics knowledge. These characteristics also brought internal dissent and schisms, which are discussed later in this thesis. With such a wide range of disciplines contributing to the science of ergonomics the question is raised ‘how was the science institutionalised?’ The literature on the formation of scientific disciplines seeks to identify and characterise the factors that underpin institutionalisation and professionalisation

There are many descriptions of the nature of scientific disciplines. Kohler suggests that disciplines are “political institutions that demarcate areas of academic territory, allocate the privileges and responsibilities of expertise and structure claims on resources.”¹²⁰ Gieryn proposes that “they give a cognitive authority to science – provide credibility, prestige, power and access to material resource.”¹²¹ Servos consider them to be “a family like grouping of individuals sharing intellectual identity at any given time by an interest in common or overlapping problems, techniques and institutions.”¹²² Lenoir suggests that disciplines make disunified science work by drawing together practitioners¹²³ and that they are “the infrastructure of science”.¹²⁴ Disciplines provide a sense of identity, structure and form for the science and practitioners and provide a platform for political influence.

¹²⁰ R. E. Kohler, *From Medical Chemistry to Biochemistry*, Cambridge, Cambridge University Press, 1982.

¹²¹ T. F. Gieryn, “Boundaries of Science” in S. Jasonoff, G.E. Markle, J.C. Peterson & T. Pinch. (eds.), *Handbook of Science and Technology Studies*. Thousand Oaks: Sage Publications. 1995, 393 – 443.

¹²² John W. Servos, *Physical Chemistry from Ostwald to Pauling. The Making of a Science in America*. Princeton: Princeton University Press, 1990, pp. xiii.

¹²³ T. Lenoir, “The Discipline of Nature and Nature of Disciplines” in E. Messer-Davidow, D.R. Shumway, and D.J. Sylvan, (eds.), *Knowledges: Historical and Critical Studies in Disciplinarity*. Charlottesville and London, University of Virginia, 1993, 70 - 102.

¹²⁴ T. Lenoir, *Instituting Science. The Cultural Production of Scientific Disciplines*. Stanford, Stanford University Press, 1997, p. 46.

Disciplines are heterogeneous entities which may accommodate an array of scientific styles, practitioners and programmes within their boundaries, and favour the development of cross boundary allegiances with other disciplines. This facilitates the formation of collaborative networks, the acquisition or transfer of knowledge and the setting of new goals for practitioners, or for the discipline itself. The early practitioners of nuclear science, for example, were physicists, chemists, medical practitioners and even geologists.¹²⁵ These practitioners brought perspectives, interpretive practices, tools and methodologies to the emerging discipline so shaping its character and identity.

There are numerous conditions which facilitate the emergence of new disciplines. Stichweh identified that they may arise from established disciplines, or from deliberate action, such as educational reform.¹²⁶ The establishment of academic degree awarding courses has been cited as an important step in discipline formation and growth. Specialist qualifications and an expansion of student training programmes are important in the professionalisation of a discipline.¹²⁷ Academic courses provide a framework for the transmission of knowledge and the norms associated with disciplines. Educational reform in nineteenth-century Germany resulted in a decentralisation of higher education away from state control and brought the academic and industrial enterprises closer together.¹²⁸ Consequently, science subjects such as chemistry and physics, which had previously been taught in faculties of theology or law, were given individual prominence. The resultant differentiation between chemistry and physics allowed space for new problems to form at the boundary between these sciences. The reorganisation also permitted the endowment of new professorial chairs in physics and chemistry, which acted to attract students to

¹²⁵ L. Badash, 'The Suicidal Success of Radiochemistry', *British Journal for the History of Science* (1979), 12, 245 - 253. Also J. Hughes, "Modernists with a Vengeance"; Changing Cultures of Theory in Nuclear Science, 1920 - 1930, *Studies in the History and Philosophy of Modern Physics*, (1998), 29, 339 - 367.

¹²⁶ R. Stichweh, *The Sociology of Scientific Disciplines: On the Genesis and Stability of Disciplinary Structure of Modern Science*, *Science in Context*, (1992), 5, 3 - 15.

¹²⁷ J. B. Morrell, "Professionalisation" in R. C. Olby, G. N. Cantor, J. R. R. Christie and M. J. S. Hodge (eds.), *Companion to the History of Modern Science*, London, Routledge, 1990, 980 - 989.

¹²⁸ See, for example, D. Cahan, *An Institute for an Empire: The Physikalisch-Technische Reichsanstalt, 1871-1918* Cambridge and New York, Cambridge University Press, 1989. This shows how the foundation of the Physikalisch-Technische Reichsanstalt as an institute dedicated to precision physics brought together scientists, engineers and instrument makers to address industrial needs for methods of making precise temperature measurements.

a science or university.¹²⁹ In the UK the expansion of higher education sector in the late 1950s, consequent upon the establishment of CATs, permitted the formation of courses in ergonomics.

Whilst academic departments and courses can set the conditions for discipline formation, growth requires a cast of human actors who build discipline knowledge and establish scientific networks and form the political and inter-disciplinary links for the institutionalisation and professionalism of the discipline.¹³⁰ The growth of biochemistry in the early twentieth century provides an example of this contingency. Gowland Hopkins, through his strategic development of facilities, experimental tools and techniques, modernised the study of fermentation at Cambridge. He also recruited physiologists and chemists to teach the subject, thereby attracting students to shape and form a discipline. Concurrently Walter Fletcher, the MRC secretary, used his political influence to institutionalise the discipline. Fletcher perceived a requirement for a national system of biomedical sciences to support and inform clinical science and was keen for Hopkins to train biochemists to meet this need. Fletcher garnered political and financial support for the establishment of an Institute of Biochemistry at Cambridge under the leadership of Hopkins, to develop and train biochemistry graduates, highlighting the synergy between teaching, the generation of new scientists and research knowledge.

Whilst the role of academic institutions in the professionalisation and institutionalisation of disciplines has attracted considerable attention, the potential influence of non-academic institutions has received less analysis. In describing the role of the Marine Research Association in the institutionalisation of experimental zoology Erlingsson proposes that this provided a venue which allowed physiologists and zoologists to work together and establish an environment in which knowledge and skills could be exchanged between disciplines.¹³¹ It also provided a focal point for

¹²⁹ D.K.A. Barkan, A “Usable Past: Creating Disciplinary Space for Physical Chemistry” in M.J. Nye, J.L. Richards & R.H. Stuewer (eds), *The Invention of Physical Sciences*, Dordrecht, Kluwer, 1992, 175 - 202 provides a detailed discussion on the political background to the changes in the German educational system which nurtured the formation of physical chemistry as a discipline.

¹³⁰ Kohler (1982), pp. 48 - 52.

¹³¹ S. J. Erlingsson, The Plymouth Laboratory and the Institutionalization of Experimental Zoology in Britain in the 1920s. *Journal of the History of Biology*, (2009), 42, 151 - 183. This provides details of the efforts of the Cambridge zoologist George Bidder to provide patronage for the establishment of the Plymouth Laboratory; a further example of a discipline builder.

discipline development, both in terms of journal production and in setting a direction and political agenda for experimental zoology.¹³²

Academic journals and textbooks serve to establish disciplinary research boundaries and identify fruitful research areas, signal the research direction of a discipline and identify cross disciplinary links.¹³³ Such literatures play a powerful role in the institutionalisation of disciplines, by codifying, sustaining and contributing to the knowledge base and shaping and directing a discipline. Olesko observes that “Textbooks can be viewed as focal points for many of the historical contingencies that shape scientific practice as well as the roles of science and the scientist in society”.¹³⁴ More recent studies have considered how physical artefacts and culture can shape disciplines. The development and widespread use of instruments such as electron microscopes¹³⁵ afforded the opportunity to determine the spatial architecture of complex structures of individual cells and their constituents. This visualisation capability underpinned the development of cell biology as a new discipline¹³⁶ and reshaped and enhanced existing sciences such as crystallography. Maria Rentetzi has taken this further by considering the role of buildings and their spatial location in shaping radioactivity as a discipline. She discusses the negotiations which attended the formation of the Radium Institute and its strategic siting on the University of Vienna campus. She argues that its close proximity to the University’s medical institutions and Physics and Chemical Institutes afforded a place for a new community of scientists working on radioactivity to interact with each other, exchange ideas and form collaborative partnerships and studies.¹³⁷ It permitted the free exchange of equipment, ideas and personnel between each institute, all of which

¹³² S. J. Erlingsson, Institutions and Innovation: Experimental zoology and the Creation of the British Journal of Experimental Biology and the Society for Experimental Biology, *British Journal of the History of Science*, (2013), 46, 73 - 95. In addition to discussing the political and intellectual issues behind the establishment and growth of the journal and the Society the paper also addresses how the discipline of experimental biology, and its techniques permitted a separation from the traditional descriptive approach of morphology. The paper also reviews how the tensions between morphologists and experimental biologists were played out against the growth of both the journal and the society.

¹³³ Barkan, (1992).

¹³⁴ K. M. Olesko. Science Pedagogy as a Category of Historical Analysis: Past, Present, and Future, *Science & Education* (2006), 15, 863 - 880.

¹³⁵ N. Rasmussen, *Picture Control: the Electron Microscope and the Transformation of Biology in America 1940 – 1960*, Stanford California, Stanford University Press, 1997

¹³⁶ Rasmussen, 1997, Chapter 3. The Rockefeller School and the Rise of Cell Biology, pp 102 - 152.

¹³⁷ M. Rentetzi, Designing (for) a New Scientific Discipline: the Location and Architecture of the Institut für Radiumforschung in Early Twentieth-Century Vienna, *British Journal for the History of Science* (2005), 38, 275 - 306.

served to cement relations between radioactivity and those disciplines, but also aided the practitioners of radioactivity to establish their own, and the discipline's identity. She contends that this proximity acted as a powerful factor in the development of the discipline.

The growth of ergonomics was marked by practitioners appropriating and recasting methodologies from the sciences which informed ergonomics – physiology, psychology and anatomy – rather than the development of new techniques. How this appropriation occurred and the effects it had on shaping ergonomics is addressed in Chapters 4 and 6. Few studies of locality factors in discipline development have considered the case where academic courses or laboratories have been established in collaboration with industry.¹³⁸ In this thesis I will show how this occurred within both DSIR and the University of Birmingham.

Professional and learned societies provide a social arena for knowledge transfer to the membership through seminars, conferences or newsletters, and provide awards such as honorary fellowships. They also set disciplinary norms and act as a conduit of scientific information to other societies, the government, industry, unions and the public. The Biochemical Society, for example, was formed to strengthen the occupational position of biochemists in industry, and held its early meetings almost exclusively on industrial premises.¹³⁹ In addition to providing an outreach function this also aided research exploitation and identification of new areas for research of importance to industry. The studies of the history of the ERS touch on relations with other groups, such as the TUC, but do not provide an analysis of such relationships, or how they may have shaped the science. This will be addressed in Chapter 5 where I discuss the ergonomics seminars that were delivered to the TUC during the 1960s.

Thus far, I have reviewed literature on the theories and concepts of the formation and growth of disciplines and indicated where specific research questions which are germane to the development of ergonomics will be addressed. The formation of learned societies, establishment of formal academic educational courses, the publication of books and journals and the physical instantiations of laboratories have

¹³⁸ See S. Boudia, *The Curie Laboratory, Radioactivity and Metrology, History and Technology*, (1997), 13, 249- 265.

¹³⁹ Kohler (1992), p198.

been identified as markers of institutionalisation. Each of these markers will be explored and examined in this thesis.

Before drawing this section to a close it is instructive to briefly review the literature on three sciences which have close relations with ergonomics: cybernetics, operational research (OR) and industrial human relations. This will highlight similarities and differences in the institutionalisation of the sciences and provide a further analytic comparator for the development of ergonomics. Ergonomics, cybernetics, OR and industrial human relations gained currency from their military application during World War 2 and sought to play a role in civilian research in the post-war years.¹⁴⁰ It should be noted that the term ‘cybernetic’ was coined in 1947. The development of cybernetic machines, theories and models of neural feedback and their application to robotic systems had first attempted to mimic human behaviour but soon suggested a role for the science in engineering.¹⁴¹

Pickering notes that cybernetics was associated with the post-war automation of production through the use of servo-mechanisms and feedback / forward loops, much of which had been developed during World War 2 for military use. The leading UK researcher in this area was the psychologist and polymath Kenneth Craik, who many have called ‘the father of ergonomics.’¹⁴² Cybernetic practitioners were formally trained in engineering, psychology, psychiatry and mathematics. In 1949, the same year that the ERS was formed, the Ratio Club was established as a venue for cyberneticists to discuss the science.¹⁴³ One of the leading members was W. E. Hick, an MRC psychologist who had attended the first meeting of the ERS (see next chapter).

Efforts to institutionalise cybernetics were rebuffed by the membership of the Ratio Club who could not see the benefit from such a move. Consequently, in the mid-twentieth century there were no formal degree awarding courses in cybernetics, so

¹⁴⁰ A.Pickering, *The Cybernetic Brain*. Chicago, University of Chicago Press, 2011, p.3.

¹⁴¹ R. Hayward, Our Friends Electric; Mechanical Models of Mind in Post-War Britain, in G. C. Bunn, A. D. Lovie and G. D. Richards (eds.), *Psychology in Britain. Historical Essays and Personal Reflections*. Leicester, BPS Press, 2001, 295 - 299, provides a narrative of the development of cybernetics in the UK up to the mid – 1960s. Pickering, (2011), provides a description of mid-twentieth century cybernetics from a non - psychology stance.

¹⁴² See next chapter for a discussion on the work and importance of Craik to the development of ergonomics.

¹⁴³ Pickering, (2011), pp 57 - 60.

there was no means of training students. Lack of disciplinary structures allowed the science of cybernetics to diffuse into other disciplines, such as computer science, but left no way of imposing standards or defining a career path.¹⁴⁴ The incursion of cybernetics into computer science came at a point when ergonomists were starting to take an interest in the cognitive issues underlying human – computer interactions.

Operational Research developed from the use of mathematical and statistical techniques to quantitatively analyse and understand the reasons for outcomes of military campaigns.¹⁴⁵ As with ergonomics and cybernetics, OR practitioners were drawn from many different disciplines. An early practitioner and driving force behind the implementation of OR during World War 2 was the noted Cambridge physiologist A.V. Hill.¹⁴⁶ Kirby also points out that OR practitioners, physiologists and psychologists worked together during the war,¹⁴⁷ with some, most notably Murrell, playing a major role in the formation and growth of the ERS.

Kirby provides a detailed description of the institutional development of OR in the post-war years.¹⁴⁸ This covers the formation of the Operational Research Club in 1948 as “a small informal group who are working in, or are concerned with, the problems associated with Operational Research. The club has been organised so that its members may meet together to discuss problems connected with their work and to assist in the development of the methods of Operational Research.”¹⁴⁹ It is instructive to compare this statement with Figure 1-1, page 20, to see the commonality of approach. This is examined in more detail in Section 2.4. Kirby’s study also highlights areas where OR and ergonomics would intersect, the relationship to the British Iron and Steel Research Association (BISRA) and the OR summer schools run at the University of Birmingham in the 1950s being examples. Kirby mentions these in the context of the institutionalisation of OR, but I will demonstrate the nature of these, and other, intersections in this thesis.

¹⁴⁴ Ibid. Masters courses in cybernetics are currently offered at Brunel and University College London. The Cybernetics Society, About Cybernetics (2002). <http://www.cybsoc.org/about-cyb.htm> accessed 25 July, 2017.

¹⁴⁵ Kirby, (2003).

¹⁴⁶ W. Thomas, *Rational Action. The Sciences of Policy in Britain and America, 1940 – 1960*. Cambridge Massachusetts, MIT Press, 2015, pp. 13 – 18 and 60 – 65.

¹⁴⁷ Kirby (2003), pp.92 - 94.

¹⁴⁸ Kirby, (2003), 365 - 411

¹⁴⁹ Ibid, p.367.

Industrial human relations is the study of the behaviours of groups and individuals in the workplace. Its aim is to identify and implement managerial, fiscal or environmental improvements which will enhance productivity and worker satisfaction. The emergence of human relations, as a sub-science of social studies, has been traced to the pioneering work of the Australian psychologist Elton Mayo. From the mid-1920s onward Mayo undertook a series of, innovative experiments which showed the importance of social and group influences on productivity and worker satisfaction.¹⁵⁰

White, however, has pointed to human relations studies by the Quaker families of Cadbury and Rowntree, which were undertaken in the UK well before Mayo's work. Many of the techniques and findings from these private studies became mainstream tools and knowledge of the science.¹⁵¹ It should also be noted that both the Industrial Health Research Board (IHRB) and the National Institute of Industrial Psychology (NIIP) also undertook human relation studies before the Second World War. During the war US human relations workers were investigating civilian morale.¹⁵² In the UK the IHRB were studying issues such as the relationship between hours of work and output and the optimum rotation of night shifts.¹⁵³ Finally, the Tavistock Clinic were involved in using tests of mental agility and performance in so-called 'leaderless tasks'¹⁵⁴ in officer selection boards.¹⁵⁵

The Tavistock Institute of Medical Psychology was founded as a voluntary clinic to treat, and research neurological disorders, such as shell shock.¹⁵⁶ At the outbreak of World War 2 the Institute was absorbed into the Directorate of Army Psychology, where the work remit was extended to include officer selection and morale.¹⁵⁷ As early as October 1945 the Tavistock Clinic, which was a division of the Institute, were

¹⁵⁰See, for example, D. Wren and R. Greenwood, *Management innovators: The people and ideas that have shaped modern business*. New York: Oxford University Press, 1998.

¹⁵¹ A.V. White, *Selling Social Science Solutions. Making the Case for the Human Relations Method of Management in Post-War Britain*. Master of Arts Thesis, University of Kent, 2012.

¹⁵² Ibid, p.27.

¹⁵³ R. S. F. Schilling, Industrial Health Research: The Industrial Health Research Board, 1918 – 44, *British Journal of Industrial Medicine*, (1944), 1, 145 – 152.

¹⁵⁴ A leaderless task may be envisaged as one in which there is no overall commander and the team co-operates to solve a particular problem.

¹⁵⁵ A. V. White, *From Science of Selection to Psychologising Civvy Street. The Tavistock Group, 1939 – 1948*, Doctor of Philosophy Thesis, University of Kent, 2015., pp 74 – 125.

¹⁵⁶ Ibid, p.1.

¹⁵⁷ Ibid, pp. 54 – 56.

receiving was receiving requests from UK industry to help with industrial relations problems. White notes that such requests were coming from demobilised industrialists who had experienced the officer selection and morale studies.¹⁵⁸ To preserve the Clinic's charitable status the Tavistock Institute of Human Relations was formed as a separate entity which could undertake paid work. White also shows that the Tavistock Institute, in addition to human relations practitioners in the UK and US, used articles in *Human Relations*, the official publication of the science, and *The British Journal of Industrial Medicine* to claim validity for the scientific methods and to advertise to potential clients the merits of the science.

This section has provided an overview of factors which stimulate and nurture the institutionalisation of scientific disciplines. These markers will be used to help interpret the growth of industrial ergonomics and, where possible will be used to compare with the institutionalisation, or otherwise, of cybernetics, OR and industrial human relations. It has also provided an outline of the emergence of three complementary sciences that aspired to make contributions to the post-war productivity drive, but that their areas of interest had minimal overlap. Ergonomics was concerned with reducing the impact of the working environment on the worker, whilst cybernetics aimed at developing machines which mimicked some human attributes, and which could be used in industry. Operational research was concerned with modelling the flow of material, including the worker, within the industrial enterprise, whilst industrial human relations was concerned with enhancing worker satisfaction by the implementation of, for example, incentives, and improvements in management practices. Each science had its own, clearly defined, sphere of interest, with the worker as a central element. It may, perhaps, be expected that there would be some form of co-operation or co-ordination between the sciences. This thesis will examine the relationships that existed between ergonomics and the other sciences and show that such interactions did not exist and explain why this was the case.

1.10: Scientific Networks and Working Worlds - Information Transfer and Avenues of Influence.

The transfer of knowledge and techniques between groups of scientists is an important facilitator of the formation and growth of disciplines. This process is facilitated

¹⁵⁸ Ibid, p. 221.

through the formation of social networks which link communities of interest. Communities of interest can be envisaged as an association of scientists, engineers, designers, even members of the public who share a common interest in a specific topic. Communities of interest may also be envisaged as constituents of “working worlds”: a construct that has been recently advanced by Jon Agar¹⁵⁹ and is discussed at the end of this section. Networks linking communities of interest, or individuals, may form across disciplinary boundaries and with other institutions, such as government departments, industry and the TUC. These latter networks may be used to advance a science or exert influence through decision making and other bureaucratic processes. In this section I will briefly review the nature of scientific networks and ‘working worlds’.

Marsh and Rhodes have observed that “policy is not made ... in the gladiatorial confrontations of Parliament, but in the netherworld of committees, civil servants, professions and interest groups.”¹⁶⁰ This ‘netherworld’ and the networks that link these actors, agencies and institutions is of importance in this thesis where I will show that it is through these processes that the human sciences research programme and industrial ergonomics was shaped and exploited. A network may be visualised as a social structure which links individual actors, groups and institutions to allow the passage of concrete or abstract knowledge, information, norms and ideals. The passage of knowledge and information may be used to inform or reinforce decision making, form allegiances and alliances or help develop sciences or technologies.¹⁶¹

The notion of using networks to understand science as a social activity was first proposed by Callon and Latour¹⁶² and has subsequently been refined by Latour and others.¹⁶³ Underpinning the social study of knowledge is Actor Network Theory which seeks to understand the nature, roles and interactions of actors, alliances,

¹⁵⁹ J. Agar, *Science in the Twentieth Century and Beyond*, Cambridge, Polity Press, 2012.

¹⁶⁰ D. Marsh and R.A.W Rhodes, *Policy Networks in British Government*, Oxford, Clarendon Press, 1992.

¹⁶¹ B. Latour, *Reassembling the Social: An Introduction to Actor-Network Theory*, Oxford, Oxford University Press (2005), p. 62.

¹⁶² M. Callon and B. Latour, Unscrewing the Big Leviathan: How Actors Macro-Structure Reality and how Sociologists Help Them to do so in, K. D. Knorr-Cetina and A. V. Cicourel (eds.), *Advances in social theory and methodology: Toward an integration of micro-and macro-sociologies*, Boston, Routledge and Kegan Paul, 1981, 277 - 303.

¹⁶³ Latour (2005).

networks and objects in decision making and knowledge generation.¹⁶⁴ Latour has suggested that the development of sciences and technologies are shaped by actors who form alliances with others to try and ensure the success of their aims.¹⁶⁵ He further advises researchers to ‘follow the actors’ as they debate the progress of technological or scientific systems, and to treat social, political and other economic factors as part of a ‘seamless’ web which surrounds the decisions made.¹⁶⁶ Robinson suggests that adopting such an approach may result in a form of self-selection of actors who may not be wholly appropriate to the area of study, or inhibit a more grounded analysis of the network.¹⁶⁷ Following this changing network of actors and institutions, with their own agendas and ideologies and influence provides a way to assess a dynamic generation, passage and use of knowledge and decision-making processes.

Robinson has pointed to the large and complex literature underpinning notions of scientific social networks,¹⁶⁸ much of which analyses US government and industrial institutions. Butler warns that this may not be appropriate for application to the UK condition.¹⁶⁹ Both have, respectively, provided detailed analyses of the networks which underpinned the development of oceanography in the UK during the Cold War in the UK and British space research policy in the 1960s. Their studies provide much needed information on the role of UK government bureaucratic networks in policy formation and decision making and the basic principles they illuminate, such as alliance formation and knowledge flows between administrators and other stakeholder groups. Robinson and Butler, however, examine networks which are associated with high-value, high-profile research, but here I will be addressing a low-value programme which attracted less central government interest.

A final piece of work deserving attention is Mort’s study of the development of Trident.¹⁷⁰ This is of importance to this thesis in that it demonstrates how trade unions

¹⁶⁴ B. Latour, *Science in Action: How to Follow Scientists and Engineers Through Society*. Cambridge, Massachusetts, Harvard University Press, 1987.

¹⁶⁵ Latour, (2005), p. 62.

¹⁶⁶ Latour, (2005), p. 12.

¹⁶⁷ S. Robinson, *Between the Devil and the Deep Blue Sea: Ocean Science and the British Cold War State*, Doctor of Philosophy Thesis, University of Manchester, 2015.

¹⁶⁸ Ibid.

¹⁶⁹ Stuart Butler, *National prestige and in(ter)dependence: British space research policy 1960-73* Doctor of Philosophy Thesis. University of Manchester, 2016.

¹⁷⁰ M Mort, *Building the Trident Network: A study of the enrolment of people, knowledge and machines*, Cambridge Massachusetts, Harvard University Press 2002.

were an active institution within the Trident network and held influence in decision making. As I show in Chapter 5 the activities of both the TUC and individual unions were key in the growth of industrial ergonomics. A key theme in the later chapters of this thesis is how support for ergonomics as a science and ergonomic institutions waxed and waned, Mort's study will assist in guiding the analysis of reasons for the changes in institutional support. The notion of networks permits the identification and description of the passage of knowledge and information between actors and institutions. The concept of 'working worlds' may assist in understanding the institutional relationship between science and social, political and cultural factors.

Jon Agar proposes that 'working worlds' are "arenas of human projects that generate problems."¹⁷¹ He argues that the descriptor, "working worlds" could replace what he views as the clichéd term "context", as it provides a more robust, precise and rich framework which encompass the social, political and cultural aspects of science. This permits a more nuanced means of conceptualising and structuring scientific endeavours, and how scientific problems are identified and solved.¹⁷² Agar further proposes that sense may be made of modern science if it is viewed as being structured by "working worlds." He suggests that examples of "working worlds" include transport, communications, computer systems, civil administration and industry.

In Agar's view "working worlds", because of their inherent complexity, are unable to solve problems directly. He argues that this complexity demands that an abstraction of a problem arising from a "working world" needs to be made by the appropriate scientific community. Here, the example is the mouse model as a representation of the cancerous body.¹⁷³ Once the model has been constructed it can be analysed and manipulated by scientists using a range of what Agar calls "developed techniques."¹⁷⁴ These techniques may be peculiar to the "working world", or may be ubiquitous across "worlds." He concludes that "science is the making, manipulation and contest of abstracted, simplified representatives of "working worlds" problems."¹⁷⁵

¹⁷¹ Ibid, p.3.

¹⁷² J. Agar, 2012.

¹⁷³ Ibid, p.4

¹⁷⁴ Ibid, p.4.

¹⁷⁵ Ibid, p.5

In the context of this thesis Agar makes two important observations. Firstly, in discussing the mechanism of problem identification and solution he draws attention to “commonalities of techniques.”¹⁷⁶ The notion here is that certain sciences, in his example statistics, have ubiquity across “worlds,” but that their utilisation will differ depending on the nature of the “world.” I have already drawn attention to the ubiquity of ergonomics and will argue that the different imaginings of ergonomics by, for example, the TUC contributed to this iniquitousness, allowing ergonomics to fulfil different roles within the “working world” of industry.

Secondly, he observes that “the working world of industry generated its own sciences.”¹⁷⁷ Agar argues that the emergence of management science was a result of industry becoming the subject of scientific enquiry proposing the emergence of Taylorism and scientific management at the start of the twentieth century and appearance of human relations studies by Mayo and industrial hygiene as evidence for this proposal.¹⁷⁸ He also suggests that OR and cybernetics arose from the radar “working world.”¹⁷⁹ This thesis will show that ergonomics may be imagined as a science that was generated from a specific “working world”, but I show that the “world” was not industry. Instead, ergonomics arose from a military “working world” and its techniques and knowledge were adapted for use in an industry “working world.”

I have attempted to identify and investigate the key themes which influenced the institutionalisation of industrial ergonomics in the post-war years, and which are addressed in this thesis. The immediate post-war years were marked by the severe balance of payments crisis which, the Lord Presidents Office believed, could be reduced by the application of human science research to increase industrial efficiency. The establishment of the ACSP as a science policy body, the increase in the government’s scientific research budget and the empowerment of the UGC to strategically develop the higher education sector all contributed to the construction and continuation of the human science research programme. In this thesis I seek to

¹⁷⁶ Ibid pp. 4 –5.

¹⁷⁷ Ibid, p.9.

¹⁷⁸ Ibid, pp. 161 – 185.

¹⁷⁹ Ibid, p.273.

understand how this programme was developed and the industrial impact of the knowledge it generated and how this promoted the institutionalisation of ergonomics.

Whilst institutionalisation remains the core question, there are other issues which will be addressed. I have drawn attention to the relative paucity of our knowledge of DSIR management processes, I will help to shed some light on the workings of DSIR in the post-war years. By tracing the management of the human science programme this knowledge gap will be filled. Such an analysis will go further, however, as studies of research and development programmes in the post-war years have concentrated on 'Big Science.' Here we will gain an insight into how low value, but politically relevant and potentially high impact science was managed. The output from the human science research programme would be implemented within industry to increase human efficiency. Such implementation would require co-operation from the TUC. There is scant information on the TUC's science policy: an examination of how they interacted with ergonomists may start to address this knowledge gap. The final issue is that ergonomics formed at the intersection of many different human science disciplines. This raises the questions, what was taught on academic courses, how were curricula constructed, and how were the academic departments formed?

1.11: A Note on Data Sources.

In addressing these questions, I have drawn my primary source data from The National Archives, Kew, the Modern Records Centre, University of Warwick, and the Victoria and Albert Museum, London. In addition, two primary source data archives which have not previously been accessed are extensively quoted in this thesis.

The R. G. Stansfield archive was discovered in the Centre for the History of Science, Technology and Medicine at The University of Manchester. Stansfield was a middle ranking civil servant who worked for the Ministry of Works and DSIR before moving to academia in 1962. The archive consists of 150 files which cover his wartime service in air OR to his retirement from public life in the mid-1980s. The papers of importance to this thesis cover his time with DSIR from 1950 to 1961, during which he helped establish the government funded human science research committees and worked with the EPA, being instrumental in forming the International Ergonomics Association (IEA).

The papers are mainly departmental policy documents and minutes which are supplemented with Stansfield's hand-written notes. Many of these documents are not found in DSIR files held at the National Archive. At some stage, a basic cataloguing notation was applied to individual files and this is used in this thesis. The documents have been transferred to the archivist at The University of Manchester where, it is probable, they will be renamed as the "History of Computing Collection."

The Hywel Murrell archive is held in the Special Collections Archive at the University of Bristol. This consists of 30 boxes and contains information from his career with Tube Industries in Birmingham in 1951, where he formed the first industrial ergonomics research unit, to his retirement from the University of Wales Institute of Science and Technology (UWIST) in the mid-1980s.

The documents pertain to the running of the ERS, non-formal and informal lectures given by Murrell, and include some personal correspondence with organisations such as the TUC and ICI. It also contains information regarding visits made by the ERS to research establishments and industrial sites. The files are not individually catalogued, a high-level cataloguing has been applied to the boxes which contain the papers and this notation is used in this thesis. The archive is readily accessible.

1.12: Structure of the Thesis.

In the context of this thesis the operational level of management refers to those processes which link strategic direction, i.e. increase or sustain productivity, to the derivation and delivery of the research to meet that strategic goal.

In this thesis, I seek to address the following research questions.

1. How was the low-value human science research programme developed, managed and exploited and how can this add to our knowledge of government support for sciences in the post-war years?
2. How did the human science research programme facilitate the emergence and institutionalisation of the science of industrial ergonomics?
3. How was the output of the research programme used by different individuals and institutions to support their ideological goals?

4. How was ergonomics taught and communicated to other scientists and professionals and what teaching material was used?

This thesis is divided into two parts. Part 1, which encompasses Chapters 2 to 4 will focus on how the ergonomics element of the human science research programme was formulated, managed, delivered and exploited by government and non-government institutions and individuals. It will seek to identify and characterise the external, institutional and individual influences which shaped the human sciences research programme and the emergence and sustainment of ergonomics. Part 2, which encompasses Chapters 5 and 6, will deal with the use of the information generated by the human science research programme by the TUC and the development of formal degree, and non-degree awarding courses in ergonomics and how this, also, shaped the science.

Chapter 2 will initially focus on the role played by the MRC and Sir Frederic Bartlett in developing civilian and military human science research facilities during World War 2 and in the immediate post-war years. The intention was that these laboratories would provide scientists and human science knowledge which could assist in post-war reconstruction and enhance productivity. I will then provide an overview of the formation of the ERS and its development up to 1960. This date represents the point when the society started to take a more open policy towards engagement with outside bodies such as the TUC and other scientific societies to the development of the science. A dominant theme, that will be highlighted throughout this thesis will be the marginal role that the ERS played in the institutionalisation of ergonomics. I will also highlight some of the reasons for this seemingly reticent approach, and how this may have given a richer meaning to the science.

From here, the narrative will show how the three government committees which directed the research programme from 1947 to 1957 were formed, the work they undertook and the impact of the funded studies on the development and shaping of ergonomics. My analysis will reveal the tensions that emerged as the MRC attempted to take primacy for the research programme and how Bartlett tried to use the research programme to secure funding for his concept of industrial psychology. Although he failed in this enterprise I will argue that it helped to demarcate the niche which ergonomics would fill.

In 1956 the MRC informed DSIR that they would no longer be involved in the management of government funded human science research. In Chapter 3 I concentrate on how DSIR managed human science research from 1956 to 1960 and will consider two activities: the formation and near demise of the DSIR Human Sciences Committee (HSC) and the department's involvement with the EPA. I will investigate the role played by R. G. Stansfield who led for DSIR in both these enterprises. My analysis will show how Stansfield had a profound influence on the internal management of human sciences within DSIR and in bringing ergonomics to the national and international stage. I will also discuss the EPA Ergonomics in Industry conference, held in 1960 which, I argue, would be a critical point in the development of ergonomics in the UK. This chapter will provide insights into the internal workings of both DSIR and the EPA - areas which have received scant academic attention.

Chapter 4 follows the development of the human science research programme from 1960 until it was subsumed into the work programmes of the SRC and the Social Science Research Council (SSRC) in the late 1960s. This covers the closure of DSIR and the formation of Min Tech. I argue that the human sciences research programme developed during this time was critical to the growth of ergonomics in the UK. During this period DSIR sought to establish its own ergonomics research capability to provide both an internal and external service. Although the capability did not fulfil DSIR's expectations it did leave two major legacies in the development of ergonomics. I will chart the rise and fall of the capability and discuss the legacy abstracting service and the 12 volume *Ergonomics for Industry* and assess their impact in the development of ergonomics. This closes the first section of the thesis.

In Part 2, Chapter 5 examines some of the activities that the TUC undertook to interact with, and promote, ergonomics and ergonomists. I will explain the nature of the TUC's interest in the science and how it interacted with individual ergonomists and the ERS Industrial Section to develop a series of seminars to educate middle ranking union officials and shop stewards. Woven into the narrative will be two instances where the TUC sought to influence central government and the Department of Transport to give greater prominence to ergonomics. These vignettes, in addition to demonstrating TUC attitudes and aspirations for ergonomics, will provide an insight into how government departments viewed ergonomics within their business models.

Chapter 6 is concerned with the development and course content of academic formal and non-degree awarding educational courses in ergonomics. The section on formal education will address two case studies: the ergonomics department at Loughborough University and the ergonomics capability in the Engineering Production Department at the University of Birmingham. I will show that in both cases it was engineers, and not human scientists who provided the conditions for the development of these courses. I will also show how a distinctive, local version of ergonomics was developed at both institutions. I will also point to the interaction between formal and non-degree awarding courses which helped to develop the curricula at each university. I will then discuss the non-degree awarding ergonomics course which were run by the West of England Engineering and Allied Employers' Association. Although it is known that the TUC and government bodies ran non-degree awarding ergonomics courses there is scant information on course content or attendees. This case study here provides a rich source of information and allows an appreciation of who attended the course and the nature of the teaching.

By examining the origins and the development of the government funded industrial human science research programme it will be possible to show how the science of ergonomics emerged and was shaped up to 1970. However, beyond that it will be possible to understand how a low-value, low-profile, non-technology research programme was managed and exploited. In an era when historians are naturally interested in how large scale research and development programmes were managed, how decisions were made and who were the key actors in these enterprises this study will provide a very different bureaucratic and institutional history.

Part 1 Chapter 2. The Development and Growth of Government Funded Human Science Research to 1957.

2.1: Introduction.

In the face of a burgeoning balance of payments crisis, E.M. Nicholson, the Lord President's Private Secretary, believed that the application of human science research could raise individual and collective productivity at the shop floor and management levels, so alleviating the critical financial situation. It quickly became clear to the Lord President's Office, which held responsibility for science and science policy in the immediate post-war years,¹ that there was insufficient knowledge regarding the physiological and psychological cost of work or the human relations aspects of work.² Without such basic knowledge it would be difficult to identify appropriate human science interventions which would increase industrial efficiency and productivity. It was from this position that the Lord President's Office launched a research programme into human sciences in the workplace in 1947.

The concept of applying physiological, psychological and anatomical research to maintain or enhance human performance was not new. The National Institute of Industrial Psychology (NIIP) and the MRC Industrial Health Research Board (IHRB) had undertaken field studies in the inter-war years to understand and ameliorate fatigue. During World War 2 the use of human sciences in sustaining or improving performance in military personnel came into prominence as the growing technological complexity of military equipment placed new adverse stresses and strains on personnel. After the war human scientists, mainly from the MRC, sought to apply military human science principles to an industrial setting with the aim of increasing productivity. These activities were, however, limited in scope, and were undertaken by a small number of researchers.

In this chapter, I will briefly review the state of industrial and military human science research up to 1945. This will highlight the role played by the MRC and, particularly, Sir Frederic Bartlett in establishing and managing a network of laboratories dedicated to human science research. I will then provide a short review of the formation and

¹ Gummett and Price, (1997).

² TNA CAB 124/694. Report Platt to Mellanby. A Note on Nutrition and Industrial Productivity. August 1947. Incentives to Production Gen 105/5 30th April 1946. Both papers identify the low level of supporting knowledge in these areas and the inability of human scientists to recommend positive courses of action.

growth of the ERS up to 1960 that will be drawn from the practitioner literature and ERS Council meeting minutes. This will identify the genesis of the support that DSIR was to afford the ERS and ergonomics and the attitudes which prevailed within the society. I will then unravel the network of committees which were established between 1947 and 1957 to define, contract, manage and exploit human factors research into the industrial base. This will also highlight the central role played by the MRC, Bartlett and ultimately, DSIR in the management of this enterprise. I will show how Sir Frederic Bartlett attempted to appropriate the human science research programme as a means of bolstering, and diverting funds towards his own concept of industrial psychology. I will demonstrate that many of the tenets of Bartlett's concept of industrial psychology were to become central themes in ergonomics.

2.2: Studying Workers in Their Civilian and Military Working Environments in the Inter War and War Years.

Interest in the relationship between productivity and human fatigue started to emerge in the UK during World War 1. In response to falling production, particularly in the armaments industry, the government formed the Health of Munitions Workers Committee.³ Employing physiologists, psychologists and statisticians, the Committee undertook a series of experiments into human health, efficiency and fatigue.⁴ The committee was disbanded in 1918. In its place two new research bodies were formed, the National Institute of Industrial Psychology (NIIP) and the Industrial Health Research Board (IHRB).⁵ Both these groups addressed occupational health issues in the workplace with the intention of improving the social aspects of work rather than investigating the underlying causes of fatigue.

The NIIP had been co-founded in 1921 by C.S. Myers, professor of psychology at Cambridge (see below) and the industrialist H.J. Welch.⁶ A non-profit making organisation, the NIIP intended to “promote by systematic scientific methods a more effective application of human energy in occupational life and a correspondingly higher standard of comfort and welfare for the workers.”⁷ Employing mainly

³ I. McIvor, *A History of Work in Britain, 1880 – 1950*. Basingstoke, Palgrave, 2001, p.131.

⁴ Ibid.

⁵ A. J. McIvor, Manual Work, Technology and Industrial Health, *Medical History*, (1987), 31, 160 - 189. See also G. C. Bunn, Charlie and the Chocolate Factory, *The Psychologist*, (2001), 14, 576 - 579 for a discussion on the formation and work of the NIIP.

⁶ Bunn, (2001).

⁷ Welch and Myers, (1932) quoted by Bunn, (2001).

psychologists, the NIIP was contracted by companies to address issues such as recruitment or market surveys of the perception of a company's goods.⁸ It continued operation until the mid-1960s.

The IHRB was founded by the MRC in 1928 as the successor of the Industrial Fatigue Research Board. The IHRB sought to obtain "exact facts about fatigue caused by industrial employment in different trades and under different conditions in the same trade."⁹ It was funded to research and report upon the physical, psychological and moral health of the workforce. Their work characterised stressors, such as extremes of heat and poor lighting, as causes of fatigue and contributors to human error, but did not probe the underlying mechanisms. Both the NIIP and the IHRB produced a large body of work on topics such as monotony at work and vocational psychology.¹⁰ Although industry was not compelled to implement their findings, a number of their recommendations, such as the provision of rest pauses, were included as statutory requirements in the 1937 Factory Act.¹¹ Both institutions continued to research worker occupational health and well-being during and after the war.¹² Members of their research teams, such as R.S. Wyatt, were to be involved in the management of the human factors panels which are discussed later.¹³

A key actor in the development of the work of the IHRB was Sir Frederick Bartlett (Figure 2-1). Bartlett gained a Bachelor of Arts in philosophy and a Master of Arts (MA) in Ethics and Sociology at London in 1911, and an honours degree in Moral Sciences at Cambridge in 1914. He was appointed as Assistant Director of the Cambridge Psychological Department in 1915, gained an MA in Psychology and was elected Fellow of St Johns College in 1917, Reader in Experimental Psychology in 1922, and Professor in 1931, a post he held until 1952.¹⁴ Bartlett's approach to

⁸ Bunn, (2001).

⁹ McIvor, (1987).

¹⁰ McIvor, 2001, pp. 134 - 135. Amongst papers produced were T. Bedford, *The Warmth Factor in Comfort at Work: a Physiological Study of Heating and Ventilation*. Industrial Health Research Board No 76, 1936, London, HMSO, S. Wyatt and J. Langdon, *Fatigue and Boredom in Repetitive Work*, Industrial Health Research Board No 77, London, 1937 and M. Smith and M. Leiper, *Sickness, Absence and Labour Wastage*, Industrial Health Research Board No 75, HMSO, London 1936. Although drawn from the same year these give a very fair impression of the spread of research topics.

¹¹ *The Factory Act*, chapter 69. HMSO, London, 1937.

¹² McIvor, (1987).

¹³ Bedford was an industrial physiologist who studied and measured thermal environments in many working environments. Wyatt was to later become director of the NIIP.

¹⁴ Broadbent, (1970).

psychology was strongly influenced by Myers, who believed in the importance of the application of psychology to solve practical problems rather than a science which simply tried to understand, for example the underlying processes of cognition.

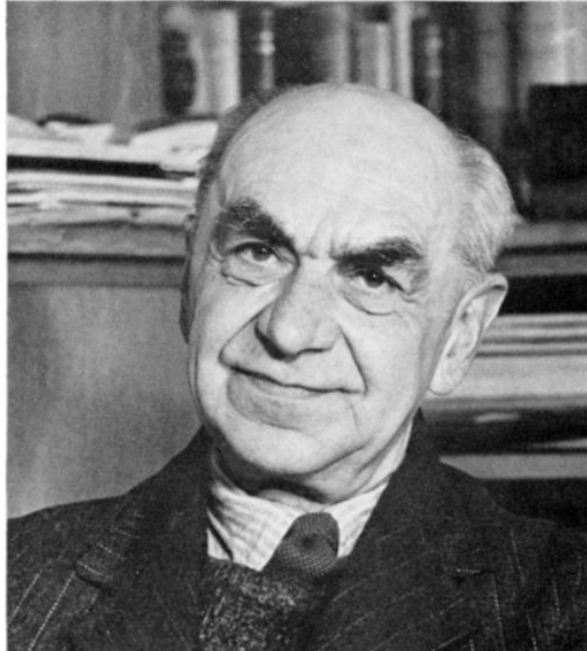


Figure 2-1. Sir Frederic Bartlett.¹⁵

Through his friendship with Myers, Bartlett gained an understanding of the work of the NIIP. He also sat on the IHRB steering committee, giving him an overview of the systematic studies that both bodies undertook into understanding the worker in their working environment, an experience which shaped Bartlett's formulation of his concept of industrial psychology (see later).¹⁶ Whilst Bartlett was involved in the management of industrial human science research he was also central to the management of military human science research and aided the establishment of the first laboratories principally concerned with the amelioration of fatigue in a military setting. These laboratories generated knowledge and techniques that would be used to investigate the stressors on the worker in a civilian environment in the post-war years.

¹⁵ Ibid.

¹⁶ The Wellcome Trust, *The MRC Applied Psychology Unit. The transcript of a Witness Seminar held at the Wellcome Trust Centre for the History of Medicine at UCL, London on 12 June 2001*. L. A. Reynolds and E. M. Tansley (eds.).

The first military human science research laboratory to be formed was the RAF Physiological Laboratory, later the RAFIAM, Farnborough.¹⁷ Established by the Air Ministry (AM) in March 1939, its research programme was guided by the Flying Personnel Research Committee (FPRC). This was an AM body comprising MRC and academic specialists in physiology, psychology – which was represented by Bartlett – and general medicine, and chaired by serving senior RAF medical officers. The FPRC would identify research requirements and advise the RAF which laboratory should undertake the research. The other services also formed personnel research councils which were managed by the MRC, with Bartlett taking a prominent role.¹⁸ The Royal Navy Personnel Research Committee directed research into sea survival and diving physiology, which was undertaken at the MRC laboratories at Hampstead.¹⁹ The Army's Military Personnel Research Council was established following a request from the War Office that the MRC establish the air ventilation rates required to clear carbon monoxide from manned tank turrets.²⁰ In response, the MRC formed the Physiological Research Laboratory at Lulworth, which it staffed with its own physiologists. Studies undertaken at Lulworth included vision in enclosed spaces and lower limb force generation.²¹ The laboratory closed in 1946. The military personnel research councils continued a research oversight function until the mid-1970s.

Two other MRC laboratories undertook studies for the War Office. Sir Wilfred Le Gros Clark's team at Oxford researched seat design and comfort,²² whilst E.A. Carmichael's group at the National Hospital, London investigated thermal effects on human performance.²³ Le Gros Clark was an anatomist and anthropologist and was the first Honorary member of the ERS.

¹⁷ T. M. Gibson and M. H. Harrison, *Into Thin Air. A History of Aviation Medicine in the RAF*. London, Robert Hale, 1984.

¹⁸ Broadbent, (1970).

¹⁹ J. Ernsting, *Defence Physiology*, in R. Bud and P. Gummert, (eds.), *Cold War Hot Science*, London. Harwood Academic, 1999, 339 - 369.

²⁰ J. Ridler, *State Scientist: Omond McKillop Solandt and Government Science in War and Hostile Peace*. Royal Military College of Canada, 2008, p.81. This thesis contains a detailed description of the work undertaken at Lulworth by MRC physiologists during the war.

²¹ P. Hugh-Jones, The Effect of Limb Position in Seated Subjects on Their Ability to Utilise the Maximum Contractile Force of the Limb Muscles. *Journal of Physiology*, (1947), 105, 332 - 344.

²² S. Zuckerman, Wilfrid Le Gros Clark, 1895 – 1971, *Biographical Memoirs of Fellows of the Royal Society*, (1973), 19, 216 - 233.

²³ *Ibid.*

Although the MRC had closed Lulworth, the army retained a human science capability. In 1945 the Army Operational Research Establishment was opened at West Byfleet. This had a section which was concerned with ergonomics, manpower planning and retention and occupational hygiene.²⁴ The Army also established the Clothing and Equipment Physiological Research Establishment at Farnborough to study the use and ergonomics of military equipment.²⁵ The human science establishments founded by the RAF (RAFIAM) and the Navy (Royal Navy Physiological Laboratory)²⁶ remained open, and all were to provide employment opportunities for ergonomists.

After the war, the MRC expanded its capability for physiological research into human performance. In 1948 the Climatic and Working Efficiency Research Unit was established at Oxford under Le Gros Clark,²⁷ followed, in 1949, by Otto Edholm's Division of Human Physiology at Hampstead. This mainly undertook research for the armed forces.²⁸ Edholm had qualified in physiology from Kings College, London in 1936 and, during the war worked on strategies to reduce haemorrhagic shock in injured service personnel before taking up the post at Hampstead. He was the ERS physiological secretary until 1959, and held numerous roles in the Society, and represented the MRC on many human science panels. Thus by 1949 the MRC had established a coherent physiological research capability which was undertaking studies into human fatigue.

In this section I have outlined the work of the bodies that were established during the inter-war years, World War 2 and the immediate post-war years to investigate and research the physiological effects of fatigue on human performance. Both the NIIP and the IHRB were concerned with the reduction of human fatigue and an increase in efficiency, well-being and productivity. Military research was directed at lessening the physical demands placed upon serving personnel by their equipment, or their working environments. The MRC dominated personnel research councils were

²⁴ G.N. Gadsby, The Army Operational Research Establishment, *Operational Research*, (1965), 18, 5-18.

²⁵ E. T. Renbourn, and H. C. W. Stockbridge, War Office Clothing And Equipment Physiological Research Establishment, *Ergonomics*, (1961), 4, 73-79.

²⁶ Ernsting, (1999).

²⁷ J. Weiner and K. Provins, Medical Research Council Climate and Working Efficiency Research Unit, *Ergonomics*, (1958), 1, 277 - 284.

²⁸ K. Collins, Obituary Otto Gustav Edholm, *Annals of Human Biology*, (1985), 12, 383 - 384.

empowered to direct and shape armed services research. By the end of the war the MRC held an executive role in managing medical and non-medical human science research for both industrial and military applications, and had established physiology laboratories capable of undertaking research. These developments, facilitated by wartime research, provided a management process and research capabilities, in terms of both scientists and facilities, that would nurture the development and institutionalisation of ergonomics. The work undertaken at these laboratories also produced human science knowledge which researchers would seek to civilianise in the post-war years to assist reconstruction. Bartlett, meanwhile, was working to establish the MRC Applied Psychology Unit (APU) and this is now discussed.

2.3: Sir Frederic Bartlett and the Formation of the Applied Psychology Unit.

During the war Bartlett had started to formulate his concept of the application of psychology to increase workforce productivity. His thinking was shaped by two major influences: observation of the impact of the implementation of military technology on human performance, and the work of his protégé, Kenneth Craik.²⁹ Through his membership of the personnel research committees, Bartlett saw first-hand how increasingly sophisticated military equipment placed new and uncharacterised psychological burdens on service personnel. For example, radar operators were placed under high cognitive demands by the need to identify singular events in cluttered backgrounds under conditions of low light and long shifts. He was also empowered to recommend which laboratories should undertake research, either at existing military facilities, MRC laboratories or his own department at Cambridge.³⁰ The leading research scientist in Bartlett's department was Kenneth Craik.

²⁹ D. Broadbent, Frederic Charles Bartlett. 1886-1969, *Biographical Memoirs of Fellows of the Royal Society*, (1970), 16, 1 - 13.

³⁰ For an appreciation of the depth and breadth of the research work overseen by Bartlett see The Psychological Laboratory, University of Cambridge Unit in Applied Psychology Annual Report 1946. This contains over 100 references and short descriptions of the work undertaken. University of Cambridge, MRC Cognition and Brain Sciences Unit, <http://www.mrc-cbu.cam.ac.uk/> accessed 11 May 2013.

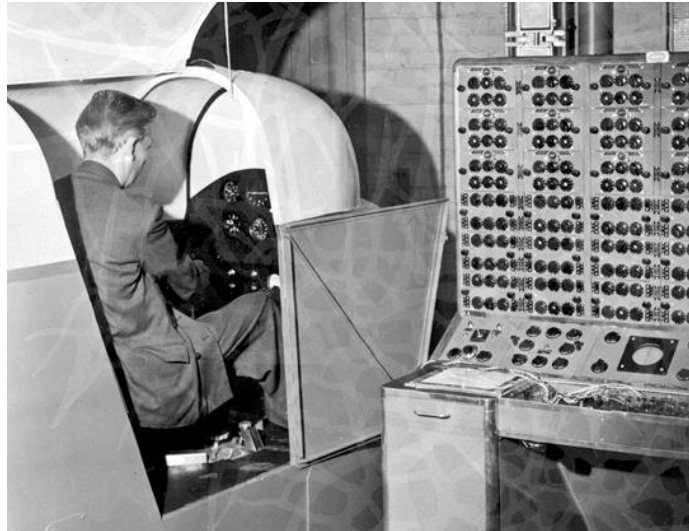


Figure 2-2. The Cambridge Cockpit.³¹

Craik joined Bartlett's Department in 1936 where his early research included visual adaptation and fatigue.³² It was his design and construction of the Cambridge Cockpit, used to assess pilot workload and fatigue, (Figure 2-2) which is considered as one of his greatest achievements.³³ This comprised a Spitfire cockpit with a full complement of controls whose movements were accurately monitored and recorded in real time so providing measures of work load, fatigue and error.³⁴ It was used to study the effects of sleep deprivation, noise and amphetamines on pilot performance.³⁵ Craik was able to demonstrate the time course of the growth of mental fatigue and its relationship to error, information which would be later applied in an industrial setting by other members of the APU.³⁶ The breadth of his expertise is revealed in his work portfolio which included cognition, error, auditory stimuli and target tracking, whilst he also sat on numerous wartime personnel research committees.³⁷ In addition to his influence on Bartlett's thinking on industrial psychology³⁸ Craik also articulated the notion of

³¹ Waterson, (2011).

³² Hayward, (2001).

³³ Gibson and Harrison, (1984).

³⁴ F. C. Bartlett. Fatigue Following Highly Skilled Work, *Proceedings of the Royal Society B*, (1943), 131, 247 - 257. This is the transcript of the Ferrier Lecture given to the Royal Society in 1941 and is the most accessible description of the early experiments, although Bartlett does not refer to the Cambridge Cockpit for security reasons.

³⁵ G. Iles and K. Craik, *Pilot Error: Some Laboratory Experiments*, London, HMSO, 1948.

³⁶ A. Collins, The Reputation of Kenneth James William Craik, *History of Psychology*, (2013), 16, 93 - 111.

³⁷ F. C. Bartlett, Obituary Notice. Kenneth J W Craik, 1914 - 1945, *British Psychological Journal* (1946), 36, 10 - 17. This also contains the complete bibliography of Craik's research.

³⁸ Collins, (2013) provides an analysis of the influence that Craik held over Bartlett.

placing the human as an equal or dominant partner in the human-machine system. He argued that ameliorating limitations in human performance caused by fatigue or poor equipment design would permit technological systems to achieve their full potential. This was, perhaps, one of the first articulations of the concept of a human in a systems engineering context (see Chapter 3). This deeply influenced Bartlett's vision of industrial psychology as a science that could aid an increase in productivity.

Bartlett believed that the increasing sophistication and complexity of machine controls, and the increase in time pressure caused by the demand for higher productivity would place unacceptable cognitive loads on the worker. His concept for industrial psychology was as a science that would characterise the effects of cognitive workload and time pressure on performance, which was a central theme in Craik's research. This characterisation would be undertaken in the laboratory and then confirmed in the workplace. Cognitive overload could then be ameliorated by the redesign of the workplace, particularly displays which the worker needed to use and interpret.³⁹ The critical element underpinning this concept was the successful garnering of funds for the laboratory studies. Bartlett's actions in attaining funding are discussed in Section 2.6.

By 1942, Bartlett had become convinced of the need for a research laboratory to specialise in industrial psychology research. This would alleviate the workload on his department and provide a venue for Craik to develop his own research concepts, and establish a centre for industrial psychology research in post-war UK.⁴⁰ To garner support for his notion, Bartlett published *Psychological Problems in the Design of Equipment and Methods of Display, and in the Training of Specialised Skills*, which set out his vision for industrial psychology in the post-war era and a dominant role for the MRC in managing and delivering such research.⁴¹

³⁹ F.C. Bartlett, Psychological Research in Industry, *Journal of the Textile Industry*, (1949), 40, 419 - 425. This provides the clearest description of his concept of industrial psychology and how he envisaged its application.

⁴⁰ A. Collins, The Psychology of Memory, in G. C. Bunn, A. D. Lovie and G. D. Richards (eds.), *Psychology in Britain. Historical Essays and Personal Reflections*, Leicester, BPS Press, 2001, 150 - 168. As examples of industrial psychology, he cites the work of Craik and Mackworth on design of displays, for a review of Mackworth's studies see The Cambridge Psychology Laboratory Annual Report, 1946.

⁴¹ F. C. Bartlett, Psychological Problems in the Design of Equipment and Methods of Display, and in the Training of Specialised Skills, *Memorandum presented to the Royal Naval Personnel Research Committee*, 3rd April 1943.

Bartlett framed his argument by observing that the MRC was the scientific institution that had encouraged the adaptation of military equipment to match users' physiological and psychological capabilities, and, as such, should collate, formulate, develop and prioritise human science research.⁴² He also introduced the term 'fitting the job to the man' to signal the move away from selecting personnel for specific tasks (fitting the man to the job) to re-designing the job, or the tools to reduce stress and strain. Here he acknowledged Craik's concept of the centrality of the human. As I show later the term 'fitting the job to the man (worker)' was to become talismanic in the promotion of ergonomics by DSIR and the British Productivity Council (BPC) from the late 1950s onwards. He concluded that a complete re-investigation of the physiological and psychological aspects of the worker in their working environment was required and that "it would seem to be an enterprise proper to the Medical Research Council, possibly more particularly to the Industrial Health Research Board."⁴³ This statement was made as Bartlett had to approach the MRC council through the IHRB for agreement to form the APU.⁴⁴

Bartlett's paper is important for three reasons: firstly, it provides an early articulation of the centrality of the operator in the human-machine system and coins a term that will become associated with ergonomics in the 1950s. Secondly, the paper is an argument from Bartlett for the MRC to establish a new laboratory. Finally, Bartlett is mapping a central role for MRC managed human science in post-war reconstruction. Since 1940 the Government had embarked on wide scale planning for post-war reconstruction in terms of provision of food, jobs and housing.⁴⁵ *Training for the Building Industry* called for the expansion of construction manpower from pre-war levels of 1 million to 1.4 million to meet the reconstruction demands.⁴⁶ Bartlett appreciated that if there was a slow rate of demobilisation, the workforce numbers would be static, older, and have a high proportion of female workers, which could slow reconstruction. Further the IHRB were keenly aware that any post-war reorganisation of industry would demand research into the "design of machinery in

⁴² Ibid.

⁴³ Ibid.

⁴⁴ Wellcome Trust, (2001). The reasons for this mechanism are not given.

⁴⁵ See for example, Peter Malpass. Wartime planning for post-war housing in Britain: the Whitehall debate, 1941–5, *Planning Perspectives*, (2003), 18, 177 - 196.

⁴⁶ *Training for the Building Industry*. Cmnd 6428, London, HMSO, 1943.

the interests of the comfort and efficiency of the worker,⁴⁷ which was one of the strands of Bartlett's concept of industrial psychology.

Although the MRC was reluctant to form the APU, it was established in 1944 as a focus for military research.⁴⁸ Craik became Director, but died in 1945, and was succeeded by Bartlett.⁴⁹ By 1946 the unit had 18 staff and, although continuing to work on military problems, was undertaking collaborative work with the Ministry of Works Building Research Station (BRS) on skills and training for recruits to the building trade, the Civil Aviation Authority and The Canadian armed forces.⁵⁰

Bartlett had successfully manoeuvred to establish the APU as a centre of excellence for research into the worker in their working environment. By agreeing to the proposal, the MRC was now in strategic control of UK non-medical human science research. Through its suite of laboratories at Cambridge, Oxford and London, it possessed a coherent physiology and psychology capability staffed with experienced scientists which was uniquely placed to research human science related workplace issues.

This section and the previous section have described the structures the MRC built for managing and delivering human science research and which would be used to support the government's industrial human science programme. But the MRC was not the only institution involved in human science research in this period. The ERS also played a role in framing the institutional landscape within which ergonomics research developed. It is to this that I next turn.

2.4: The Formation and Growth of the ERS.

The ERS was formed in 1949 by Hywel Murrell. He had read chemistry at Oxford and joined the Royal Engineers in 1940, then transferring to Air Defence Operational Research Group where he undertook assessments of crew space layout in pre-production equipment and manpower studies.⁵¹ At the end of the war, he joined the Naval Motion Study Unit (NMSU), where he was secretary of the Operational

⁴⁷ R. S. F. Schilling, (1944),

⁴⁸ Ibid. The identity of those who were reluctant is not revealed, nor the nature of their opposition.

⁴⁹ Wellcome Trust, (2001).

⁵⁰ MRC Progress Report 1949 - 1950. <http://www.mrc-cbu.cam.ac.uk/>

⁵¹ R. Stammers, What did You do in the War Hywel? *Some Foundations of Ergonomics. Contemporary Ergonomics*, London, Taylor and Francis, (2006), 132 - 136.

Efficiency Sub-Committee.⁵² The NMSU researched and modelled the flow of materiel and personnel within, and between, naval structures, i.e. ships and shore bases. During one meeting, an unidentified naval officer suggested that a forum should be created to allow researchers interested in problems associated with human work to meet and discuss issues. As secretary, Murrell was tasked with arranging an inaugural meeting.⁵³ This was held in the Admiralty in July 1949 to set the aims and scope of the group. Attendees are given in Table 2-1.

Attendee	Affiliation
H. Murrell	NMSU
Lt T.P. Randle	NMSU
S. Murch	NMSU
Dr H. Darcus	MRC Climate and Working Efficiency Research Unit
Dr N. H. Mackworth	MRC Applied Psychology Unit (APU)
Dr W. E. Hick	MRC APU
C. B. Gibbs	MRC APU
Wg Cdr W. K. Stewart	RAF IAM
Wg Cdr H. P. Ruffell-Smith	RAF IAM
Surg. Lt Cdr S. G. F. Linton	RAF IAM
H. Mound	Army Operational Research Group

Table 2-1. Attendees at Human Research Society foundation meeting.⁵⁴

The forum was originally called the Human Research Group, until the title ERS was adopted in early 1950. The first formal meeting was held at the MRC's Oxford laboratory in September 1949 and comprised demonstrations and papers given to invited attendees from academia, government departments and military research establishments, including the US Office of Naval Research, who were visiting Admiralty research establishments at the time and were invited to attend and present.⁵⁵ Another attendee was R. G. Stansfield from DSIR, who was to have a major influence on the growth of ergonomics and the human science research programme.

⁵² H. Murrell, Occupational Psychology Through Autobiography: Hywel Murrell, *Journal of Occupational Psychology*, (1980), 53, 281-290.

⁵³ Ibid.

⁵⁴ Ibid.

⁵⁵ Edholm and Murrell, (1973), pp. 6 - 7.

Stansfield read physics at Cambridge and was awarded an MA in 1940.⁵⁶ He served in OR Sections in the Ministry of Aircraft Production (MAP) and Coastal Command,⁵⁷ and, on Bartlett's recommendation, took a degree in psychology where his interest lay predominantly with social psychology. After the war he joined the BRS, where he sat on the Scientific Advisory Committee Building Industry Sub-Committee Human Efficiency Panel, which was chaired by Bartlett.⁵⁸ He moved to the Board of Trade in 1948 to become Sir George Schuster's secretary on the Committee for Industrial Productivity (Human Factors) (CIP (HF)) panel (see below). He joined DSIR in 1950 and supported the human science panels described in this thesis. He also sat on the ERS Council and played a key role in the internationalisation of ergonomics.

The ERS council structure was based on that of the Physiological Society. There was no Chairman but, instead, secretaries for individual sub-disciplines. Thus, Edholm was physiology secretary, whilst Murrell was psychology secretary.⁵⁹ This arrangement was to be part of the cause of the internecine rivalry that marked the early years of the society, see Section 3.6. Further, by not appointing a council chair, who could have acted as a clear focal point for dealing with external organisations, the ERS may, inadvertently, have inhibited the growth of ergonomics and their own ability to institutionalise the science. As an example, the Operational Research Club, later Operational Research Society (ORS), had been formed in 1948 as a forum to discuss and advance the science of operational research, which were similar goals to the ERS. The important difference was that from its inception the chairs of the ORS were politically powerful individuals such as Sir Charles Goodeve, Sir Owen Wansborough-Jones, Chief Scientist to the Ministry of Supply and, in 1960, Lord Halsbury, who had been director of the National Research Development Corporation.⁶⁰

Thomas points out that these chairs were promoters, rather than practitioners, of operational research. They used their political positions to promote the use of operational research by both government and industry. Indeed, it was not until the

⁵⁶ R. G. Stansfield Obituary, *Clare Association Annual*, 1993 - 94, p 71.

⁵⁷ Stansfield Archive (STAN) U6. Scientific Officer and Senior Scientific Officer Application Form, 1945.

⁵⁸ STAN U 6. Letter Philip to Stansfield 10th September 1945.

⁵⁹ Edholm and Murrell, 1973, p.7.

⁶⁰ Thomas, (2015), pp 166 – 167.

mid-1960s that an academic was appointed chair of the ORS: by which time operational research had “assumed the mantle of a profession.”⁶¹ In fairness, the ERS had not appointed such politically powerful patrons to the council, mainly because there were no obvious candidates. Key members such as Bartlett and Le Gros Clark were held in high academic esteem, but did not command the political stature, or have comparable industrial connections as individuals such as, for example, Goodeve. As I shall demonstrate this meant that the ERS did not enjoy such a high level of political patronage as, for example, OR. The outcome was that the institutionalisation of the science was driven by individuals and institutions, with their own agendas, and without overt support from the ERS.

In common with the Physiological Society, membership of the ERS was by invitation only. By 1951 there were 88 members, increasing to 300 by 1957, mostly drawn from the human sciences, medicine and engineering.⁶² Some new members were recruited directly by invitation, but there were other possible routes for the expansion of the membership. From 1950 onwards the ERS held scientific meetings at academic and industrial sites as an outreach function.⁶³ As pointed out in the review of disciplines the Biochemical Society had used a similar mechanism in the early twentieth century to recruit new members. Visit reports provide a record of presentations and demonstrations but little on other interactions.⁶⁴ The other possible forum was the annual symposia.

From 1951 onwards the ERS held annual symposia which were open to academia, industry and the TUC and were themed to address topics of interest to the attendees. The first symposium, ‘Human Factors in Equipment Design,’ attracted 145 delegates from academia, government and industry and was opened by Sir Ben Lockspeiser, the Secretary of DSIR, at the invitation of W.F. Floyd.⁶⁵

⁶¹ Ibid.

⁶² Unattributed, List of Members and Their Appointments, *Ergonomics*, (1957), 1, 94 - 100.

⁶³ Bristol University Special Collections Archive (BUSCA) DM 26/4183. This box contains the agenda of ERS visits to such venues as S.Smith Ltd, Cricklewood in 1951, the OR Division of British Railways and British European Airways both in 1953. There are no records of how these visits were received.

⁶⁴ See, for example, DM 26/4182. Visit of Ergonomics Research Society to Doncaster Rescue Station. 30th November 1955. This describes how the mines rescue service is organised and a description of the self contained breathing apparatus.

⁶⁵ Edholm and Murrell, (1972), p.11.

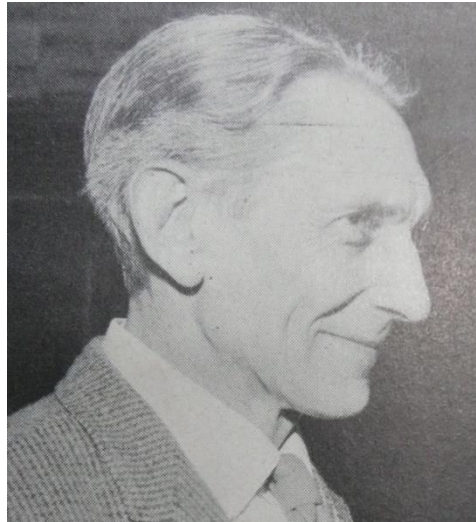


Figure 2 - 3 W.F. Floyd.

Floyd (Figure 2-3), who developed the first degree level course in ergonomics at Loughborough University (Chapter 6), had initially gained a BSc in mathematics from UCL in 1931 and had started a mathematics PhD at King's College. This was interrupted when he was elected to the Leon Fellowship in the Department of Physiology at UCL, attaining a BSc in physiology in 1936. After the War, he lectured in physiology at Middlesex Hospital Medical School attaining his PhD in 1952.⁶⁶ Floyd was elected to the ERS Council in 1950, becoming the physiology secretary in 1951, where he arranged the first four ERS symposia.⁶⁷ He was sub-contracted by the Post Office to investigate physiological problems faced by postal workers,⁶⁸ which had brought him to the attention of the TUC where he was held in high regard.⁶⁹

The presence of industrial representatives was a result of DSIR extensively advertising the meeting. Unfortunately, the ERS had arranged a scientific conference, but the largely industrial audience did not appreciate the scientific content of the meeting.⁷⁰ The scientific content of subsequent symposia, which were on topics such as *Fatigue* (1952) and *Ergonomics: its place in industry* (1959), were organised to

⁶⁶ Loughborough University Archives (LUA) LCT/G/P3 Extended Agenda Governors Meeting. Post graduate Work In Ergonomics and Cybernetics, Agenda Item 7. 2nd Feb 1960. Curriculum Vitae of William Frederick Floyd.

⁶⁷ Edholm and Murrell. (1973), p 35.

⁶⁸ Ibid, p.7.

⁶⁹ MRC.MSS.292/571.89/1a. Letter Fletcher to Poole, 8th February 1960. "his Post Office ergonomics work ... I believe to have been undertaken in full recognition of the trade union interests." Poole was chair of the Boot and Shoemakers Union and a governor of Loughborough CAT.

⁷⁰ Ibid. p.12.

appeal more to industry. DSIR support for the symposia was to continue for many years. The initial reason for this support was, as I discuss later, that by 1951 DSIR was working towards the establishment of the Individual Efficiency Committee (Section 2.8) which would sponsor industrial ergonomics research. Supporting the ERS symposium series would afford DSIR the opportunity to identify emerging research needs a forum where their sponsored research could be exploited.

Practitioner histories of the society write guardedly about the schisms that were prevalent during the 1950s and 1960s, but fail to provide details about the nature of these tensions.⁷¹ The closest we may come to understanding this issue is from Murrell who identifies the existence, but not the membership, of two camps within the ERS, one of which saw ergonomics as an inter-disciplinary research activity which should support industry. The other, who saw ergonomics as a technology “whose purpose was to interpret the findings of researchers who continue to work in their own disciplines.”⁷² As I show in Section 3.6, there were also rivalries between the disciplines within ergonomics. Murrell, writing in *Ergonomics News* in 1970 and reported by Waterson and Sell,⁷³ admits that “none of us envisaged the development of a professional ergonomist,”⁷⁴ hinting at a degree of isolationism within the society. How these attitudes impacted the acceptance of ergonomics by government, industry and the TUC is a major theme in this thesis.

During these formative years the ERS had very few interactions with other societies. Waterson and Sell report a meeting held with the British Occupational Health Society in 1957.⁷⁵ During the early 1950s the ORS had tried to hold collaborative meetings with the ERS. The ERS minute book⁷⁶ reveals that by 1950 the society was becoming concerned that an overlap over interests and goals might exist between the two societies. Murrell wrote to Goodeve suggesting that the difference between the two sciences was that OR practitioners were more interested in experimental studies, whilst ergonomists interests lay in observational science.⁷⁷ It is instructive to

⁷¹ Waterson and Sell, (2006), pp.781 - 782.

⁷² H. Murrell, Why Ergonomics? *Occupational Psychology*, (1967), 41, 17 - 24.

⁷³ Waterson and Sell, (2006), p.782.

⁷⁴ Ibid.

⁷⁵ Ibid, p.765.

⁷⁶ This uncatalogued ERS minute book is held at the offices of the Chartered Institute of Ergonomics and Human Factors in Loughborough.

⁷⁷ ERS Minutes, April 1950.

compare this to the comments made by Murrell in 1970 regarding the two camps within the ERS (see above). Goodeve's response is not recorded in the minutes, but up to 1953 there are numerous references to the ORS attempting to set up collaborative meetings. On each occasion, the ERS, for reasons that are unclear, declined. A collaborative meeting with the ORS, or any other learned society, would have identified areas of co-operation and demarcate areas of influence. It was not until the 1960s that the ERS held collaborative meetings with other learned societies.

I have shown how and why the ERS was formed, and identified two important events in its the development, the early association with DSIR and the divide between the memberships over what was ergonomics was supposed to achieve. For DSIR, an association with the ERS would be important as it could provide a conduit from the department to academia and industry. This would permit the passage of knowledge and information between the groups and act to exploit DSIR sponsored research.

One of the outcomes of the tension that existed within the ERS was, as I show later, to prevent an agreed and understandable definition for ergonomics being developed. The disagreements would also slow the development of a consensual statement on the relationships between ergonomics, work study and occupational health. How these issues impacted on the growth of ergonomics will be discussed throughout this thesis. I shall also be arguing that the absence of a strict definition was advantageous as it allowed other actors and agencies to make their own interpretation of the science and mould it to meet their own goals. This would be an important step in the institutionalisation of ergonomics. Having provided contextual detail on the development of MRC non-medical human science research facilities and the formation of the ERS, I will now turn to the government funded research programme.

2.5: Setting the Research Agenda - The Committee on Research and Productivity.

Three committees directed government funded human science research from 1947 to 1957, the first being the Committee on Research and Productivity (CRP). This was formed following a directive from the Lord President to the ACSP to identify "the appropriate form of research effort to assist the maximum increase in national productivity during the coming decade."⁷⁸ The reason for the formation of the CRP

⁷⁸ *Advisory Council on Scientific Policy, First Report*, Cmd. 7465, London, HMSO, 1948, para. 1

was that in August 1947, the government announced a set of measures to address the balance of payments crisis which included a ration reduction of about 400 calories per person, which would effect savings on the cost of imports of foodstuffs.⁷⁹ The issue was would such a reduction adversely affect physical performance at the workplace? E.M. Nicholson, Private Secretary to the Lord President, identified that the only source of data on the calorific requirement for heavy and light manual work was a study published in Germany during World War 2.⁸⁰ No one in the UK could advise if a reduction in intake of 400 calories would adversely affect work performance. The ACSP was, therefore, directed to identify how to increase productivity through the application of human sciences. As the ACSP was a strategic advisory body, it formed the CRP, whose membership is given in Table 2-2, to work on the directive.

Name	Affiliation	Notes
Sir Claude Gibb	MD C. A. Parsons	Was Director General Armoured Fighting Vehicles
Sir Frank Ewart Smith	Technical Director ICI	Superintendent of Armament Design for the Ministry of Supply at Fort Halstead
W. Strath	Central Economic Planning Staff.	Author of the 1954 Strath Report into the implications for the UK of a nuclear war
S. Wyatt	MRC	Member of the IHRB
E. M. Nicholson	Office of the Lord President	Private Secretary to the Lord President.

Table 2-2. Initial Membership of the CRP.⁸¹

The CRP first met to consider a discussion paper prepared by the Lord President's Office on the potential causes of low productivity in industry.⁸² Drawing on the 1947 *Economic Survey*,⁸³ it identified issues such as insufficient fuel, shortage of raw materials, and an aging workforce as causes of low productivity. These were codified into physical and human issues (Table 2-3; overleaf).

⁷⁹ TNA CAB 124/1045 Balance of Payment Gen 179/22 13th August 1947.

⁸⁰ H.Kraut and H. Bramsel, Der Calorienbedarf der Berufe Ermittelt aus den Erhebungen von Wirtschaftsrechnungen im Deutschen Reich vom Jahre 1927/28, *Arbeitsphysiologie* (1942), 12, 197 – 221. Ultimately the CRP decided that the issue of nutrition and work capacity was an activity which the government should consider and decide what future work was necessary (TNA CAB 132/84 S.P. (R.P.) 47 6th meeting of the CRP 29th October 1947).

⁸¹ TNA CAB 132/84. Committee on Research and Productivity. First meeting, S.P. (R.P.). 47. 25th July 1947. S.P. (R.P.). 47.

⁸² Ibid.

⁸³ *Economic Survey for 1947. Cmd 7046*, HMSO, London.

Physical			Physiological	Psychological	Organisational
Material	Machinery	Fuel			
Shortage of Raw materials	Obsolete Machinery	Insufficient Fuel	Inadequate Nutrition	Inadequate Training	Wrong Type of Personnel.
Inferior Quality of Raw Materials	Insufficient Mechanisation	Poor Quality Fuel	Inadequate Welfare Arrangements	Lack of Incentives to Work	Inadequate Numbers of Engineers and Technologists
Misuse of Raw Materials	Shortage of Transport in and out of the Factory		Advanced Age of Workers	Restrictive Practices	Lack of Technical Experts on Boards
Shortage of Containers	Shortage of Mechanical Handling Equipment			Lack of Competitive Spirit	Lack of Liaison Between Research Workers and Users
Shortage of Packaging				Lack of Pride in the Job	Lack of Enterprise in Adopting New Practices and Policies
				Unattractive surroundings for Work	Excessive Variety of Products
				Lack of Incentives to Management	

Table 2-3. Causes of Low Productivity.⁸⁴

This table is significant in the development of ergonomics. Possibly for the first time, there is a codification of the physical and human issues which could cause low productivity. Such codification identified human science issues, such as age, training, morale and workplace design, which would attract extensive research funding over the coming years. It also drew attention to cross-discipline issues, such as mechanisation, which would require engineering, human relations and ergonomics research to resolve.

The paper also considered the long and short-term problems of productivity and proposed palliative measures. Long-term solutions, such as re-equipping and re-building programmes, were restricted by lack of capital funds and could not be readily implemented. Short term gains could be achieved by re-organisation of work processes and improved managerial professionalism. Following discussion of the

⁸⁴ TNA CAB, 132/84. Potential Causes of Low Industrial Efficiency. S.P. (RP). (47). 28th July 1947.

paper two recommendations were made to the Lord President. One drew his attention to the impact of low quality coal on productivity; the other was that a working party should be formed to investigate the effects of illumination, interior decoration and cleanliness on productivity.⁸⁵

The CRP undertook work in other areas such as standardisation and metrics for productivity. Its paper, 'Human Factor in Production,' made the link between human sciences and industrial output by identifying primary and secondary human science shaping factors.⁸⁶ Primary factors acted at the national level, were cultural, and included hours of work and consumer satisfaction. These could only be influenced by national policy, where human science could have an influence on the economic climate. Secondary factors acted at the local level and included industrial relations which would be influenced by human sciences research.

The CRP was wound up in December 1947 following the appointment of Cripps, then Minister of Economic Affairs, as Chancellor following Hugh Dalton's resignation. This afforded Cripps the opportunity to amalgamate the two offices, thereby bringing the Treasury into the centre of economic planning.⁸⁷ He agreed with the Lord President's Office that the CRP's work should be transferred to a new group, the Committee for Industrial Productivity (CIP), which would be chaired by Tizard and contain representatives of the Economic Planning Staff. This latter body was part of the Economic Policy Committee which Cripps had also established to bring the supply of goods, labour, power and fuel under his control.⁸⁸ This placed productivity research and economic planning under the control of Cripps and the Treasury.

The CRP was a short-lived committee which played an important role in establishing the requirement for a human sciences research campaign. By relating the causes of low productivity to physical and human science issues, it established an outline framework which would serve to shape the research programme developed by the Committee for Industrial Productivity Human Factors panel (CIP (HF)), and which can be traced in the work of subsequent human science research panels.

⁸⁵ TNA CAB 132/84. Committee on Research and Productivity. First meeting, S.P. (R.P.). 47. 25th July 1947. S.P. (R.P.). 47.

⁸⁶ TNA CAB 132/85. The Human Factor in Production. S.P. (R.W.P) (47) 6 dated 15th December 1947.

⁸⁷ Chick, 1998, p. 10.

⁸⁸ Bryant, 1997, p. 384.

2.6: Raising Productivity - The Committee for Industrial Productivity Human Factors Sub - Committee.

The Committee for Industrial Productivity (CIP) was to advise the Lord President's Office "on the form and scale of the research effort in the natural sciences, which will best assist an early increase in individual productivity and further to advise on the manner in which the results of such research can best be applied."⁸⁹ It was supported by four Sub-Committees, Technical Information Services, Technical and Operational Research, Import Substitutions⁹⁰ and CIP (HF), the membership of which is in Table 2-4. It is unclear how the members were recruited.

Name	Affiliation
Sir George Schuster (Chair)	Ex Chair of Cotton Working Group
G.B. Blaker	Treasury (Economic Affairs)
Dr C.B. Frisby	NIIP
L. Moss	Social Survey, Central Office of Information
J. Neil	North Eastern Marine Engineering Company
E. M. Nicholson*	Office of the Lord President
J.Tanner	Amalgamated Engineering Union
M.D. Tennant	Ministry of Labour and National Service
Brigadier A. Torrie	War Office
Dr S. Wyatt*	MRC
L. O. Russell	British Institute of Management
Dr A. T. M. Wilson	Tavistock Institute of Human Relations

Table 2-4. Initial Membership of CIP (HF).⁹¹ * = sat on CRP.

Frisby was to become director of the NIIP whilst Wilson was Director of the Tavistock Institute.⁹² Torrie was the Army's Director of Psychiatry, whilst Tanner, a leading trade unionist became TUC president in 1954. His inclusion reflected Cripps's belief in democratic planning, which had, at its heart the notion that consultation and consent between representatives of government, employers and unions, within a committee, would ensure the dissemination of government policy.⁹³ The Chair was Sir George Schuster who had worked for Cripps in the MAP, and with Nicholson on

⁸⁹ Zuckerman Archive University of East Anglia (SZ) SZ/CIP/1. CIP (48).1 Terms of Reference and Composition of Committee 30th January 1948.

⁹⁰ The Import Substitution panel was tasked to consider ways of using alternative indigenous materials.

⁹¹ SZ / CIP / 1 C.I.P (48) 3. Panel on Human Factors Affecting Productivity. 3rd February 1948.

⁹² E. Trist and H. Murray, *The Social Engagement of Social Science, A Tavistock Anthology*. <http://www.moderntimesworkplace.com/archives/ericssess/tavis1/tavis1.html> accessed 28th June 2016.

⁹³ J. Tomlinson, (1993). For a deeper discussion on Cripps's tenure in both the war and post-war administrations and his consensual approach to productivity panels see C. Bryant, 1997.

the Council of Political and Economic Planning.⁹⁴ He is described as “having a deep conviction that too little was understood about the reality of human relations in industry, that the social sciences were essential in establishing harmony at the workplace, but that they were insufficiently developed to be of use.”⁹⁵

With a Treasury allocation of £50K per annum,⁹⁶ and faced with the need to quickly develop a research programme, Schuster met with the MRC, the Tavistock Institute and universities to identify current human science studies or planned research which could be accelerated by a further injection of funds.⁹⁷ Schuster lacked research management expertise, and so instructed Nicholson to enquire if the MRC would be prepared to fulfil that role. They would have control over research methodology, approval of research team personnel, publication rights and be informed of the progress and direction of the work.⁹⁸ In return, Schuster would sit on the MRC Council.⁹⁹ The appointment of Schuster to the MRC appears to be a simple *quid pro quo*, and it would certainly allow him to appreciate how the work of CIP (HF) fitted within the MRC’s work programme.

The resultant programme (Table 2-5) reflects both the importance attached to management and human relations studies by the Labour administration,¹⁰⁰ and the dearth of human engineering studies in academia. The framework for the research programme, and the use of the term ‘Human Engineering’, was the work of Schuster.

⁹⁴ G. Schuster, *Private Work and Public Causes. A Personal record 1881 – 1978* By Sir George Schuster, Cowbridge, D Brown and Sons, 1979, pp. 140 - 149.

⁹⁵ A. King, *Let the Cat Turn Round. One Man’s Traverse of the Twentieth Century*, London, CPTM, 2006, p.192.

⁹⁶ TNA FD 1/301. Letter Nicholson to Mellanby, 5th March 1948.

⁹⁷ TNA HF CAB, 132/32. C.I.P (HFR) (48) 1 dated 28th January 1948. Committee for Industrial Productivity Panel on Human Factors. Research Advisory Group. Composition and Terms of Reference.

⁹⁸ TNA FD 1/301. Memo Research into Human Factors in Industrial Productivity. MRC 48 / 157, 17th March 1948.

⁹⁹ Ussishkin, (2013).

¹⁰⁰ D. Ussishkin, Morale and the Postwar Politics of Consensus, *Journal of British Studies*, (2013), 52, 722 - 743. See also Tomlinson, 1997 chapters 4 and 5 for further information on Labour’s policies on human relations.

Research Areas	Studies ¹⁰¹	Research Group
Extensive Surveys of Existing Practices in British Industry.	The Status, Selection and Training of Foremen and Supervisory Grades.	NIIP
Intensive Studies of Human Relations in Particular Cases.	A Study of Human Relations in the Glacier Metal Company. (Jaques)	Tavistock Institute
	East Fife Coal Mining Study. (Paterson).	MRC Department of Anthropology, Cambridge
Comparative Case Studies.	A Study of Human Relations in Three Merseyside Companies.	NIIP
Human Engineering Studies.	Investigation of work load problems and the design of machine controls. (Mackworth)	MRC APU
	Problems of Aging. (Welford).	Nuffield Unit for Research Into Problems of Aging
	Unit of Work. (Frisby)	NIIP
Study of Methods of Communication in Industry.	The Communication Project.	Tavistock Institute

Table 2-5. CIP (HF) Work Packages and Sample Studies.¹⁰²

This agreement that the MRC should manage quickly resulted in tensions between Schuster and Bartlett. Although Schuster had suggested the management arrangement he quickly concluded that control and development of the research programme had been taken out of the panel's hands.¹⁰³ Bartlett was vehemently opposed to the human relations studies, an area which Schuster believed could make the more important contribution to productivity.¹⁰⁴ At the heart of Bartlett's opposition was his conviction that human relation studies were incapable "of solution by scientific research,"¹⁰⁵ and that they were not underpinned by testable and viable basic research or techniques. This also reflected the prevailing view in the Psychology Department at Cambridge,

¹⁰¹ Names in brackets are lead researcher where known.

¹⁰² TNA CAB 132/32. CIP (HF) (48) 9. Interim Report of the Research Advisory Group 1st March 1948.

¹⁰³ G. Schuster, *Research in the Field of Human Factors in Industry in Human Relations in Industry*, Ministry of Labour and National Service, 1952.

¹⁰⁴ Ussishkin, (2013).

¹⁰⁵ Ibid, p. 734.

where there were no social science lecturers or researchers. The first were not employed until the mid-1950s.¹⁰⁶ There is another plausible reason, which is that Bartlett was attempting to make space, and gain funding for industrial psychology.

The CIP (HF) studies made important contributions to both human relations and human engineering. Ussishkin has analysed the significance of the human relations studies of Jacques and Patterson (Table 2-5), but not the human engineering studies.¹⁰⁷ The work of Mackworth and Welford were extensions of the wartime studies of the APU and, given that the remit of CIP (HF) was to accelerate existing work, should be viewed as the ‘civilianisation’ of military research. Mackworth used the funding to employ two graduates to investigate workload, interface design and human skill. This extended the understanding of the interactions between time pressure and performance, which Craik had first observed using the Cambridge cockpit, into a form applicable to an industrial setting.¹⁰⁸ The results and techniques were later used by the APU in studies for the Post Office on the design of telephone exchange systems and mechanisation of sorting offices.¹⁰⁹

Welford’s study used methodologies, developed by Craik and Bartlett during the war, to understand human skill and applied them to identify if either fine manipulative or gross movement industrial tasks were best undertaken by middle aged male and female workers.¹¹⁰ As noted earlier, the post-war workforce contained a high proportion of older workers, and to gain improved productivity from this group it was necessary to ensure that the ‘job fitted the aged worker.’ This work was a central part of Welford’s *Aging and Human Skill*, which was the first book to address the effects of age on industrial skills. The unit of work study aimed to identify major areas of job satisfaction and relate them to features of work and so allow a particular task to be redesigned.¹¹¹ This was not a success, as it had to be industry-based, and required

¹⁰⁶ A. Costall, Why British Psychology Is Not Social: Frederic Bartlett's Promotion of the New Academic Discipline. *Canadian psychology – psychologie canadienne*, (1992), 33, 633 - 639.

¹⁰⁷ Ussishkin, (2013).

¹⁰⁸ Unattributed, Applied Psychology Unit Annual Report 1950 – 1954.

¹⁰⁹ R. Conrad, Performance of Telephone Operators Relative to Traffic Levels, *Nature*, (1956), 178, 1480 - 1481.

¹¹⁰ A. Welford, *Aging and Human Skill*, Oxford, Oxford University Press, 1958.

¹¹¹ G. Schuster, Some Conclusions from the projects sponsored by the Schuster Panel on the Human Factors in Industry in *Human Relations in Industry: report of a conference arranged by the Ministry of Labour and National Service*. London, HMSO, 1952.

representative numbers of workers engaged on the same task for a prolonged period of time. Such conditions could not be fulfilled.

By 1950 Tizard, the chair of CIP, concluded that because of a shortage of funds to implement findings, and the long lead time for scientific research to reach maturity, CIP could not deliver the hoped-for immediate increase in productivity.¹¹² He recommended to the Treasury that CIP should close, but that the work of CIP (HF) should continue, because “the importance of the human side of the problem (productivity) has not yet been given sufficient recognition.”¹¹³ He proposed that future human science research should be managed by a joint committee of the MRC and DSIR, reasoning that the MRC was well placed to maintain an academic oversight, whilst DSIR, with their network of Research Associations (RA), provided a route for research exploitation. This proposal, although superficially pragmatic, moved the management of the human science programme from a department which was headed by a cabinet member, to DSIR, which did not have cabinet representation. Effectively, the management of human science research was being pushed down the bureaucratic ladder. The impact of this will be reviewed in Chapters 3 and 4.

I have reviewed the formation and management of the work of CIP (HF) and drawn attention to the tensions which started to emerge between Schuster and Bartlett regarding the importance of human relations research. Nicholson’s request to the MRC that they should manage the CIP (HF) research programme provided the MRC with the opportunity to effectively take control of both civilian and military non-medical human science research as applied to the worker in their working environment. It will be recalled that the MRC already had an executive role on the military personnel research councils which allowed them to direct those research programmes. What we are also seeing is the ‘civilianisation’ of human science research, a phenomenon already shown for technology and OR.¹¹⁴ In the next section, the events leading up to the formation of the Human Factors in Industry committees will be described.

¹¹² Kirby, (2003), p. 205.

¹¹³ SZ/CIP/3 C.I.P. (50) 6. Draft report of the Committee for Industrial Productivity. 29th March 1950.

¹¹⁴ E.g Agar (1998) and Kirby (2003).

2.7: The Formation of the Human Factor in Industry Committees – 1950 to 1953.

The official request from the Lord President that DSIR and MRC should jointly manage a future human factors research programme also stated that, as Schuster had been successful in managing CIP (HF) he should be given a significant role in the new enterprise.¹¹⁵ This was to bring to a head the animosity between Schuster and Bartlett. At this stage both Schuster and Bartlett were members of the Council of the MRC. Schuster was alive to this animosity for, without mentioning names, he noted that the MRC made him feel like “a cuckoo in the nest.”¹¹⁶ What appears to have brought this animosity into the open was Schuster’s suggestion that future human factors research should be considered under the same categories he had devised for CIP (HF), (Table 2- 5), but that a separate working party be established to direct human behaviour and relations research.¹¹⁷ Bartlett rejected Schuster’s proposal stating that “current deficient scientific methodologies prevented meaningful research being undertaken in those areas.”¹¹⁸ Schuster suggested that any decision be made once the MRC had reviewed the CIP (HF) work programme, and there the issue lay.

The CIP (HF) programme had been an exercise in pump-priming existing research. If the MRC and DSIR were to establish a new programme it would be necessary to understand what work was already in progress to prevent duplication of effort. Both agencies undertook surveys to map the extent of research and identify research centres.¹¹⁹ The DSIR review, undertaken by Stansfield, was concerned with human relations studies. The unattributed MRC review, which addressed the totality of human factors research, revealed the paucity of research capability.¹²⁰ Most was concentrated in MRC laboratories, a few academic centres, such as the Engineering Production Department at Birmingham (see later), military research establishments, and the mining industry.¹²¹ It also identified some basic research which could be

¹¹⁵ TNA FD 1/303. Letter Lord President – Himsworth 30th June 1950

¹¹⁶ Schuster, (1979), pp. 144 - 145.

¹¹⁷ TNA FD 1/303. Letter Himsworth – Lord President undated.

¹¹⁸ TNA FD 1/301. Memorandum of meeting between representatives of DSIR and Medical Research Council to discuss future work in productivity. 23rd May 1950.

¹¹⁹ TNA FD 1/303. Unsigned letter MRC – Lord President 5th July 1950.

¹²⁰ TNA FD 1/303. Undated and unsigned “Survey of Current Research of Human Factors in Industry.” DSIR also published a survey which addressed human relations and social studies.

¹²¹ Ibid.

exploited into industry, but this again was meagre. What this exercise could not do was identify the research that was actually required, as no one asked that question.

Schuster continued to lobby for the establishment of a human behaviour and relations committee.¹²² This was due, in part, to his concern that the MRC and DSIR research reviews would ignore the area, but also to his conviction that it was necessary to promote promising research in human relations.¹²³ This insistent lobbying irked the MRC, and Bartlett in particular, as Schuster had been told that a decision would not be taken until after the MRC's Occupational Psychology Committee, chaired by Bartlett, had reviewed the CIP (HF) work portfolio to identify which research programmes should retain funding once the new committee had been established.¹²⁴ The conclusions were damning. The work of the Tavistock Institute and the Anthropology Unit were deemed to be showing "no appreciation of the nature and requirements of scientific method"¹²⁵ and funding was stopped. The work of the NIIP and the APU was highly praised, with the recommendation that further research in those areas was to be actively encouraged.¹²⁶ Bartlett, by stopping future funding for the CIP (HF) human relations programme, had, effectively, commenced carving a niche area in the human sciences which could be filled by industrial psychology.

The decision to cease future funding for the CIP (HF) human behaviour and relations studies spelt the end to Schuster's involvement with human science research. He had lobbied for a body to manage research in those areas, but with no research planned he, and such a body, would not be required. In 1951 the Conservative Lord President wrote to Schuster thanking him for his services.¹²⁷ It is unclear if the MRC lobbied for his removal, or if he was a casualty of the change of government in 1951, or both. His autobiography diplomatically makes few mentions of the MRC, but expresses disappointment at his time with CIP (HF) because of "the negative and un-cooperative

¹²² TNA FD 1/303. Letter Schuster – Himsworth, 31st October 1950.

¹²³ Ussishkin, (2013).

¹²⁴ TNA FD 1/303. Letter Himsworth – Schuster 7th November 1950. It is not known who sat on this body.

¹²⁵ TNA FD 1/303. Unreferenced and undated Recommendations of the Psychology Committee With Regard to the Experimental Investigations Undertaken by the Human Factors Panel.

¹²⁶ *Ibid.*

¹²⁷ Schuster, (1979), p. 146.

attitude of the leaders of British industry” which he saw as preventing a meaningful discussion with the unions over human relations.¹²⁸

With Schuster’s role now ended Harold Himsworth, the MRC Secretary, wrote to Lockspeiser, the DSIR Secretary, outlining his views on how the research should be constituted. He proposed three committees dealing with Industrial Disease and Physiology, which equated to the work of the IHRB; Human Engineering, which included work measurement, personnel selection and training; and Human Relations in Industry, which would address the social aspects of work.¹²⁹ Himsworth argued that Human Engineering was supported by “knowledge waiting to be applied and where we (the MRC) had enough knowledge to undertake profitable research”, but did concede that developing more research in other laboratories was also important.¹³⁰ He viewed human relations methodologies as immature and un-validated. Such methodologies and techniques would need to be developed before proceeding with funded research. Lockspeiser disagreed, observing that the Human Engineering category was “such a mixed bag that I cannot think of any statement that could be applied in common to all constituent items.”¹³¹ He took a less cautious approach to developing a human relations research programme, believing that an empirical approach to a small number of programmes would be justified.

This exchange reveals much about the institutional thinking of the two organisations. The MRC clearly wished to distance itself from human relations research, citing issues with methodology as a major reason, which they, and, Bartlett, viewed as having a poor scientific basis.¹³² We are also seeing Bartlett’s pragmatism in play. He was keen to institutionalise industrial psychology as a discipline, or sub-discipline, with the APU as the leader in the field, but he would also need to ensure that a funding stream could be accessed by his laboratory to pursue his goal. By proposing

¹²⁸ Ibid.

¹²⁹ TNA FD 1/306. Unreferenced letter Himsworth to Lockspeiser – Survey of Research and Its Applications to Human Factor in Industry 16th April 1951.

¹³⁰ Ibid.

¹³¹ TNA FD 1/306. Letter Lockspeiser to Himsworth 1st May 1951.

¹³² TNA FD 1/306. Letter Bartlett – Himsworth, 10th April 1951. Bartlett’s view is summed up in this passage “to differentiate the human relations studies from the other two main approaches will run the most serious of risk of letting loose all the woolliest of thinkers with the shoddiest criteria in the most difficult of all these fields without any effective control”.

human engineering as a category which the MRC would manage, Bartlett manoeuvred himself into a position to exert strategic and financial control of the programme.

From its inception, DSIR's responsibilities included increasing the supply of trained research workers, expanding university research and the encouragement of industrial research through their RAs.¹³³ This allowed the consolidation of research undertaken by individual industrial concerns and the opportunity for them to participate in co-operative government funded research with academia.¹³⁴ DSIR, therefore, saw science as answering objective questions requiring the interaction of academics and industry, which explains Lockspeiser's observations. The difficulty for DSIR was that they had no experience of managing human science research. They did, however, have R. G. Stansfield, who worked in Headquarters Division and was a qualified psychologist.

In the 1950s and 60s DSIR was functionally organised into four divisions: scientific grants, industrial grants, research stations and headquarters.¹³⁵ Scientific and industrial grants divisions provided monies to academia and industry respectively to encourage and support research. Scientific grants also funded studentships and provided post graduate training awards. The research stations division set policy across the DSIR RAs and managed their output. Headquarters division provided administrative support to the other divisions as required.

Headquarters division, which was to manage the human science research programme, was divided into general administration, establishment, research associations and intelligence and publicity departments.¹³⁶ Intelligence and publicity departments liaised across government, academia and industry, both in the UK and internationally on science policy, research and development. Stansfield, who was employed in the intelligence department (ID), was required to brief DSIR departments on human science research activities, liaise with industry and academia to undertake what we would now term 'horizon scanning', brief these institutions on DSIR research and

¹³³ Vig, (1968), p. 10. For an analysis of the formation of DSIR see A. Hall, War of Words: the Public Science and the British Scientific Community and the Origins of the Department of Scientific and Industrial Research, *British Journal of the History of Science*, (1999), 32, 461 - 481.

¹³⁴ Varcoe, (1981).

¹³⁵ Melville, 1962, pp 55 - 74.

¹³⁶ Under the 1956 Department of Scientific and Industrial Research Act, which is described later, Headquarters division was reduced to 3 departments, which were split into 2 sub-departments each.

identify research requirements. As I discuss in the next chapter, he was also the DSIR representative on the European Productivity Agency (EPA).

The two organisations now proceeded to establish the new committees. Bartlett and Himsworth were responsible for selecting the IEC membership whilst Stansfield recruited members for the Human Relations in Industry Committee. The suitability of proposed members would be discussed through an MRC / DSIR Co-operative Committee.¹³⁷ It is unclear why it took two years for memberships to be agreed, when those for the CRP and CIP (HF) were settled within three months. One possibility is that the election of a Conservative government in October 1951 may have affected planning as both the MRC and DSIR sought to understand how to respond to any policy changes resulting from the change in administration. Another possibility is that it was difficult to find suitable industrial representatives who had both the experience and time to commit to the committees. Finally, there was also an extra layer of bureaucracy in the Co-operative Committee, which may have added to the delay.

It was then realised that although the Lord President had promised £50,000 per annum he had not identified the funding source.¹³⁸ Neither institution had sufficient funds to cover the extra work, nor would the Treasury provide any new funds. Funding was finally obtained from US Conditional Aid¹³⁹ which provided loans to industrial and government agencies for programmes which would encourage increases in productivity.¹⁴⁰ Conditional Aid was also used to fund the EPA, which is discussed in Chapter 3. The granting of Conditional Aid funds to the MRC / DSIRC joint committees would ensure that the UK would have scientific information which it could share with EPA partners. Work could now commence.

Nearly three years had elapsed from the closure of CIP (HF) to the inaugural meeting of the IEC, much of this time had been taken up with the bureaucracy of identifying potential committee members and securing funding. In establishing the form and function of the joint committees I would suggest that the most critical of the activities were the research reviews. These were the first such rigorous analyses of the state of

¹³⁷ TNA DSIR 17/426. Letter Himsworth to Lockspeiser 7th November 1951. STAN U2. Letter Stansfield to Cox 5th February 1952. This refers to “the Co-operative Committee machinery between MRC and DSIR.” A search of both MRC and DSIR files failed to yield any further information.

¹³⁸ TNA FD 1/303. Letter Lord President – Himsworth 30th June 1950

¹³⁹ TNA FD 1/7544. Letter Lush to Bartlett 18th April 1953.

¹⁴⁰ Carew, (1987) pp. 167 - 171.

industrial human science research in the UK. In addition to preventing nugatory work, they provided a snapshot of the health of national research in terms of coverage and identification of laboratories which could deliver the research programme. This, in turn identified skill shortages in the science base which could be addressed by executive action by the new committee. The resilience of the reviews was such that they were still relevant when the Human Science Committee was constructing its research programme in 1957. I now consider the work of the IEC in more detail.

2.8: The Individual Efficiency Committee.

The IEC, chaired by Bartlett, was charged with developing a targeted human factors research programme, to advise on emerging research areas and to consider and report on training requirements for research workers and technologists. The membership (Table 2-6) comprised those who had experience of serving on government committees and members of the ERS. Frisby and Green had served on the CIP (HF), providing continuity with the predecessor committee. Killick sat on the National Coal Board's physiology committee and the IHRB.

Name	Affiliation
Sir Frederic Bartlett*	Cambridge University
W. V. Beard	Gen Sec United Patternmakers Association
J. O. Blair - Cunynghame	Chief Personnel Officer, British Overseas Airways Corporation.
Prof J.V. Connelly*	Dept of Aircraft Economics and Production, Cranfield
J. Crawford	National Union of Boot and Shoe Operatives
Prof. J. Drever	Dept of Psychology, Edinburgh.
C. B. Frisby*#	Dir NIIP
L. V. Green#	Hd Personnel Research Dept Dunlop Ltd
Prof. Esther Killick	Dept Physiology, Royal Free Hospital
Prof. W. E. Le Gros Clark*	Dept Anatomy, Oxford
N. G. McCulloch	Chair, Council of British Cotton Industry RA.
Prof. R. W. Russell	Dept Psychology, University College London
Nora Wynne	Director, Carr's Biscuits

Table 2-6. Initial Membership of IEC.¹⁴¹ # member of CIP (HF), * member of ERS.

¹⁴¹ STAN B100. MRC.53/345 IE.Ag.1 22nd May 1953

Comparison with the membership of CIP (HF) (Table 2-4) shows a greater representation from industry – three on the IEC, compared to one on CIP (HF) – and academia – six on the IEC, compared to three on CIP (HF). There were no representatives from government departments such as the Treasury or the Ministry of Labour, although they had sat on CIP (HF). Other government departments with an interest in the work of the IEC would need to rely on annual reports and briefing from Stansfield to appreciate the totality of the work.

At the inaugural meeting Bartlett attempted to stamp his authority on the Committee by indicating three lines of investigation which he deemed to be significant: industrial training methods, the design of working tools and equipment and studies of industrial stress conditions.¹⁴² All were areas where the MRC APU had been particularly active over the years and were the foundation of his concept of industrial psychology.¹⁴³ He then proposed that all research should go to universities, the MRC or RAs who had the capability and capacity to undertake the work. Bartlett was attempting not only to impose a research programme framework which matched his research interests, but also to be the final arbiter regarding contract placement.

Bartlett backed down when members pointed out that the MRC / DSIR Human Relations in Industry Committee was circulating widely a call for research proposals and that the IEC should do the same.¹⁴⁴ Bartlett now proposed that the IEC should get two or three projects underway and then circulate a call for proposals to institutions identified in the research reviews, to which the rest of the committee agreed. Hand written notes from Stansfield show that the whole committee reviewed each research proposal for scientific merit and possible exploitation.¹⁴⁵ Effectively, Bartlett's aim to run the IEC as his own fiefdom had been thwarted.

The funded research programme along with delivery organisations are given in Table 2-7.¹⁴⁶ Only one proposal was rejected, and that was from Murrell, which Stansfield

¹⁴² STAN B100. MRC 53/346 Joint Committee on Individual Efficiency. Preliminary statement by the Chairman.

¹⁴³ The MRC APU Progress Report for 1950 - 1954 notes amongst its eight main lines of research training, new devices and procedures and unusual environments (heat, cold and noise). It also predicts that training and studies of industrial stress would be future growth areas.

¹⁴⁴ These were the Human Relations Committee and the Economics Research Committee. The latter Committee was managed by the Board of Trade, and a small number of their projects had some human factors element, particularly studies into the economics of different shift patterns.

¹⁴⁵ STAN B100. Notes from second meeting of the Joint Committee on Individual Efficiency.

¹⁴⁶ From Stansfield's handwritten notes.

recorded as being vague and unfocussed.¹⁴⁷ The MRC was the largest research provider, with much of the work aimed at generating basic knowledge to address industrial workplace problems. These studies, however, reflect the changing research direction of the APU. Under the directorship of Norman Mackworth, who had also been a disciple of Bartlett,¹⁴⁸ research was focussed on cognition and human information processing, hence the studies on manual control and visual fatigue, with industrial psychology afforded lesser importance. Objective studies were undertaken by the RAs and organisations listed under Industrial Engineering Techniques. The IEC had very quickly let a number of long-duration (i.e. 24 months or more) contracts, which used up their total financial allocation within the first six months of their work.

Research Institution	Title of Project	Lead Researcher	Comments
Influence of Equipment Design and Working Conditions on Operator Efficiency			
BISRA	Design and Layout of Control Points in Steel Works, with special reference to Crane Cabs.	Sell	See text.
MRC APU	Manual Machine Control Studies.	Gibbs Brown	The effects of micrometer displays on lathes with a digital display.
MRC APU	Studies of Visual Fatigue.	Saldanha	Deterioration in visual performance during prolonged visual tasks.
Shoe and Allied Trades Research Association (SATRA).	Study of Machine controls in relation to Equipment used in the Boot and Shoe Industry.	Singleton	See text.
MRC Climate Research Unit, Oxford	The Age Factor in work in High Temperature.	Welford	IEC provided the subjects.
Industrial Engineering Techniques			
Birmingham University: Department of Engineering Production	The Nature and Acquisition of Industrial Skills.	Dudley Crossman	Nature and learning of skills in repetitive industrial processes.

¹⁴⁷ Ibid.

¹⁴⁸ Wellcome Foundation, (2001).

Cranfield College of Aeronautics: Department of Aircraft Economics and Production	Work Study Rating, Rest and Fatigue Allowances.	Belbin Williams	A study to provide a rational basis for developing and implementing shift patterns.
Training			
SATRA	Methods of Application to Training and Re-training Operatives.	Singleton	The establishment of a "training laboratory"
NIIP	Methods of training in Industrial Skills.	Blain	Comparative studies of the progress of trainees in different training programmes.
University of Oxford: Institute of Experimental Psychology	Conditions Influencing the Rate of Learning of Paced and Unpaced Motor Skills.	Annette	Investigations of the conditions which influence the learning of simple skills and enhancing the learning experience.
North Western Polytechnic	Research into Reading Efficiency.	Hart	Research into increasing reading speed.
Other Studies			
MRC APU	Effects of Knowledge on Results of Production.	Gibbs	Understanding motivation during repetitive tasks.
NIIP	Investigation of Indices Commonly Regarded as Indicating the Adjustment of the Individual to his job.	Frisby	Indices included labour turnover.
University of Cambridge: Department of Psychology	A Study of Automation in relation to Skill and Design of Machines.	Not known	Ergonomic issues which will be encountered with the introduction of automation to the workplace

Table 2-7. Research Studies Sponsored by the IEC.¹⁴⁹

It is notable that two RAs were funded to undertake research. The MRC's 1951 survey did not identify either SATRA or BISRA having a human science capability.¹⁵⁰ Yet within three years both were employing psychologists to undertake human science research, Singleton at SATRA and Sell at BISRA. It is not known how or why Singleton was employed, but Sell has provided a practitioner's account of how

¹⁴⁹ STAN B28.MRC /DSIR Joint Committee on Industrial Efficiency in Industry. Report for the Period April 1953 – March 1957. Undated.

¹⁵⁰ TNA FD 1/303. Undated and unsigned "Survey of Current Research of Human Factors in Industry." DSIR also published a survey which addressed human relations and social studies.

the human factors capability was formed at BISRA.¹⁵¹ Under Sir Charles Goodeve's directorship, BISRA had, in 1946, established an OR department which eventually comprised operational investigation, systems evaluation and human factors.¹⁵² Sell identifies two key actors in the formation of the human factors capability, Isabel Minto Slade and L. N. Bramley. Slade, a psychologist, had worked with Goodeve when he was Deputy Controller of Naval Research and Development during the war, and moved with him to BISRA to become Information Officer. Slade was one of the earliest members of the ERS, and it was she who persuaded Goodeve of the necessity to establish a human factors unit in the OR department.¹⁵³ Bramley was from the aircraft industry where he had been involved in cockpit design. Bramley was so shocked at the poor design of the crane cab used in throughout the steel industry that he produced, in association with H. Darcus from the MRC¹⁵⁴, a style guide for the design of crane cabs. It was this document which served as the basis of Sell's study.

The formation of the human factors capability at BISRA is one of the first instances of the institutionalisation of the science, and provides an example of how actors, mainly from other disciplines, established an ergonomics capability. Slade provided the political impetus by using her influence with Goodeve to argue for the creation of the capability. Bramley developed the style guide which set the parameters for Sell's work, but did so by enrolling Darcus from the MRC. The combined efforts of Slade, Bramley and Darcus had created the space for a capability at BISRA, and had also provided a model for where, in an industrial organisation, a human scientist could be employed to maximum effect. The success of the cab crane study resulted in the formation of a Human Factors Advisory Service at BISRA in 1960. Sell does not provide any details on the how this new capability was formed. The service continued until well into the 1970s.

With all the research budget allocated the only tasks open to the IEC was to monitor the progress of the research. In mid-1954 Le Gros Clark suggested that the IEC might consider subsidising a *Journal of Ergonomics* in which their sponsored research could

¹⁵¹ R.G. Sell, *Ergonomics in action - 4. The Human Factors Section of Bisra, 1950-1964.* (The Corporate Laboratories, British Steel Corporation). *Applied Ergonomics*, (1971), 2, 226-229.

¹⁵² Kirby, (2003), pp. 214 - 215.

¹⁵³ Sell, (1971).

¹⁵⁴ Darcus had worked at the Physiological Laboratory at Lulworth, was employed in Le Gros's Department at Oxford and had attended the first meeting of the ERS. (see Sections 2.2 and 2.4).

be published.¹⁵⁵ Usually learned societies, publishers or wealthy individuals founded and funded scientific journals.¹⁵⁶ Now a government institution was considering fulfilling that role. Strictly, this did not contravene the rules of Conditional Aid funding, which was supposed to be used to increase productivity, as it could be argued that a such a journal would provide a vehicle for the publication and exploitation of IEC-funded productivity research.

From its inception, the ERS had sought to establish its own journal. In 1951 the editorial board of the *Operational Research Quarterly* had proposed a joint journal with a name that would reflect the two sciences. The proposal was declined as it was felt that other journals would have room for ergonomic articles.¹⁵⁷ Finally, in 1953 the ERS concluded that it could not afford to establish a journal by itself. The terms of the IEC offer was £500 per annum for two to three years for “assembling and communicating information.”¹⁵⁸ Welford, who was negotiating for the ERS, responded with a request for £1000 per annum for two years which he based on a cost breakdown from publishing firms and from sales of symposium proceedings.¹⁵⁹ The offer was withdrawn.¹⁶⁰ Why Welford took this approach is unclear. An ergonomics journal could have provided a focussed forum for publishing IEC research to a wider audience. The journal *Ergonomics* was eventually published in 1957.

This was the only occasion that the IEC formally interacted with the ERS. This may seem odd as the ERS had, in 1954, positioned itself as an agency which would facilitate the exchange of research findings and requirements between industry and academia (Figure 1-1, Page 20). The ERS was already holding academic meetings at industrial premises, and so would be well-placed to provide that link for the IEC. Yet there is no mention in any meeting minutes of the ERS briefing the IEC on their work.

¹⁵⁵ STAN B100. Handwritten notes from Stansfield for 4th meeting of the Individual Efficiency Committee. April 1954.

¹⁵⁶ Although unusual see for example Erlingsson, (2013) who describes how Crew, the Director of the Animal Breeding Research Department in Edinburgh underwrote the guarantee to the publishers of the *British Journal of Experimental Biology*. Also, the *Journal of Physiology* was founded by the Society with the help of funding from a rich member. The Physiological Society, History of the Physiological Society and its Journals: Information Sheets, <http://www.physoc.org/history-physiological-society-and-its-journals-information-sheets> accessed 2 March 2016.

¹⁵⁷ ERS Minute Book, June 19th 1951.

¹⁵⁸ STAN B100. Handwritten notes from Stansfield for 4th meeting of the Individual Efficiency Committee. April 1954.

¹⁵⁹ STAN B100. MRC.54/209. Proposal for the Publication of a New Journal Covering the Field of Ergonomics, undated. ERS Council minutes do not discuss why such an inflated bid was tabled.

¹⁶⁰ Ibid.

It is difficult to understand why there was not a closer relationship between the ERS and the IEC, when both bodies could have benefited from such an arrangement. This apparent marginalisation of the ERS from the industrial human science research programme may be a further reason for the society taking a minor role in the institutionalisation of ergonomics. It did not have a first-hand knowledge of the progress of the totality of the individual programmes and, so, could not contribute to the shaping the direction of the research. Further, it could not help exploit the research.

The IEC ceased work in March 1957 by which time it had overseen 14 peer reviewed projects at 10 research sites. Aside from the MRC laboratories, research monies had been provided to two RAs, two universities, Cranfield and Birmingham, and the North Western Polytechnic, none of which had previously received government-sourced human science funding. This helped launch the careers of Singleton and Sell, who were to influence the development of ergonomics and the ERS during the 1960s. It also sustained a nascent ergonomics capability at Birmingham and established a short-lived one at Cranfield. In total sixty-eight papers were published in prestige journals such as *Nature*, *Occupational Psychology*, the *British Journal of Psychology*, the *Journal of the Institute of Production Engineers* and *Ergonomics*, which vindicated the ERS's view that other journals would publish ergonomics research.

2.9. Visualising the IEC Research.

In assessing the impact of a research programme an approach would be to evaluate the outputs, both published and concrete, and seek to show how these positively influenced other workers and research programmes. In the case of the IEC much of the research was depicted in a film, *Fitting the Job to the Worker*, which aimed to educate all levels of the workforce on the meaning and benefits of ergonomics. It also showed the enrolment of the workforce in the development of the research campaign by highlighting them providing insights into their work to the researchers. Analysis of this film permits a novel opportunity to assess the impact of the research, and to understand how the research was performed.

Fitting the Job to the Worker was produced by the British Productivity Council (BPC). The BPC was formed in 1952 by the Conservative administration as a successor to the AACP, to promote industrial productivity through lectures, seminars

and, from 1953 onwards, the use of film. The BPC sponsored nearly 100 films from 1954 to 1975 such that “no other sponsor afforded film production a greater importance in meeting of core organisational objectives, nor wove film making so tightly into its administrative structure.”¹⁶¹ In 1959 the BPC decided to run ergonomics courses and invited W.F. Floyd, who, as described in Chapter 6, was developing a degree-awarding ergonomics course at Loughborough, to discuss developing the courses.¹⁶² From this meeting an ‘Ergonomics: Fitting the Job to the Worker’ panel was formed which included Murrell and Singleton from the ERS, Edwin Fletcher from the TUC (see Chapter 3) and A. Graham, a work study specialist from ICI to develop the seminar structure.¹⁶³ The film would be shown during the seminars, or to the work force during lunch breaks at individual factories.

It is not known who scripted the film, or who determined the content. ‘*Fitting the Job to the Worker*’ was issued in 1961 and comprised two distinct sections. The first reviewed workplace stressors, such as poor interface design, heat and noise, and showed how the application of ergonomics would significantly improve working conditions and, by implication, productivity. A typical image is shown in Figure 2-4, which contrasts the working environment in a power station control room, purportedly before and after the application of ergonomics: ‘purportedly’ as, clearly, the film was stage managed. The message is that the application of ergonomics results in a light, airy and comfortable working environment. The film showed images of experimentation at the workplace, e.g. the collection of noise data and then use of the information in a laboratory setting. It also advanced the notion that automation and mechanisation were not technological advances to be feared. In a section on the development of protective clothing for furnacemen, the narrative states that a better solution might be to “get machines to do the job done by human beings,”¹⁶⁴ articulating the view that one of the benefits of mechanisation and automation could be to protect the worker from adverse environmental effects.

¹⁶¹ P. Russell and J. P. Taylor, Sponsorship in *Shadows of Progress. Documentary Film in Post – War Britain*. Basingstoke, Palgrave MacMillan, 2010, p.70.

¹⁶² BUSCA DM 2648/21. Letter Floyd to Murrell 13th October 1959. A profile of Floyd is provided in Chapter 6.

¹⁶³ MRC.MSS.292D/571.89/1. Notes of Decisions Taken at the 2nd Meeting of the “Ergonomics: Fitting the Job to the worker” Seminar Panel. 5th April 1960.

¹⁶⁴ *Fitting the Job to the Worker*. Soundtrack at 10 minutes 35 seconds.



Figure 2-4. Power station control room before and after the implementation of ergonomic design principles.¹⁶⁵

The second section showcased the research undertaken by Singleton at SATRA and Sell at BISRA. Both were concerned with redesigning a working environment. Singleton addressed a mass workplace, a shoe factory closing room where uppers and soles are stitched together, whilst Sell addressed an individual workplace, the crane cab. Singleton's study was undertaken in conjunction with work study specialists whilst Sell worked with engineers. Singleton's sequence addresses implementation of his findings at the workplace, whilst Sell's sequence pays greater attention to experimentation. Both sequences also describe worker participation and satisfaction with the outcome. Together, these provide a rich picture of workforce participation, human experimentation at the workplace, the positive implementation of automation and mechanisation, and the potential relevance and worth of DSIR research.



Figure 2-5. Original Closing Room.¹⁶⁶

¹⁶⁵ Ibid, Soundtrack at 4 minutes.

¹⁶⁶ Ibid Soundtrack at 13 minutes.

The original closing room (Figure 2-5) was a cramped, overcrowded and poorly lit environment: boxes of shoes were manually transported and placed in any available space near the worker. The sewing machines were fixed-speed, which was varied by the operator repetitively using the foot treadle to switch the machine on and off and manually slow the balance wheel to vary the speed (Figure 2-6). Working conditions appeared to have changed little over many years.



Figure 2-6. Slowing the sewing machine using hand pressure on the balance wheel.¹⁶⁷

The narrative describes how the work study team deconstructed the closing room tasks into their component parts from which Singleton redesigned the work space layouts. We are told that the staff were consulted by the research team and their observations shaped the development of the new working environment.¹⁶⁸ This suggests to the audience that a positive partnership existed between work study practitioners, the ergonomist and worker during the study. This is reinforced by the description of the new working layout (Figure 2-7). The workers were given a choice between work being delivered either by a trolley or by an automated belt system, and we are told that the “girls overwhelmingly preferred the automated system.”¹⁶⁹

¹⁶⁷ Ibid. Soundtrack at 13 minutes 40 seconds.

¹⁶⁸ Ibid. Soundtrack at 12 minutes.

¹⁶⁹ Ibid. Soundtrack at 14 minutes 30 seconds.



Figure 2-7. The newly designed closing shop. Note the automated conveyor belt for moving work to and from each work station.¹⁷⁰

Singleton and his team did not merely re-design the closing room: they also revised the training courses, both in terms of equipment and curriculum for new entrants, thereby moving ergonomics into a new field. The film provides a short sequence on organised classroom tuition in the use of sewing machines, rather than the haphazard on-the-job training shown in Figure 2-6. Such organised training would ensure that trainees would reach a benchmark level of competency in the tasks required of the craftswomen. Singleton's study was an all-encompassing redesign of the task, training and the working environment for a large group of workers.

Three points emerge from the description of Singleton's study. Firstly, ergonomics is a participatory science that continually elicits and analyses personal observations from the workforce to understand the problem space. Secondly, automation and mechanisation are depicted as improving working conditions: the narrative underlines that their implementation will not necessarily result in de-skilling or threaten long-term employment prospects. Thirdly, the integrated application of work study and ergonomics can transform a working environment into something that is light, airy and modern.

There are also messages for the TUC and employers. From the TUC General Council's perspective, Singleton's study demonstrated to the shop floor worker that concerns over the negative impacts of work study, automation and mechanisation were more imagined than real. For the employer the point is made that the redesign of

¹⁷⁰ Ibid. Soundtrack at 14 minutes.

the closing room would mean “more work of better quality as the girls and their machines are in harmony.”¹⁷¹ The phrase “more work .. better quality” implies that ergonomics could deliver cost benefits.

Sell’s study was the redesign of the cab of a crane that was used to move steel rolls to and from railway wagons in a storage facility. The original cab (Figure 2-8) was open to the elements, provided a restricted view of the hook used to move the steel rolls and required the operator to stand throughout his shift. The controls were three awkwardly located circular hand controllers. The sequence commences with Sell talking to the driver in his cab about his task and the purpose of the controls. Knowledge elicitation is informal, Sell is dressed like the crane operator, as if to minimise any social barriers, although comparison of the crane drivers’ attire with that in Figure 2-11 suggests a degree of stage management.



Figure 2-8 Old design of crane cab and with Sell eliciting information.¹⁷²

The film shows the stages of the experimental campaign, a literature survey being undertaken to help “guide the experimental approach”,¹⁷³ and then researchers familiarising themselves with the current controls. Data on controller use and operation during a working day is shown being analysed by a computer, which determined frequency and sequence of use of the controllers. Analysis showed that the hoist was operated concurrently with either of the travel controls, which was critical to the subsequent design of the cab. Given the cramped nature of the cab, such information could not have been gathered by the traditional direct observational work study methods. Rapid prototyping assessed the crane cab structure which gave the

¹⁷¹ Ibid. Soundtrack at 15 minutes 30 seconds.

¹⁷² Ibid. Soundtrack at 16 minutes 40 seconds.

¹⁷³ Ibid. Soundtrack at 17 minutes 30 seconds.

driver maximum visibility (Figure 2-9). Rapid prototyping is a method where a 3-dimensional model is made of an assembly to help appreciate how each element fits together and how it may be re-arranged to reduce fatigue and increase productivity. The researchers are shown assessing different types of controller before settling on a joystick, which would allow combinations of control of movement of cab and hoist. The final scene is the laboratory assessment of the new controls (Figure 2-10).



Figure 2-9. Laboratory mock-up of crane controls and rapid prototyping to determine prime cab position on the gantry.



Figure 2-10. Joystick Controller undergoing laboratory assessment.

There are few documentary films showing the application of ergonomics to address human stresses at the workplace.¹⁷⁴ Here, in addition to showing the application of

¹⁷⁴ During the 1960s Pathe News released short films about the work of the RAF IAM, British Pathe, RAF Institute of Aviation Medicine, (1960), <https://www.youtube.com/watch?v=J7LoTtnTbvk> and British Pathe, RAF Institute of Aviation Medicine, (1964), <https://www.youtube.com/watch?v=6PwmZfyPypk> accessed 6th January 2015.

ergonomics and worker participation, the sequence on experimentation provides a view of modernisation with the use of computer analysis. The message in this sequence is that computers, a symbol of automation and worker participation, were integral and critical to the successful outcome of the experiment.

We finally see the new crane cab (Figure 2-11) enclosed in glass with a properly designed seat and the joy-stick controller readily accessible to the operator. The narrator states that the “drivers are at one with the crane and the controllers are extensions of the operators’ limbs”¹⁷⁵. The only piece of information missing is cost of implementation and savings accrued from the ergonomic intervention. Colcott estimated that the layout redesign of the crane cab cost £250 but this saved £1500 per annum in repair bills to railway wagons.¹⁷⁶

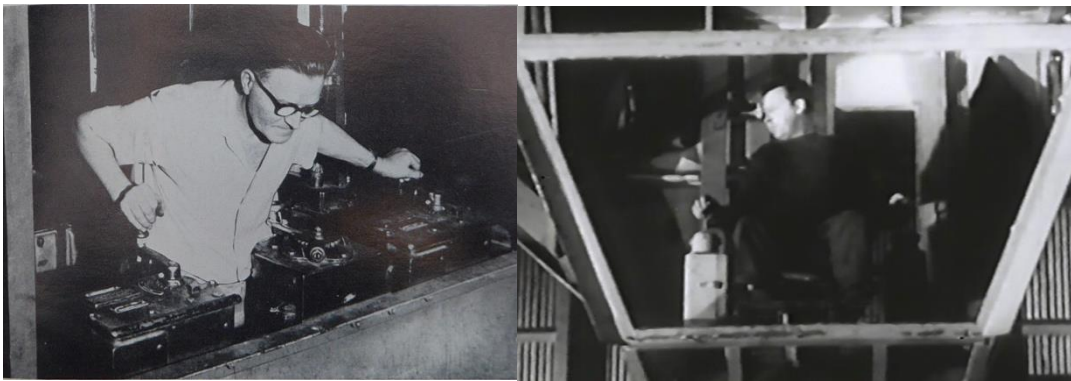


Figure 2-11. Operation of the Old and New Crane Cabs.

The IEC work described in this film also helped launch the careers of Singleton and Sell. In 1960 Singleton was appointed lecturer in ergonomics and systems design at Cranfield College of Aeronautics. It was here that he developed his theories of human representation in systems engineering. In 1964 he was appointed Professor of Psychology at Aston University, where he formed an ergonomics department. He retired in 1982.¹⁷⁷ Sell remained at BISRA until the early 1960s before moving onto the Central Electricity Generating Board. He has held many executive posts in the ERS Council and is still an active author.

¹⁷⁵ *Fitting the Job to the Worker*. Soundtrack at 20 minutes.

¹⁷⁶ R. H. Colcutt, *The First Twenty Five Years of Operational Research*, BISRA, Old Woking, Gresham Press 1965.

¹⁷⁷ M. Edwards, W. T. Singleton, Emeritus Professor, Aston University. Short Biographical Note and Introduction to the Festschrift, *Ergonomics*, (1995) 38, 431 - 436.

This section has described how the IEC developed a human science research programme and assessed the impact of the funded research. Previously I had shown that the CIP (HF) programme was an acceleration of current studies being undertaken in a few specialist departments. Here the IEC developed the first industrial human science research programme. It addressed new research areas and produced new information which would, in time be exploited into industry. The research programme also expanded the number of research centres which could undertake industrial human science research. A unique feature of the IEC research programme was the inclusion of two pieces of research in the BPC film *Fitting the Job to the Worker*. Not only did this help demonstrate the worth of DSIR research to industry, it also provided a glimpse of human experimentation and modernisation of the workplace and brought ergonomics to the attention of the workforce.

2.10: Conclusions.

This chapter has addressed the establishment and development of the government funded industrial human science research programme up to 1957. Launched by the Lord President, Herbert Morrison, the programme's initial aim was to generate knowledge which could be used to rapidly alleviate the balance of payments crisis. It is a moot point if this would have been successful, given the long lead time for research findings to emerge and their exploitation into the industrial base. The election of a Conservative government in 1951 brought into power an administration which viewed productivity as a way of fuelling and sustaining consumerism, rather than the cure of an economic crisis. Increased productivity would result in increased wages which could be spent on consumer goods.

Despite this change in emphasis, the research programme was not cancelled, even though it took nearly three years of negotiations to establish the committees and funding. A cogent reason why it avoided cancellation is that the funds for the programme came from US Conditional Aid and not the Treasury. Conditional Aid was meant to be used on projects and programmes which supported or increased industrial productivity and, as I will show in the next chapter, the European Productivity Agency was funded by Conditional Aid from 1952 onwards. DSIR officials, including Stansfield were very active in promoting a role for both the UK and ergonomics within the EPA. Thus, funding of the IEC programme from

Conditional Aid would ensure continued participation for the UK in this area. The impact of UK participation in the EPA on the development of ergonomics is discussed in the next chapter.

The impact of the human science research programme was, that in addition to generating knowledge and scientific techniques, it also provided funding which launched the careers of scientists and helped to establish and sustain institutions which could employ these workers. Perhaps the most interesting example was the work of Slade and Bramley to institutionalise human factors within BISRA. This institutionalisation also sought to bring ergonomics and OR closer together to the mutual benefit of each science. It was also to be the precursor to the formation of an in-house human factors capability.

Much of the narrative in this chapter has been dominated by the efforts of Bartlett to develop industrial psychology as a scientific discipline and establish a network of laboratories which would be capable of undertaking research in that area. Through his work with the armed forces personnel research councils Bartlett contributed to the development of a human science capability which encompassed laboratories, methodologies, trained personnel and concepts of industrial psychology. All of this contributed to post-war reconstruction and provided Bartlett, and the MRC, with the credibility to direct any government funded non-medical human science research for both civilian and military purposes in the post-war years.

In establishing industrial psychology, Bartlett needed to carve a niche for the science and secure funding. The opportunity arose when the MRC was requested to manage the CIP (HF) programme. Bartlett succeeded in ensuring that the Human Factors in Industry committees would be separate entities: one for human relations, one for industrial efficiency. His appropriation of the direction and funding of the IEC could have helped him achieve his aim. It did not. The science Bartlett aspired to build was narrow. It rejected social science and afforded little importance to physiology and anatomy. It was laboratory-based, and Bartlett had failed to undertake any major outreach activity towards industry. At the same time, through their annual symposia the ERS was developing the philosophy of a multi-disciplinary approach to addressing workplace stress, which may have made the science seem more pertinent, practical, and with a greater direct applicability to industry.

In the next chapter I will show, through the actions of Stansfield, how DSIR set about establishing and managing the successor to the IEC, the Human Sciences Committee (HSC), and I will chart the early progress of this enterprise. I will also examine the role that Stansfield played in developing ergonomics into a nationally and internationally recognised science through his activities within the EPA, and indicate the rise of TUC interest in ergonomics.

Part 1 Chapter 3: Ergonomics at DSIR and the European Productivity Agency - 1956 to 1960.

3.1: Introduction.

I showed in the previous chapter how Bartlett had tried, but not succeeded in establishing industrial psychology as an investigative cognitive science. He did, however, succeed in mapping out an area which ergonomics could fill. For ten years, he and the MRC had played a major role in defining, managing and delivering government-funded industrial human science research. In 1956 both Bartlett and the MRC decided to withdraw from this activity. Until the late 1960s, the stewardship of the human science research programme would reside with DSIR and, then the Ministry of Technology (Min Tech). DSIR's role in defining and supporting industrial research has received little attention,¹ so here, and in the next chapter, I will examine their managerial and procedural processes, which shaped the formation and work of the Human Sciences Committee (HSC). Intended to carry forward the work of the joint committees, the HSC was formed at a time of organisational change within DSIR which afforded it far greater managerial and financial freedom than previous committees. This freedom would allow the HSC the authority to divert funds to emerging areas of industrial research needs, so constructing an agile and tightly aligned research programme. Yet, within 12 months, the HSC was facing an uncertain future, following a failed bid to the Treasury for an increase in funding to build the research programme. In the first part of this chapter, I will trace the events leading to the failed bid and the subsequent responses by DSIR.

DSIR, through its support for ERS activities such as the annual symposia, was also assuming the mantle of champion for ergonomics in the UK. The second part of this chapter will examine how Stansfield worked with the EPA to promote ergonomics on a national and international stage. The activities of the EPA have also attracted little attention. It was an intergovernmental organisation created by the Organisation for European Economic Co-operation (OEEC) with the purpose of improving

¹ There is a body of work on some of the DSIR laboratories, D. M. Yates. *Turing's Legacy: A History of Computing at the National Physical Laboratory, 1945 – 1995*. London, Science Museum, 1997, concentrates on the work of the laboratory. Agar, 1998, provides a detailed discussion of DSIR's involvement in the Jodrell Bank project. Melville, 1962, provides an overview of the work of DSIR laboratories.

productivity across Western Europe, so encouraging European integration.² Stansfield, through his work for the EPA, defined the need for three international ergonomics conferences and played a central role in the formation of the International Ergonomics Association (IEA). These conferences provided an international venue where industry, the Trade Unions and leading ergonomists could meet and exchange views. I will argue that the final event, the 1960 Ergonomics in Industry Conference, was significant in shaping the nature and direction of ergonomics by exposing how industry, the unions and the ERS visualised ergonomics, and the tensions that existed between the institutions.

Any attempt to develop a linear chronological narrative here and in the next chapter would result in a dense and confusing account. To avoid this, here I deal with the formation and work of the HSC up to 1959 and the work of the EPA up to 1960, which permits a critical analysis of the 1960 Ergonomics in Industry conference. The next chapter will then follow the work of the HSC from 1959 onwards, which will encompass the closure of DSIR and management by Min Tech and, finally, the Science Research Council (SRC) and Social Science Research Council (SSRC).

3.2: The End of the Partnership.

Negotiations over the future management of the human science research programme began in late 1955 with Bartlett announcing his intention to stand down as Chair of the IEC in 1957.³ After further exploratory talks, the MRC announced that it no longer wished to be involved in managing the human science research programme as they were more interested in the acquisition of fundamental knowledge, although they “would continue [their] interests in human factors in industry ... but not in industrial organisation or productivity.”⁴ The MRC’s decision appears to be based upon two factors. Firstly, Donald Broadbent, who had succeeded Norman Mackworth as the Head of the APU, placed greater emphasis on understanding the processes underlying perception and cognition.⁵ He aimed to develop knowledge and techniques to meet

² See Carew, 1987; Tiratsoo and Tomlinson, 1998; and M-L Djelic. *Exporting the American Model. The Postwar Transformation of European Business*, Oxford, Oxford University Press, 1998.

³ TNA DSIR 17/728. Notes of a discussion between Sir Frederic Bartlett, Dr Norton, Mr Hudson and Mr R. G. Stansfield at the Applied Psychology Research Unit, Cambridge, 31st October 1955.

⁴ STAN B100. MRC.56/902. Future of the Committees on Human Relations and Industrial Efficiency in Industry Appointed Jointly by the Council and the Department of Scientific and Industrial Research.

⁵ Wellcome Trust. (2001) pp. 14 - 15. Broadbent had joined the APU in 1949 and was director from 1958 to 1974. His remit was to investigate the extent to which technological systems tax the human

the growing human science challenges of the implementation of computing and automation in the workplace.⁶ For example, he used information and techniques from basic cognition experiments to study aural perception and discrimination and the ability of telephonists to recall telephone numbers and postal codes.⁷ In contrast, Bartlett's concept of industrial psychology would have addressed how a stressor such as pace of work affected recall and not the underlying processes.

The MRC's decision may also have been influenced by the implementation of the *Scientific and Industrial Research Act 1956* (see below).⁸ This gave greater powers of autonomy to DSIR, whilst opening it to closer scrutiny by the Treasury. Previously, MRC personnel serving on the joint MRC / DSIR human science committees had been accountable to the MRC Council for their actions. Under the terms of the 1956 Act, MRC personnel serving on executive committees would be accountable to the Treasury and the Lord President for the financial and scientific health of the research programme. Such a situation may well have been difficult for the MRC to accept and may be why they withdrew from the executive management of the human science research programme. This did not signal the end of MRC involvement, as members continued to sit on non-executive bodies which supported the work of the HSC (see Chapter 4).

3.3: The DSIR Human Sciences Committee.

The DSIR Committee on Human Sciences in Industry, later known as the HSC,⁹ aspired, as the name indicates, to cover the full range of biological, social and cultural aspects of work whilst allowing space for disciplines such as economics and politics to be included in the work programme.¹⁰ Such an aspiration would require clear and skilful strategic leadership to ensure a balanced and valid programme.

psychological system, and elucidate causes and mechanisms of any degradation. The APU research programme was established in four areas, the background conditions of work, intake of information, central processing of information and execution of actions. See also D. Jones, Obituary Donald Eric Broadbent. *International Journal of Psychology*, (1993), 28, 746 - 748.

⁶ Wellcome Trust (2001), pp. 6, 14 - 15.

⁷ MRC Progress Report 1954 – 1960. The categories were background conditions of work, intake of information, central processing of information and execution of actions.

⁸ *Scientific and Industrial Research Act, 1956, Cmnd 9734*. London, HMSO

⁹ TNA DSIR 17/728. Proposed committee of the Council on Human Sciences in Industry. R.C. (56–7) 33, 10th January 1957. TNA DSIR 46/6 R.C. (56 - 7) 8 19th December 1956.

¹⁰ STAN B27. Minutes Smith – Mitchell – Elkington – Gatrell – Stansfield October 1958.

DSIR's management of the human science research was shaped by the *Scientific and Industrial Research Act* (1956). After the war, there had been an expansion in the number of, and funding for, DSIR Research Associations's (RA). Funding had declined over time which prevented DSIR from completing planned RA expansion programmes. In addition, internal scientific and technical information facilities were considered not fit for purpose.¹¹ In 1955 the Conservative Lord President, the Marquess of Salisbury, appointed Sir Harry Jephcott to chair a Committee of Inquiry to review DSIR organisation and processes and propose improvements to procedures and financial prudence.¹² Most DSIR management boards and committees were advisory, with executive power residing with the Lord President. Jephcott proposed that the DSIR Advisory Council, which set strategic direction, should be disbanded and replaced by an empowered Council for Scientific and Industrial Research, better known as the DSIR Research Council (DSIR RC).¹³ This would allow DSIR to bid for additional Treasury funding above their block grant and to move funds between programmes to accelerate lines of research. In return, the Public Accounts Committee would have greater oversight and authority for the annual DSIR expenditure.¹⁴

Jephcott's review also examined the small, but significant programme undertaken by the Headquarters Division and, especially, the Intelligence Department (ID). The ID had provided secretarial and strategic support to both the IEC and the Human Relations in Industry Committee (HRIC) and took the lead for interaction with the EPA.¹⁵ Jephcott noted that the work of the ID allowed support and investigation of what he termed 'new or fashionable subjects', specifically identifying human sciences. He argued that the ID research programme should be separated from the Division's administrative work, be shaped to meet industry's needs and be subjected to scrutiny by the DSIR RC.¹⁶ The impact of this move would soon become clear.

The HSC first met in December 1957, with Stansfield being responsible for identifying and recruiting the committee members (Table 3-1). He proposed that "disciplines which needed to be represented on the committee were sociology,

¹¹ Vig (1968) pp 18 - 22.

¹² Jephcott was a chemist by trade and a director of Glaxo until 1956. He sat on the ACSP from 1953 to 1956 and was Chairman of the Council for Scientific and Industrial Research from 1956 to 1961.

¹³ TNA DSIR 45/8. DSIR Enquiry Committee. Final Report to the Lord President, undated.

¹⁴ Melville, (1962), pp. 49 - 51.

¹⁵ Ibid. See also previous chapter.

¹⁶ TNA DSIR 45/8. DSIR Enquiry Committee. Final Report to the Lord President.

psychology (general) physiology, which would be covered by one person, social psychology, social anthropology and industrial relations.”¹⁷ It is not known how he identified and recruited the membership.

Name	Affiliation	Speciality and Previous Human Factors Panels
W.L. Heywood replaced by	National Union of Dyers, Bleachers & Textile Workers Member of RC.	Later member of the Restrictive Practices Court.
L. T. Wright.	Amalgamated Weavers Association and Cotton Board.	Later president of the TUC and political advisor to Harold Wilson.
P.W. S. Andrews.	Fellow, Nuffield College.	The economics of industry and trade.
H. Briggs.	Personnel Division, Unilever.	Personnel Research.
Prof. J. Drever. *	Department of Psychology, Edinburgh.	Theories and practices of higher education.
E. Fletcher. #	Head of Production Department, TUC.	Specialised in Production and Management Practices.
Prof. M. Gluckman.	Dean Economics and Social Science, University of Manchester.	Professor of Social Anthropology.
H. G. Jones.	Deputy Head of Laboratories, UK Atomic Energy Authority, Dounreay.	Health Physicist.
H. G. Nelson.	Managing Director English Electric.	Mechanical and Electrical Engineering.
Prof. E. Robinson.	Sidney Sussex College, Cambridge.	Economics of Competitive Industry.
Miss B. N. Seear.#	Lecturer in Social Sciences, London School of Economics.	Educational Sociologist.
Dr A. T. M. Wilson.#	Director Tavistock Institute.	Sociologist. Sat on CIP (HF)
R. G. Stansfield. #*	DSIR.	Secretary.
G. C. H. Slater.	Ministry of Labour and National Service.	Assessor.

Table 3-1. Initial Membership of the Human Sciences Committee.¹⁸ # = Sat on HRIC,

*= member of the ERS.

Compared to the IEC (Table 2-6) there were three fewer members, with industrial representation being cut from five to three representatives. There were no representatives from the IEC. The union representatives had greater seniority and executive power than those who had sat on the IEC. A striking feature is the absence of physiologists and cognitive or perceptual psychologists, even though Stansfield had identified that these disciplines needed to be represented. It appears that Stansfield

¹⁷ STAN B24. Unreferenced note Stansfield to Knox 6th February 1957, Knox was head of the Information Division of DSIR and had responsibility for the management of the HSC

¹⁸ TNA DSIR 17/681. Minutes of 1st Human Sciences Committee Meeting HS-C 1 18th December 1957.

was unable to identify and persuade suitable, or willing, candidates from elsewhere in academia to sit on the HSC. This academic imbalance meant that the HSC would be poorly placed to assess the merits and applicability of any non-social science proposals, unless they specifically seconded members onto the committee. Eventually, an Ergonomics Sub-Committee was formed to develop a research programme for that science. The formation and work of this body is discussed in the next chapter.

The DSIR RC expected the HSC “to look especially at the human aspects of equipment design and at problems of training and human relations in industry.”¹⁹ They would submit annually a broad programme of research, and advise on human science research grants. Research was not constrained to directly addressing productivity which meant that basic research could be funded if the HSC perceived that it had future utility. Identifying equipment design and training as key issues reflected the changing nature of work, the move from heavy to light intensity work and the introduction of automation.²⁰ Unlike CIP (HF), or the IEC, the HSC did not have a fixed term of office, which meant that a dynamic, structured research programme could be constructed.

The inaugural meeting was attended by DSIR Divisional Heads to allow cross-briefings on the workings of their committees and units and identify interactions with the HSC.²¹ For example, close working relationships would be needed with the ID’s Industrial Operations Unit which was responsible for gathering information on, and demonstrating the benefits of, techniques such as operational analysis and production engineering tools to industry. The HSC would provide specialist advice and guidance to inform their work, whilst they could act as a research exploitation route to industry.²² The HSC would also be the UK focal point for dealing with the EPA on human science matters.

¹⁹ TNA DSIR 17/728. Report of the Research Council for the Year 1956 – 57.

²⁰ McIvor, (2013). This provides a detailed narrative of the changing nature of work from 1945 onwards.

²¹ The attendees were Francis and Knox from Headquarters Division, Greenall the Head of Grants and Cawley the Head of Stations Division. Department heads had not previously attended either IEC or HRIC meetings.

²² TNA DSIR 17/681. Minutes of 1st Human Sciences Committee Meeting HS-C 1 18th December 1957, p.3.

Stansfield delivered a detailed report describing the courses of action which the HSC could follow in discharging their duties and defining their levels of empowerment.²³ They had the authority to direct funds into supporting all, or any of the research categories below.

- a) support for promising research projects proposed by Universities or Colleges, by DSIR Grants;
- b) a coherent DSIR research programme of extra - Departmental research contracts;
- c) research by DSIR aided Research Associations;
- d) support for research groups on a basis more continuous than project by project;²⁴
- e) research / teaching posts (including senior posts) at Universities and Colleges of Technology;
- f) research Studentships and Fellowships.

Previous committees had only been empowered to let research contracts against a fixed limit of liability set by the block grant from the Treasury or Conditional Aid. Now, the HSC was afforded the opportunity to use all avenues of DSIR research funding, but, although free from Treasury block grant restrictions, would still need to apply to the Treasury for funding.

Stansfield pressed the HSC to decide on a strategy for the development of the human science research programme, based either on their collective knowledge or taking proposals from industry and academia.²⁵ Drever, who chaired the HSC, believed that developing a programme around specific themes could be constraining, as external researchers would only propose achievable programmes.²⁶ Others argued that a broad programme structure would attract young researchers by highlighting key and

²³ STAN B28. The Field of Activity and Methods of Operation of the Human Sciences Committee. HSC-7 18th December 1957.

²⁴ Stansfield noted that policy on DSIR research units in universities had not been settled.

²⁵ STAN B28. The Field of Activity and Methods of Operation of the Human Sciences Committee. HSC-7 18th December 1957, p 5.

²⁶ Ibid.

important problems for study. With time pressing, the committee deferred a decision until the next meeting, and directed Stansfield to prepare a paper to provide further strategic details and a list of prioritised possible research areas.²⁷ Meanwhile, they commenced allocating funds to proposals for human relations research.

Stansfield's next paper proposed that programme construction could either "start with existing knowledge and emergent ideas of academic workers as pointers to lines of future basic research" or take "practical needs of industry and work down to problems of applied research and so to challenges to open up new areas of basic knowledge and understanding."²⁸ This was not a clear course of action: it simply restated possibilities. Potential research areas were placed under generic headings: ergonomics, design of machine controls, effects of environmental conditions and fatigue were placed under Individual Efficiency.²⁹ Headings were intended to allow the HSC to visualise the extent of the potential research areas and develop strategies for building the portfolio. The HSC noted the report's contents but did not take any executive action. They were more concerned with proposing a research programme for the DSIR RC to include in their quinquennial financial recommendations to the Treasury the following Spring.

Stansfield also produced a paper identifying and ranking, according to reputation and academic activity, university departments and other research organisations, which the HSC could fund to sustain or build a human science capability.³⁰ Much of this work was taken from the DSIR and MRC surveys produced in 1951.³¹ The only centres identified as being suitable for capability development were the MRC and the Engineering Production Department at Birmingham University. Previous committees had been charged with developing opportunities to train scientists who could undertake and interpret human science studies for industry, but had been unable to fulfil this requirement due to funding restraints. Bartlett had worked with the UGC to identify psychology departments which could offer courses in ergonomics, but

²⁷ Ibid.

²⁸ TNA DSIR 17/681. Fields of Work Possibly Suitable for DSIR Support. HSC – 15 23rd January 1958.

²⁹ Ibid. The other research areas were human relations, problems of management of an organisation and human factors in technology change. This latter topic was concerned with the cultural aspects of change rather than re-training.

³⁰ TNA DSIR 17/681. Research Groups Possibly suitable for DSIR Support. HSC – 16, 23rd January 1958.

³¹ There was a month's gap between the two HSC meetings which included national holidays of Christmas and New Year.

funding restrictions, discussed in Section 1-3, had prevented progress. An action which Stansfield could have recommended would be that the HSC fund research in selected CATs to help build a capability.

Institution	Project
Sheffield University.	An enquiry into the social and personal factors involved in the transition from school to work of secondary school children.
Acton Society.	What factors within a company encourage or discourage management initiative?
University College Cardiff.	Technological change and industrial – community relationships.
Oxford University.	A systematic investigation of some conditions affecting quantitative judgements in social situations.
LSE.	A follow – up study of a national sample of undergraduates in respect to their subsequent career.
Institute of Education.	Factors affecting the choice of scientific careers by grammar school boys.
LSE.	A study of the employment of married women in a Leicester hosiery factory, having regard to the problems posed both for industrial management and factory life.
Queens, Belfast.	A study of working mothers in selected factories in Northern Ireland.
Edinburgh University.	Adaptability to work among the clerical and footplate staff of British Railways, with a special reference to ageing.
Mrs E. Belbin. (Independent Research Worker)	Further development of a training method for skilled operatives in industry with special reference to the older worker.
Manchester College of Science and Technology.	Management and technical change.

Table 3-2. Initial Grants Supported by the HSC.³²

The HSC submitted their quinquennial bid for £410,000 up to Financial Year (FY) 1963/64 to the DSIR RC in April 1958.³³ It is unclear who wrote the bid: it was most likely Stansfield. Calculated from extrapolation of funds expended by previous committees, with an uplift based on anticipated extramural contracts, the bid laid out the HSC's intentions to continue to support applied research and to increase the

³² TNA DSIR 17/683. Human Sciences Committee HSC – 23, 17th April 1958.

³³ TNA DSIR 17/683. Human Sciences Committee: Quinquennium 1959 – 1964. Proposed Provision for Expenditure on Research Contracts and Grants. R.C. (57–8) 69, 10th April 1958. The funding profile was Financial Year (FY) 59 – 60 £60K; FY 60-61 £70K; FY 61-62 £80K; FY 62-63 £100K and FY 63-64 £100K. By comparison CIP (HF) was given a budget of £50K per annum over two years whilst both the IEC and HRIC received £50K per annum for three years.

proportion of basic studies to provide underlying knowledge.³⁴ The bid also included those grant aided studies which the HSC would fund (Table 3-2). The Treasury were expected to announce their decision on funding by the autumn of 1958, but already some HSC members were concerned about the outcome; however, they were assured by the DSIR RC that a funding cut was unlikely.³⁵ The Treasury awarded the HSC £250,000 over five years, a 40% cut in their request. This meant that because the HSC had fully committed funds for the forthcoming financial year they were precluded from starting any new work. They appealed to the Treasury, pointing out that the cut represented 0.25% of the DSIR budget for natural sciences and technology, but they were unsuccessful.³⁶

Why was the bid rejected, particularly when it was for such a relatively small sum? Compared to national spending it is highly unlikely that the funding reduction would have made any significant contribution to any government savings target. The real issue may have been the structure of the bid. The proposed programme addressed major social issues such as the changing nature of the workplace and female part-time working, it did not contain any studies of human physiological or psychological performance, or the design of equipment. The HSC bid proposed direct funding for “build[ing] up the stable research teams [in academia], able to offer continuity of research and to retain more senior research workers ... such groups would need DSIR support at the rate of £5,000 to £10,000 per annum.”³⁷ It did not indicate how this would be achieved, or which departments would benefit. Finally, there was no exploitation plan to take research findings into industry. Given the paucity of concrete details in the bid, it is unsurprising that the Treasury reduced the funding.

The Treasury’s response may have been a result of the nature of the guidance provided by Stansfield to the HSC. The HSC members worked on a part-time basis and occupied senior posts in their home institutions. They were critically dependent on Stansfield to provide strategic guidance and support, rather as an academic Board of Governors depends upon their Clerk. Although Stansfield prepared strategy papers,

³⁴ Ibid.

³⁵ TNA DSIR 17/684. Human Sciences Committee. Minutes of 3rd Meeting HSC - 31, 7th May 1958.

³⁶ TNA DSIR 17/ 690. Second Annual Report of the Human Sciences Committee to July 1959. HSC/101, November 1959, p 3.

³⁷ TNA DSIR 17/683. Human Sciences Committee: Quinquennium 1959 - 1964. Proposed Provision for Expenditure on Research Contracts and Grants. R.C. (57–8) 69, 10th April 1958. p 2.

he did not recommend courses of action, but simply indicated alternatives. Meeting minutes show that strategy issues were deferred on a regular basis to accommodate, usually, reviewing grants. Consequently, the bid was a list of potential alternative courses of action rather than a tight focussed proposal with clear outcomes. The reasons why Stansfield did not provide clear direction could be that he had a limited strategic view, or was risk-averse, or both. As shown in the next chapter DSIR management believed that he lacked strategic vision, but this raises the question why was he placed in such a position? The likely answer is that there was no one else with the broad understanding of the totality of previous DSIR human science programmes.

In the light of the rejected Treasury bid, the HSC came under scrutiny from DSIR. Greenall, the Head of Grants Department, noted that “it has been a matter of some disappointment that since it first met in late 1957 the Human Sciences Committee has not so far identified any specific research projects in the human sciences which should be undertaken in the national interest beyond those that have come before it through applications from universities, colleges and other outside bodies applying more or less spontaneously for grants for special circumstances.”³⁸ He was, however being slightly unfair as the HSC, unlike previous committees, had not been allocated an initial budget. They could not start detailed programme formulation until they knew their financial limit of liability. It was also true that they had no coherent research strategy, despite Stansfield’s promptings.

The DSIR RC had identified a further issue. In a paper on the future organisation of human sciences in DSIR they concluded that “combining within one very small group (the ID) ..., the responsibility for administering grants to universities and other institutions, carrying out a research programme, and affecting the dissemination and application of results” was not feasible.³⁹ In addition to being secretary to the HSC and his other tasks, Stansfield was also the UK representative to the EPA Working Party 4 (WP4) Human Factors in Productivity, where he had a major influence in establishing ergonomics both nationally and internationally. This is discussed in the rest of this chapter.

³⁸ TNA DSIR 17/689. Identifying research requirements in the human sciences suitable for DSIR contracts. Internal memorandum 7/43/2/9, 15th April 1959.

³⁹ TNA DSIR 46/25. DSIR and Research in the Human Sciences. R.C. (58 - 9), 104, 14th May 1959.

The DSIR RC's plan to revive the HSC had a dramatic effect on the management of human science research within DSIR and will be discussed in detail in the next chapter. In outline, the solution was to transfer Stansfield's team to Warren Spring Laboratory (WSL) in Stevenage to manage Headquarters research. The HSC, which would be refreshed with new members and a new Secretary, and would revert to be an advisory body to consider policy requirements in the light of industrial needs. Their first task would be to submit a new bid to the Treasury.

This section has described the formation and early work of the HSC. The importance of understanding the genesis and difficulties faced by the HSC is that the remedial actions put in place by the DSIR RC, in response to the failed Treasury bid, shaped the future development of ergonomics and ergonomics research. Formed as the successor body to the IEC, the HSC was expected to develop a coherent and wide-ranging human science research programme. The absence of clear strategic direction and a rejected funding bid to the Treasury resulted, in the short-term, in this aim not being fulfilled.

We have also seen how Stansfield attempted to direct the work of the HSC, but was seemingly unable to provide the strong leadership that was necessary to develop a long term strategy (see Chapter 4). It is true that he was under pressure from his commitments to other DSIR activities, particularly the EPA. In the next section I will examine the activities of the EPA, and Stansfield's actions, which contributed to the emergence of ergonomics on a national and international stage.

3.4: The EPA: a Short Review.

Stansfield's activities in promoting ergonomics through the EPA had a profound and positive effect on the national and international growth of the science, which would culminate in the Ergonomics in Industry Conference held in London in 1960. This conference influenced the management of human science research in DSIR and the shape of ergonomics. In addition, Stansfield introduced the term 'ergonomics' into the EPA lexicon and facilitated the first official visit to the US by ERS members to compare national uses of ergonomics and exchange views and knowledge. He was a member of the committee which established the IEA. Before describing his contributions and the impact that they made on the development of ergonomics, it is necessary to provide some background to its formation and activities of the EPA.

The EPA was formed in 1953 as an integral part of the OEEC. It was “reluctantly accepted by some as a temporary experiment, ambitiously viewed by others as the embryo of a comprehensive European productivity policymaking body”.⁴⁰ Funding came from US Conditional Aid, under which Western European nations received monies to enhance productivity and counter restrictive business practices, but in return were expected to allocate 8% of their grant to fund EPA activities.⁴¹ The aim of the EPA was to “seek, develop and promote the most suitable and effective methods for increasing productivity in individual enterprises ... it shall undertake, and promote measures tending to the acceptance and adoption of the best and most modern techniques and to the removal of factors limiting their adoption.”⁴²

The twin purposes of Conditional Aid funding were to engender higher levels of productivity and encourage the growth of non-communist labour organisations.⁴³ Boel points out that in the post-war years trade unions in both France and Italy were strongly influenced by their national Communist parties. US policy was that bolstering moderate national unions would counterbalance the influence of the more radical, communist-leaning or dominated trade unions and help bind nations together. Thus, in addition to promoting productivity the US also expected the EPA to help bind together the Western European nations by assisting in the strengthening of non-communist trade unions,⁴⁴ and so providing a buffer against Communism.⁴⁵

The early years of the EPA were difficult as some nations were concerned that such an organisation would dictate national productivity policy, and so wished to limit its powers. Others were fervent supporters.⁴⁶ Karl Harten, the first Director was a political appointment aimed at bringing West Germany into the European arena. He was not a success as he had limited international working experience and was supported by a largely untrained staff.⁴⁷ He was also particularly hostile towards the trade unions, a strange posture when a key aim for the EPA was to strengthen the non-

⁴⁰ B. Boel, *The European Productivity Agency and Transatlantic Relations 1953 – 1961*, in M. Rudiger and M. Pelt (eds.), *Studies in 20th and 21st Century European History. Vol 4. Copenhagen, Museum Tusulanum Press*, (2003) p. 61.

⁴¹ Carew, (1998), pp. 167 - 184.

⁴² OEEC, *Acts of the Organisation*, vol. 12, pp. 91 - 93.

⁴³ Carew, (1998), p. 167.

⁴⁴ Boel, (2003), pp. 149 - 154.

⁴⁵ Boel, (2003), p. 199.

⁴⁶ Boel, (2003), p. 66.

⁴⁷ King, (2006) pp. 224 - 228. This reviews Harten’s performance and Gregorie’s appointment.

communist unions. Harten was quickly replaced by the Frenchman Roger Gregorie as Director, who was far more sympathetic to the unions, and Edwin Fletcher as Deputy Director. Fletcher's appointment was the result of an agreement whereby the Trade Union Advisory Council (TUAC) were entitled to propose candidates for positions in the secretariat.⁴⁸ Boel notes that it was these appointments that brought order, purpose and vision to the operation of the EPA.⁴⁹



Figure 3-1. Edwin Fletcher, Deputy Director of the EPA and Secretary of the TUC Production Department.⁵⁰

Fletcher (Figure 3-1) played an important role in establishing the TUC's interest and support for ergonomics. Little is known about his background, except that he was the first secretary of the Trades Union Congress Production Department (TUCPD), which was established in the early 1950s (Section 1-7). The TUCPD's human science concerns were the effects of mechanisation and automation on skills and employment levels and the increasing use by management of work study to bring greater shop-floor efficiencies. He was later appointed as Director of the Department of Work Study and Staff Training at the West of England Engineering Employers Association.

⁴⁸ Boel, (2003), p. 162.

⁴⁹ Boel, (2003), p. 70.

⁵⁰ E. Fletcher, Industrial Relations and the Production Engineer, *The Institution of Production Engineers Journal*. (1959), 38, 475 - 479.

From its inception until closure in 1961, the Agency launched a series of national and international initiatives aimed at increasing productivity. These ranged from training courses for union officials and management⁵¹ to sending groups of experts to impoverished regions of Southern Europe to help establish enterprise zones to encourage productivity.⁵² The EPA also sponsored specialist conferences on topics ranging from human relations to accounting.⁵³ It was through such conferences that the EPA would nationally and internationally advance ergonomics.

This section has provided background information on the formation and political goals of the EPA. Funded by US Conditional Aid monies the EPA was envisaged as a means of stimulating national productivity, and as a buffer against the spread of communism in Western Europe. Productivity was to be stimulated either through direct action or education. I will now examine in detail the events surrounding and leading to the 1960 Ergonomics in Industry conference. Growing from an initiative launched by Stansfield, the conference had a major effect on the development of ergonomics in the UK.

3.5: Fitting to Job to the Worker - Stansfield and the EPA.

Although the Board of Trade was the government point of contact for EPA issues other departments were allocated primacy for specific work areas.⁵⁴ DSIR's involvement in the EPA had started when Alexander King, who was the DSIR Chief Scientific Officer, was appointed as a member of the OEEC Working Party which planned the establishment of the EPA; he was also approached to be the first Director.⁵⁵ Further, as DSIR's UK role was the use of research to stimulate productivity they were the obvious department to work with the EPA.

The EPA's interest in human factors first arose when the OEEC Sub-Committee for Productivity Studies agreed to devote a half day at their November 1952 meeting to a

⁵¹ Carew, (1987), pp. 189 - 193.

⁵² Boel, (2003), pp. 199 - 220.

⁵³ Ibid, pp. 228-229.

⁵⁴ TNA BT 258/96. Sub-Committee on Technical Assistance. United Kingdom Co-operation with European Productivity agency. T.A. (L) (54) 32, 12th March 1954. This policy document gives the government's view on the worth of engagement with the EPA, how to address industry's concerns, the role of the Trades Unions and funding issues. Documents mention that DSIR will take a lead role but not on how this decision was reached.

⁵⁵ Carew, (1998), pp. 193 - 195 and 220 - 235.

discussion on Human Factors in Productivity.⁵⁶ Stansfield and un-named representatives from France and Austria were directed to prepare national position papers on human factors and productivity.⁵⁷ This resulted in the formation of OEEC Working Party 4 (WP4), Human Factors in Productivity, with Stansfield as the UK representative.⁵⁸ Their remit was to undertake initiatives aimed at “increasing the interest of the worker in his work, in productivity and in the firm”.⁵⁹

Stansfield is credited with introducing the term ergonomics into the EPA lexicon. He records that it was “remembered apparently very clearly that it was in 1953 in WP 4 of the OEEC that I suggested that the EPA should concern itself with promoting ergonomics at that meeting, no one knew the word, so I explained it.”⁶⁰ It is not known how Stansfield defined ergonomics or distinguished it from human factors. He obviously provided a clear distinction as the term ‘human factors’ became diminished in the EPA lexicon. Further, he had framed the term and concept such that the international learned society, the IEA, had ergonomics in its title, as did those ergonomics societies formed in other European nations.⁶¹

The UK and Germany proposed an international conference, called *Fitting the Job to the Worker*, to promote the use of ergonomic methods in industry.⁶² The proposal stated that “Ergonomic methods are not widely known in Europe, and the means of disseminating knowledge of this subject are inadequate. The problem of finance has, in particular, made it difficult for experts and representatives of industry and the

⁵⁶ STAN B30 PRA (52) 32, 14th October 1952. This proposal was before the formation of the EPA but the file gives no background detail on how it emerged. Attendees are not listed either.

⁵⁷ STAN B30 Productivity and Applied Research Committee Sub-Committee for Productivity Studies Human Factors in Productivity. PRE / PS (52) 4, 5th November 1952. Boel (2003) p 20 notes that most of the documents relating to the internal workings of the EPA have not survived. Minutes and other official papers do not list attendees.

⁵⁸ STAN B30. Working Party No 4 of the Sub Committee for Productivity Studies for the Study of Human factors in Productivity. PRA/PS/WP4 (53)7, 11th July 1953. This is a note by Stansfield on the Provision at Universities and Technical Colleges for Study of Subjects Relevant to Human Factors in Industry, but states that he was asked to produce the note at the 1st meeting of Working Party 4.

⁵⁹ BUSCA DM 26/4187. Ronald G. Stansfield, The Origins of the International Ergonomics Association. Paper Presented at the 7th Congress of the International Ergonomics Association. 27th August 1979.

⁶⁰ STAN B 26. History of Ergonomics. Information collected at the 1973 IEA Conference in Amsterdam.

⁶¹ Association of Canadian Ergonomists, National Ergonomics Societies, https://www.ace-ergocanada.ca/national_ergonomics_societies.html accessed 5 Jan 2017.

⁶² STAN B30. Suggested Project to be Studied by Working Party PRA/BA/WP4 International Conference to Promote the Use of Ergonomic Methods in Industry. EPA/HU/358, 14th May 1954.

Trade Unions who are interested in these methods to attend conferences organised in countries other than their own.”⁶³

The conference budget included funds for researchers to visit, informally, each other’s laboratories, and for the UK and Germany to hold an international meeting of experts to develop the core theme.⁶⁴ The international conference did not occur. Under OEEC regulations any productivity initiative had to be preceded by reciprocal visits of experts between Europe and American to inform on the state of knowledge and help frame the proposed event.⁶⁵ The original proposal was revised and retitled *EPA Project 335 – Fitting the Job to the Worker*. This aimed at “strengthening contacts between the specialists (ergonomists), and to inform the European Productivity Agency and National Productivity Centres of the activity in progress in various countries.”⁶⁶ Specialist teams would pay reciprocal visits to key research facilities and their visit reports would be presented at an international conference of scientists, industrialists and union members in Leiden in 1957.

A team of European scientists was now recruited to visit US research establishments to study industrial physiology and engineering psychology approaches to researching the worker in their working environment and the methodologies employed. (Table 3-3). It is not known how other nations selected their members but DSIR asked the ERS to propose UK representatives for the visit. This visit would allow UK ergonomists the opportunity to meet and network with researchers in Europe, through membership of the team, and in the US. This would permit network formation between scientists for future exchange of knowledge and information. It should also be noted that the four European members of the team had joined the ERS by 1957.⁶⁷ Murrell was the organising secretary and would also present the visit report to an international meeting of scientists and engineers in Leiden.⁶⁸

⁶³ Ibid.

⁶⁴ STAN B30. Current Activities of the European Productivity Agency of Interest to the Committee on Individual Efficiency. A note by DSIR. HF (IE) (54) 18, Undated. It is assumed that a similar report for the HRIC was also prepared. The identity of the German lead was not revealed.

⁶⁵ P. H. Cook. *The Productivity Team Technique*, London, Tavistock Institute of Human Relations, 1951.

⁶⁶ STAN B28. OEEC P/335 European Productivity Agency Project 335. Fitting the Job to the Man. Seminar held at Netherlands Institute for Preventive Medicine, Leiden. 28th March – 3 April 1957. Note by R. G. Stansfield.

⁶⁷ 1957 Ergonomics Research Society Membership List.

⁶⁸ Edholm and Murrell. (1973), p.25.

Name	Affiliation	Nation
P. F. Blau.	JTUAC. ⁶⁹	French.
Dr.F. H. Bonjer.*	Head of Department of Occupational Medicine, Netherlands Institute for Preventive Medicine.	Netherlands.
Dr.A. Iannacone.*	Professor of Industrial Medicine, Florence.	Italy.
K. R. Karlsson.*	Produksjonteknisk, Forsknings Institutt, Oslo.	Norway.
Prof. B. Metz.*	Research Centre of Industrial Physiology, Strasbourg.	France.
F. Schofe.	Consulting Engineer	Austria.
Dr.B. Schulte.	Method Engineer, Siemens-Schuckertwerke, A.G.	Germany.
W. T. Singleton.*	Ergonomics Section, SATRA.	UK.
K. F. H. Murrell.*	Department of Psychology, Bristol.	UK.

Table 3-3. Members of EPA US Visit Ergonomics Team.⁷⁰ * indicates member or future member of the ERS.

The delegation visited research facilities and institutions such as Minneapolis Honeywell and the US Public Health Service, but things did not progress smoothly. The delegation met for a day prior to leaving for the US. Not all were fluent English speakers, making strategy formulation problematic.⁷¹ The US hosts briefed their laboratories that the mission title was “adjusting industrial workers to the technical means of production” rather than the mission title.⁷² For US human scientists ‘adjusting industrial workers’ implied personnel selection, training and occupational health. There was no equivalence to ‘fitting the job to the worker.’ US human scientists sought to redesign the steps in a job process to make it more efficient and so ameliorating fatigue. Effectively, the US approach was fitting the worker to the job. Interface design, except for computer interfaces, was not afforded the same level of importance as in Europe. In Europe, human scientists sought to reduce stress at the workplace by lessening the impact of environmental stressors or through interface design: essentially or by fitting the job to the worker. Although the presentations gave an insight into how work study and human sciences were applied, it was not what the European team had come to hear. After two weeks of interesting, but ill-adapted

⁶⁹ The Joint Trades Union Advisory Council (JTUAC) had been founded by the TUC in 1948 following an international meeting in London of all non-communist trade unions which resulted in the TUAC being formed. In 1954 the TUAC was expanded to include both the socialist International Confederation of Free Trade Unions and the International Federation of Christian Trade Unions. The JTUAC now assumed the role of the union partner in the EPA. See Boel, pp.45 for a further discussion of the role of the JTUAC.

⁷⁰ STAN B30. Suggested Project to be Studied by Working Party PRA/BA/WP4 International Conference to Promote the Use of Ergonomic Methods in Industry. EPA/HU/358, 14th May 1954, Appendix III undated.

⁷¹ BUSCA DM 26/4841. Interim Report. EPA Project 335. Fitting the job to the Worker.

⁷² Ibid.

presentations, Murrell wrote to the remaining laboratories they were due to visit giving explicit direction on the context and the topics they wished to discuss.

Murrell's visit report was presented at the Leiden conference in 1957. This attracted seventy attendees from thirteen nations (approximately equal numbers of scientists and non-scientists). He reported that there were few, or no, major differences between the US and Europe in terms of ergonomic knowledge or its application.⁷³ The visit had succeeded in promoting a better understanding of ergonomics between scientists from different nations and in establishing a platform for future co-operation, hinting at the development of informal networks between the scientists. The meeting resulted in two main proposals: that a larger meeting should be held specifically for employers and trades unionists, and that an International Organisation of Human Work Scientists, later the IEA, should be established to allow scientists to formally meet and exchange information on a regular basis.⁷⁴ A steering committee, with Stansfield representing the UK, was formed to draft a statement of purpose and define the scope, structure, membership and relationship of such an organisation to other societies. The desire to form the IEA appears to have arisen from an observation made by Blau (Table 3-3) that there was no tradition of social contact between ergonomists and industrialists. The "interdisciplinary nature of the field causes a lack of professional societies, conferences and publications covering the whole range of problems, and finding the common interest of research and industry (and is a serious block on communications)".⁷⁵

ERS conferences were attended by European workers, these were usually department Heads such as Bonjer and Metz (Table 3-3),⁷⁶ but there were few opportunities for more junior workers to attend the conference, which limited opportunities for researchers to share and exchange knowledge. Establishing an international society would meet an aim of EPA 335, the strengthening of contacts between ergonomists, and support an overarching aim of establishing groups of experts to advise upon methods to stimulate productivity. An international ergonomics learned society might

⁷³ Ibid.

⁷⁴ STAN B28. OEEC P/335 European Productivity Agency Project 335. Fitting the Job to the Man. Seminar held at Netherlands Institute for Preventive Medicine, Leiden. 28th March – 3 April 1957. Note by R. G. Stansfield, p.9.

⁷⁵ STAN B 30. Communications Between Industry and Research – Attitudes of Management and Labour. OEEC P/335 undated. bid. p.6.

⁷⁶ Edholm and Murrell (1973), pp. 17 - 19.

well persuade scientists to form national societies. Indeed, the Dutch Ergonomics Society was the first European group to be established after the formation of the IEA in 1957. The ERS declined to take an active role believing that if they did it would upset their colleagues abroad.⁷⁷ Stansfield had been placed in the position where he was representing DSIR on the EPA and on the IEA working party, whilst he also sat on the ERS council, and they wished to have nothing to do with the venture.

The conference specifically aimed at employers and trades unionists was held in Zurich in 1959, with the aim of enabling “leading scientists to meet influential persons from industry and to present simple and concretely - illustrated descriptions of what has already been done and now being achieved”.⁷⁸ This attracted two hundred attendees, again approximately equal numbers from academia and industry, from thirteen countries. There was little difference in the agendas between the Zurich and Leiden meetings, but the EPA deemed that the meeting was such a success further conferences should be held in Dublin and in London. The EPA would be looking to DSIR to host the meeting in London in 1960. What is unclear is whether WP4 were driving the ergonomics agenda, or if this was part of a larger EPA strategy.

The EPA was conceived as a body to raise productivity across Western Europe through seminars, training events and establishing expert groups. This provided an international institution in which ergonomics, which aimed to show how human science research could increase efficiency and productivity, could make a significant contribution and flourish. Stansfield, through WP4, played a key role in allowing the ERS access to fellow human scientists in Western Europe and the US, and was also part of the team which formed the IEA. In this way, he, and the EPA, were critical in the development of ergonomics in the 1950s. Despite his important contributions to the growth of ergonomics, however Stansfield is rarely mentioned in practitioner histories and remains a largely forgotten figure. My account sheds light on his key role in institutionalising and shaping ergonomics in the mid-twentieth century.

What is unclear is why the ERS did not wish to support the formation of an institution which would result in the internationalisation of ergonomics, particularly when

⁷⁷ Ibid. However, F. H. Bonjer. The EPA and Contacts with Ergonomics. in I. Kuorinka (ed). *The History of the International Ergonomics Association: The First Quarter Century*, Santa Monica CA, IEA Press, 2000, pp. 53 - 64.

⁷⁸ Edholm and Murrell, (1973), p. 27.

Murrell and Stansfield had been major contributors to the formation of the IEA. Bonjer has reported that some ERS members felt that there was no need for an international body as the society was already meeting that need.⁷⁹ In the next section I will further examine the insular environment within the Society. I will also discuss the events leading to, and outcomes of the Ergonomics in Industry conference which was to have a marked effect on the development of ergonomics in the UK.

3.6: The DSIR / EPA Ergonomics in Industry Conference.

I will now argue that the 1960 Ergonomics in Industry conference, held in London, was a significant event in the development of ergonomics in the UK and that comments made at the conference resulted in the RC making decisions which profoundly influenced how DSIR managed ergonomics and human science research. In addition, the London conference revealed much about perceptions within industry, the TUC and DSIR on the state and health of ergonomics, and how such institutions viewed their interactions with practitioners and the ERS. The conference also exposed the frustrations felt by the TUC at government support for ergonomics and the support provided by the ERS to industry.

Before addressing these issues, it is necessary to understand the attitudes prevailing within the ERS. I have already shown that in the early 1950s the ERS was riven with internal schisms and had an ambivalent attitude towards industry. Had these attitudes softened or hardened in the intervening years and what was the nature of the society's relationship to industry? The clearest impression is gained from Alec Rodger's review of the 1959 ERS symposium '*Ergonomics and its Place in Industry*.'⁸⁰ Rodger had read psychology at Cambridge, was the first Senior Principal Psychologist in the Civil Service and first Professor of Organisational Psychology at Birkbeck.⁸¹ Through his efforts to gain academic recognition for organisational psychology, he was well placed to report on the health of the ERS.

His review portrayed an insular and internally divided society. Although the conference theme was *Ergonomics in and its Place in Industry*, few papers addressed the topic, with one presenter suggested that meetings with industry were "a doubtful

⁷⁹ Bonjer, (2000).

⁸⁰ A. Rodger, Ten Years of Ergonomics, *Nature*, (1959), 184, 4688, 20 - 22.

⁸¹ K. F. Taylor, Obituary Professor Alec Rodger, 1907 – 1981, *Australian Psychologist*, (1982), 17, 117 - 118.

blessing.”⁸² Rodger highlights papers from the APU and UCL on complementary studies for the Post Office, but where no attempt was made to integrate their findings into what could be called ergonomics; they were either applied psychology or applied physiology. He pondered if ergonomics really did “seek to be regarded as a new science” and, if so, what was its claim to independent scientific status, and did it have any distinctive concepts or methods?⁸³ These are telling points made by a scientist who had worked to establish his own specialisation as a distinct entity within psychology. They point to a learned society with no strategy, or maybe no desire for the development of ergonomics as a distinct discipline.

Group unity was finally observed when “the physiologists and psychologists ... somehow did battle together with the delegates from industry.”⁸⁴ Rodger does not divulge the nature of this ‘battle’, but does draw attention to a spat between Murrell and A. Graham from Imperial Chemical Industries.⁸⁵ Graham questioned why work study engineers should be expected to prefer ergonomics when what they really needed was help in understanding how to apply the science. No one from the ERS could provide a cogent answer.

Rodger was not simply an observer: he also gave a paper comparing the first ten years of ergonomics with that of organisational psychology. His main observation was that ergonomics had narrow horizons which would limit its growth and use to industry. He pointed out that organisational psychology encompassed some social science topics, such as attitudes to work, and that for ergonomics to flourish it, too, would need to embrace elements of social science.

Summarising, Rodger suggested that “there was little to be gained from making ergonomics a science”, as it was a “conglomeration of technologies” and should be left as such.⁸⁶ His article provides a portrait of the atmosphere in the ERS; he reports that Murrell had to rewrite his presentation after a midnight argument with (an) unidentified colleague(s). Rodger provides us with a clear outsider’s view of the environment within the ERS during the late 1950s. Divisions appeared along pre-

⁸² Rodger, (1959).

⁸³ Ibid.

⁸⁴ Ibid.

⁸⁵ Graham was to contribute to the 1960 conference, see below.

⁸⁶ Rodger, (1959).

existing disciplinary lines between physiologists and psychologists; and this from a science which made a virtue of having a multi-disciplinary approach. Underlying this division was a shared 'distaste' for engagement with industry, even though the ERS supposedly sought such an arrangement.

McAllister has investigated inter-disciplinary competition between practitioners working in the same field, in this case physicists and chemists undertaking cold nuclear fusion research.⁸⁷ Chemists had claimed to have achieved room-temperature nuclear fusion, which was disputed by physicists. In reviewing the causes of the competition, McAllister suggests that a factor was that despite working in the same field each group still wished to maintain rigid boundaries to ensure the existence of a clear demarcation and discourage incursions of physicists into chemists' 'territory', and vice versa. A similar social act of boundary work may well have been enacted within the ERS, particularly as the society had had, up until late 1956, separate secretaries for physiology and psychology (see Chapter 2). I suggest that such an arrangement strengthened disciplinary boundaries in a science which apparently made a virtue of being multi-disciplinary. An outcome of this polarisation would be the plethora of descriptions and definitions for ergonomics and ergonomists coloured by disciplinary views.⁸⁸ This was glaringly exposed during the Ergonomics in Industry conference.

The conference was chaired by Jephcott and opened by Lord Hailsham, the newly appointed President of the Council and Minister for Science. Over two hundred attended, with roughly equal numbers from the sciences, industry and the Trade Unions. The thematic programme addressed the Place of Ergonomics in Industry, Ergonomics and Production, Ergonomics in the Post Office, Ergonomics in the Steel Industry, Ergonomics and Products and the Future of Ergonomics. Each session comprised three or four papers given by academics, industrialists or trade unionists followed by a discussion session reported verbatim in the conference proceedings, providing a rich picture of the intensity of the debates.⁸⁹ The academic studies were enthusiastically received and attracted lively and positive exchanges of technical

⁸⁷ J. W. McAllister, Competition Among Scientific Disciplines in Cold Nuclear Fusion Research. *Science in Context*, (1992), 5, 17 - 49.

⁸⁸ See Waterson and Sell, (2006), p. 786 which lists 7 distinct descriptions and definitions.

⁸⁹ *Proceedings of the Conference on Ergonomics in Industry 27 – 29 September 1960. London, HMSO, 1961.*

information between presenters and the audiences. The impression gained is that non-academic attendees were keen to engage, inform and learn from ergonomists, and vice versa.

Both industrial and TUC representatives gave their views on ergonomics and how the science should be communicated across the industrial spectrum. Robinson of the National Union of Boot and Shoe Operatives (NUBSO) reviewed the conduct of Singleton's SATRA research, highlighting shop-floor suspicion that the study was more concerned with rate cutting, rather than the introduction of improved working conditions. He attributed this to Singleton's failure to communicate to local union representatives the purpose of the work.⁹⁰ Robinson also produced an example where the inability to engage with shop stewards before commencing an experiment resulted in the workers believing that their aptitude was being tested rather than the effects of the environment on their work – a misunderstanding which resulted in the workers withdrawing their co-operation. It is most likely that this was the first occasion that Singleton had worked on the shop floor. He had graduated from Cambridge and worked at the Nuffield Institute with Welford until 1954 when he moved to SATRA and almost immediately started on the closing room study. The thrust of the union presentation was that ergonomists had to understand, or want to understand how to communicate and co-operate with shop floor workers.

Industrialists also commented on the perceived communication issues between themselves and ergonomists. A.J. Mann from David Harcourt Ltd, a subsidiary of Smiths Industries, observed that industry existed to produce dividends for its shareholders and that ergonomics would need to prove its value within that framework.⁹¹ Graham, who had been at the centre of the 'battle' at the 1959 ERS conference, said that the pre-requisite for the future of ergonomics was for the perceived communications barriers between industry and ergonomists to be broken.⁹² Industrialists needed to understand the mechanics of the application of ergonomics

⁹⁰ S. A. Robinson, A Contribution, in *Proceedings of the Conference on Ergonomics in Industry 27 – 29 September 1960*. London, HMSO, 1961, pp. 46 - 49.

⁹¹ A.J. Mann, A Contribution in *Proceedings of the Conference on Ergonomics in Industry 27 – 29 September 1960*. London, HMSO, 1961, pp. 42 - 46. Non-scientific papers were simply called 'A Contribution' from a specific author. Mann had recently retired as Director and General Manager of David Harcourt Ltd, a subsidiary of Smiths Industrial Division.

⁹² A. Graham, A Contribution in *Proceedings of the Conference on Ergonomics in Industry 27 – 29 September 1960*. London, HMSO, 1961, pp. 168 - 172. Graham was the Head of Performance Section in the Works Study Department of ICI.

and practitioners needed to understand how business operated. He stressed the need to integrate ergonomics, and the ergonomist, into the framework of the company to ensure an effective contribution, but offered little in the way of how this could be achieved. If communication was an issue then so also was the ‘simple’ question, what are ergonomics and ergonomists?

It was M. Bogod from J. Lyons who flushed this out when he asked that question and continued by asking how would he know if he had employed such a specialist, how would he train him and where would he fit in the organisation? The response from Joe Weiner, a senior member of the ERS was hardly inspiring: he suggested that if ergonomics could not be defined, then it was a state of mind or that it was “the ability to apply a certain body of knowledge ... to the working situation”.⁹³ This muddled response was symptomatic of the debate within the ERS regarding a definition for ergonomics, for there was no consensus amongst the leading members of the society, nor regarding its relationship to other disciplines. Even the abolition of the discipline secretaries, which should have at least softened the intra-discipline barriers, was not wholly successful. From Rodger’s observations it is clear that the effects of this move had not been felt by 1959; although at least both camps did unite to do “battle together with the delegates from industry.”⁹⁴

These exchanges laid bare the problems of communication, co-operation and identity of ergonomics and the insularity of the ERS. From its formation, the society had set working with industry as a major goal, with interactions being through the annual symposia and regular factory visits. These events were supposed to facilitate knowledge sharing, yet the society showed no interest in understanding how industrial management worked. There are no records of the ERS council meeting with senior figures in employers’ associations, such as the Federation of British Industry. The ERS did form an Industrial Ergonomics Group in 1960,⁹⁵ which is discussed in Chapter 5, but it focussed on the TUC.

In the closing discussions Fletcher pointed out that “the important factor in this subject – the future of ergonomics – is surely the amount of cash and organisation

⁹³ Ibid, p. 149.

⁹⁴ Rodgers, (1959).

⁹⁵ The first sub-group that the ERS formed was in sports science in 1958.

which is going to be put behind it in the future ... the human science research efforts and the activities of the Warren Spring Laboratory are quite trivial.”⁹⁶ He suggested that over course of the conference the attendees had seen most, if not all the ergonomists in the country, and concluded that “speaking from the trade union side, we suffer every day from the inadequate application of work study in industry, because of a lack of knowledge of the ergonomic factors by practicing work study people.”⁹⁷ Fletcher and the TUC was determined to address these issues, and this is described in Chapter 5.

His observations on lack of knowledge for work study practitioners were not entirely accurate, as G.P. Wade had discussed the Engineering Employers’ West of England Association ergonomics courses for engineers and designers, which was a joint venture with Murrell.⁹⁸ This was one of the first ergonomics educational courses that was delivered through an employers’ association rather than academia. Floyd also announced that he was developing a degree course in ergonomics at Loughborough University; both these initiatives are discussed in Chapter 6. Yet Fletcher’s comments on how DSIR managed ergonomics research and the promotion of ergonomics were to have a rapid and profound effect on decisions made by the DSIR RC.

The conference demonstrated that individuals such as Murrell and Floyd⁹⁹ were taking steps to promote ergonomics and communicate with potential stakeholders, such as the TUC. They were building networks with the TUC, industry and academia which they employed to exploit their research, and would use to develop educational courses which would accelerate the institutionalisation of ergonomics. The ERS itself was not putting in place mechanisms to build corporate networks, although they could have access to Stansfield, who sat on the ERS Council and who could help. Star and Griesemer point out that science requires co-operation between practitioners and users to create common understanding and the gathering of information.¹⁰⁰ They also show

⁹⁶ Proceedings of the Conference on Ergonomics in Industry 27 – 29 September 1960. London, HMSO, 1961. p. 179.

⁹⁷ Ibid.

⁹⁸ G. P. Wade, A Contribution in *Proceedings of the Conference on Ergonomics in Industry 27 – 29 September 1960*. London, HMSO, 1961, pp. 152 - 156.

⁹⁹ These were not the only individuals establishing networks. Others such as Michael Farr, Brian Shackel and John Chris Jones were actively working to network design and ergonomics.

¹⁰⁰ S. L. Star and J. R. Griesemer, Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39, *Social Studies of Science*, (1989), 19, 387 - 420.

how inter- and intra-institutional co-operation and communication results in a series of shared goals which fulfil the aims of the stakeholder groups. What is clear from the London conference is that DSIR, industry and the unions had similar goals and wanted to embrace ergonomics. The ERS, with notable individual exceptions, was reluctant, or finding it difficult, to enter into a co-operative or collaborative agreement.

In this chapter I have shown that the key mediator between DSIR, the ERS and the EPA was Stansfield. He was empowered to talk and act on behalf of DSIR and had close relations with the ERS, individual ergonomists, the TUC and industry. This enabled him to communicate, and be a communication conduit, with the different stakeholders. Both Stansfield and the ERS, however, faced a major difficulty in that none of the employers' organisations had a similar actor, or group of actors, who acted as a point of contact for the ERS or ergonomics. In effect, ergonomists and the ERS could only interact with individual companies who had an interest in ergonomics. There was no overarching employers' body which could help exploit the science to all appropriate parts of the industrial enterprise. There was no industrial champion for ergonomics.

Mort demonstrates how 'enrolment' – which she defines as “the definition and distribution of roles by an actor world”¹⁰¹ of the workforce and management at Vickers, Barrow, government agents and technology into a coherent network facilitated the production and delivery of the Trident submarine. It should be noted that Vickers were the prime contractor for Trident and in Mort's network represented industry. Similarly, Whitfield has shown how Metrovick, the Royal Aircraft Establishment and government advisors worked together on gas turbine technologies.¹⁰² Both Mort and Whitfield address the production of a technological solution to meet a capability gap by a discrete and bounded set of actors. The problem facing the ERS was that ergonomics had utility across industry, implying a potential multiplicity of possible partners. Their difficulty was how to effectively communicate, and build relationships, with such a potentially large and diverse group. For industry the problem that was clearly exposed during the 1960 conference was who was the

¹⁰¹ Mort, (2002), p 22.

¹⁰² Whitfield, (2012).

point of contact in the ERS who could advise on the implementation of ergonomics knowledge. Given these two difficulties it is hardly surprising that a robust corporate social network between industry and the ERS could not be constructed. For individuals such as Murrell and Floyd, the problem did not necessarily exist, since they were dealing with a much smaller sub-set of institutions and could identify points of contact. Whilst the ERS did form an Industrial Relations sub-committee this was orientated towards the TUC and had no interactions with the employers' associations.

The evidence from Chapters 2 and 3 shows that the emergence and growth of ergonomics was in response to the need to increase productivity to contribute to the economic health of the nation. This was a problem which arose from a government "working world, and not from an industry "working world." Influential institutions such as DSIR and the TUC were viewing ergonomics as a science which could solve the human problems, such as fatigue, which attended increased productivity. Industry, as a monolith, did not share such a vision. This notion that ergonomics arose from a government "working world" needs to be considered against Agar's proposal that human relations, at least in the US, arose from the industry "working world."¹⁰³ What this indicates is that complementary, or at the very least, parallel sciences can arise from different worlds to solve common problems which may be shared by those worlds.

Here I have concentrated on the 1960 Ergonomics in Industry conference and the themes and issues that were raised during the discussion groups. To help frame the narrative surrounding the conference I have also reviewed the 1959 ERS conference. By 1960 despite regular national ERS conferences, which were attended by industry and the unions, there was still confusion regarding what constituted ergonomics and what was an ergonomist. Much of the problem lay with the institutional reticence of the ERS to communicate effectively with key stakeholders and so develop co-operative networks through which knowledge and information could be transacted. The ERS was still riven with internal differences which hindered co-operation between members and the development of a clear identity, or strategy for ergonomics. In its defence, a major issue for the ERS was identifying a key stakeholder who

¹⁰³ Agar, (2012) pp. 180 – 183.

represented industry per se and not just a single company. Ergonomics in Industry had highlighted these shortcomings.

3.7: Conclusions.

This chapter has addressed two significant episodes in the development of the human science research programme and ergonomics: the formation and near collapse of the HSC, and the work of WP4 of the EPA, the culmination of which was the 1960 Ergonomics in Industry conference. The importance of these events, as the next chapter demonstrates, are that they provided the conditions and opportunities for growth and focusing of the human science research programme and obliged the ERS to take a more outward looking and expansive approach to other communities. This chapter has also demonstrated how Stansfield, a middle-ranking civil servant, was able to play a significant role in both the management of the human science research programme and in bringing ergonomics to the international stage.

In the case of the HSC, I have suggested that the cause of the reduced Treasury funding and near collapse of the committee can be attributed to the absence of a suitable strategy for the development of a human science programme. Part of the reason may be that Stansfield did not have the necessary vision to provide direction to the HSC, and this is explored further in the next chapter. It should be noted, however, that he was heavily involved in other duties, particularly with EPA WP4, which may have meant that he was unable to provide adequate attention to the work of the HSC. Underlying these observations were the institutional and procedural changes wrought within DSIR by the passage of the 1956 *Scientific and Industrial Research Act*.

The Act had increased the level of DSIR's empowerment so providing the HSC with executive powers such as the ability to move funds between programmes or to bid into the Treasury for extra monies. Such fundamental changes in the business enterprise of DSIR should have been matched by appropriate structural and procedural changes. In the case of the human sciences these changes were, as I show in the next chapter, enacted after the HSC had run into financial difficulties. A further outcome of the act was that empowerment was pushed down to Stansfield. The chairs of the previous human science committees, Schuster and Bartlett, were strong characters with a clear vision and purpose. Stansfield had advised both, but when

placed in an empowered position to make strategic decisions he deferred to the chair of the HSC, rather than provide clear guidance.

Stansfield's work with the EPA was significant in bringing the concept of ergonomics to the attention of Western Europe and nurturing the science by developing, with others, the concept of a series of international conferences on the science. By also ensuring that ERS members were funded to undertake exchange visits he facilitated the exchange of concepts, ideas and impressions of European and US views of ergonomics. Finally, he was an original member of the group which helped form the IEA. It is peculiar that despite Stansfield's role in raising the international profile of ergonomics, he is all but forgotten in ergonomics circles.

The Ergonomics in Industry Conference was important in that it laid bare the issues of communication, identity, internecine rivalry and insularity within the ERS. The inability to effectively communicate or co-operate with industry and unions meant that the society was unable to provide an accessible and understandable identity for ergonomics which the stakeholders could situate in their respective enterprises. These issues also inhibited the attainment of shared goals between ergonomics practitioners and key stakeholders. This lack of communication, coupled with the confusion of the nature of ergonomics, meant that potential stakeholders in industry, government and academia had no clear idea of the aims and ideals of the ERS. Nor did they have a unified view of the nature of industrial ergonomics. This lack of clarity of communication, and vision, of the ERS meant that the society would be forced into playing a marginal role in the institutionalisation of ergonomics. It is important to remember, however, that government, industry and academia did hold certain practitioners, such as Murrell and Floyd, in high esteem. Their individual roles in institutionalising ergonomics will be further examined in the next chapters.

The inability of the ERS to effectively promote ergonomics resulted in DSIR, through the management of the research programme taking that role. It has been shown in this chapter that the TUC were concerned at how DSIR was managing and exploiting ergonomics research. The closing statements made by Fletcher that to have a starker and more immediate effect on the management of human sciences within DSIR and their attitude to ergonomics. They were to result in the RC making a series of conflicting decisions on the management and direction of ergonomics research in

DSIR. The London conference exposed the critical issues of identity and communication between the communities.

I will now examine how the HSC was reformulated and describe the emergence of a dedicated Ergonomics Sub-Committee to advise the HSC on research programme formulation. I will show how this afforded the ERS the chance to take a more active role in shaping and directing human science research and how, quite unexpectedly they took the opportunity. I will also focus on the formation, and subsequent demise, of the ergonomics capability at Warren Spring. This will provide an insight into science management within DSIR. I will also address the transition of the management of ergonomics from DSIR to Min Tech and the impact of the formation of the SRC and SSRC on government funding for ergonomics.

Part 1 Chapter 4: Ergonomics at DSIR and Min Tech - 1958 to 1968.

4.1 Introduction.

In Chapter 3 I described the establishment of the Human Sciences Committee (HSC) as the body to formulate and manage the DSIR industrial human science research programme. I also described how the HSC was initially unsuccessful in meeting its objective “to look especially at the human aspects of equipment design and at problems of training and human relations in industry.”¹ This was due, in part, to the absence of a clear strategic vision for the development of the research programme. The absence of a clear strategy also resulted in the Treasury offering a significantly reduced financial settlement consequent upon the HSC funding submission.

Internally, the HSC was criticised for the narrowness of the focus of the research programme it had constructed. All this obliged the DSIR RC to undertake executive action to ensure the construction and delivery of a coherent research programme. These decisions were that the HSC would become an advisory body with no research managerial or contractual obligations, and programme formulation would fall to a new sub-committee. In addition, a DSIR human science capability would be established at WSL to contract and undertake research.

I have also described how Stansfield influenced the EPA to establish a series of international conferences on ergonomics which culminated in the 1960 Ergonomics in Industry Conference. I have argued that this conference was a significant step in the development of ergonomics in the UK, in that it highlighted issues of communication, the identity of ergonomics and the insularity of the ERS and, as I will show in subsequent chapters, resulted in some changes of attitude within the society. In addition, Fletcher from the TUC criticised DSIR, in front of the Secretary Sir Harry Melville, for its approach to promoting the human sciences, including ergonomics. These criticisms may have also influenced the RC’s decisions. In this chapter I will describe the outcomes of the responses made by the RC’s revision of human science research and management.

The HSC’s original academic membership was drawn exclusively from the social sciences, which meant that they were ill-equipped to assess research proposals outside

¹ TNA DSIR 17/728. Report of the Research Council for the Year 1956 – 57.

that domain. This was addressed by the formation of an Ergonomics Sub-Committee to identify and advise on appropriate research and undertake reviews of the provision and exploitation of ergonomic research. This was the first government-appointed body which specifically addressed the development of ergonomics research and offered members of the ERS an opportunity to work within the framework of a major government department. The work of the Sub-Committee will be described and analysed in this chapter, with attention being paid to how the research programme contributed to the development of ergonomics in the early to mid-1960s.

The human science research capability at WSL was originally intended to undertake cross-discipline research. The DSIR RC, for reasons explained in this chapter, directed that the capability should only research ergonomics and would provide a service to both industry and the RAs. The work of the laboratory, tensions generated within DSIR regarding the change in research emphasis, and the subsequent closure of the capability will be discussed. This will provide an insight into DSIR management processes during the final years of its existence.

The mid-1960s were a turbulent time in the management of government science, wrought, partly, by the election of the Wilson administration in 1964. DSIR was dissolved in 1965 with the formation of Min Tech to manage the DSIR research stations, including WSL, and the establishment of the SRC to manage the research, university grant and post graduate awards portfolio.² In addition, the SSRC was established to manage and direct all government social science research.³ These fundamental changes had a profound effect on government funding for ergonomics research, and I will review the impact of these changes.

4.2: The Ergonomics Sub-Committee.

At its inception the HSC had established specialist sub-committees on the EPA and work study to report and advise on developments in these areas.⁴ The formation of the Ergonomics Sub-Committee arose from a recommendation in a DSIR report on a

² Vig, (1968), pp. 50 - 52.

³ *Report of the Committee on Social Studies*, Cmnd 2066, London, HMSO, 1965.

⁴ The work study sub-committee was chaired by Briggs who was an ordinary member of the HSC. Fletcher chaired the EPA sub-committee.

meeting in April 1958 to develop a strategy for training ergonomists.⁵ The meeting, which had been called by the HSC, also discussed the future need and nature of ergonomics research and the establishment of a national ergonomics consultancy.⁶ The report gives little impression of the discussion but concludes that the “meeting agreed that research in the general field of ergonomics should be increased, and supported Dr. Cherry’s plea that DSIR should help in this respect.”⁷ It was this plea that resulted in the formation of the Ergonomics Sub-Committee.

Name	Affiliation
Prof. J. Drever.*‡	Department of Psychology, Edinburgh.
D. E. Broadbent.*#	Director MRC APU and member of the ERS Council.
Prof. G. C. Drew.#	Professor of Psychology, UCL.
Dr. O. G. Edholm.*#	National Institute for Medical Research and ERS Secretary.
E. Fletcher.‡	TUC and Member of the HSC.
Dr H. Kay.#	Institute of Experimental Psychology, Oxford.
Dr. A. T. Welford.*#	St Johns College, Cambridge.
Dr. A. H. Jones.*	Division Medical Officer, British Railways.
Mr. W. H. Larke.	General Manager, Stewart and Lloyds.

Table 4-1. Initial Membership of the Ergonomics Sub-Committee⁸ * = Member ERS, # = MRC, ‡ = Member of HSC.

The Ergonomics Sub-Committee met in November 1958 and names and affiliations of the members are given in Table 4-1. It is not known how they were selected, or by whom, but it included MRC representation. I have previously suggested that the MRC’s withdrawal from the partnership with DSIR was because their personnel serving on an empowered executive committee would be accountable to the Treasury for the financial and scientific health of the programme rather than the MRC. The

⁵ TNA DSIR 17/684. Training in Ergonomics HSC – 28 17th April 1958. Twenty five people attended the meeting, with representatives from DSIR (notably Greenall), Murrell, Floyd, Sell and Singleton from the ERS, Edholm and Weiner from the MRC, Fletcher from the TUC and H.K. Mitchell from the British Employers’ Confederation.

⁶ Ibid. p. 3.

⁷ Ibid. p. 6. The word ‘agreed’ is underlined in the report. Cherry was a cognitive psychologist and Chair in Telecommunications at Imperial College.

⁸ TNA 17/683. Ergonomics sub-committee. Introduction, Membership and Terms of Reference. HSC / E-2. 20th November 1958.

Sub-Committee had no delegated financial authority and would not be accountable to the Treasury, which may explain why the MRC supported this group.

The committee comprised influential human science practitioners, with a single industrialist. Drew was an advisor to the APU and, with Craik, had constructed the Cambridge Cockpit. He conducted much of the early research into the effects of alcohol on driving ability,⁹ which led to the development of the breathalyser.¹⁰ Kay had worked with Welford at the Nuffield Centre for Research into Problems of Aging at Cambridge. He later became President of the British Psychological Society and Chairman of the MRC Environmental Medicine Research Policy Committee.¹¹ Jones served on the ERS Council during the 1960s.

The Sub-Committee's remit was to review developments in ergonomics research and advise on the suitability of grant applications. In addition, they were to stimulate the dissemination of research findings to industry and take steps to further the development and application of ergonomics.¹² It is unclear how research applications were elicited as existing papers merely provide discussions on their merits or otherwise. The Sub-Committee met bi-annually to review research proposals and progress of contracts. At their initial meeting, for example, they discussed a request from the GPO for research into the utility of the Dvorak keyboard.¹³ This had been patented by August Dvorak, Professor of Education at University of Washington in Seattle in 1936. The layout was supposed to reduce the number of required keystrokes compared to a normal QWERTY keyboard, leading to a reduction in muscle strain.¹⁴ US research had shown that the keyboard could increase typing speeds by up to 25% with little or no degradation in accuracy. The GPO had been researching the implementation of the keyboard but felt that they had insufficient expertise to continue the studies and so approached the Ergonomics Sub-Committee. The

⁹ See, for example, G.C. Drew, W.P. Colquhoun and H. A. Long, Effect of Small Doses of Alcohol on a Skill Resembling Driving, *Medical Research Council Memorandum, No. 38*. London, HMSO, 1959.

¹⁰ J. Noyes, Over a Century of Psychology at Bristol. A Short History of the Department of Experimental Psychology, University of Bristol, (2008), <http://www.bristol.ac.uk/expsych/media/experimental-psychology-history.pdf> accessed 26 September 2016.

¹¹ Wellcome Foundation, (2003).

¹² TNA 17/683. Ergonomics sub-committee. Introduction, Membership and Terms of Reference. HSC / E-2. 20th November 1958.

¹³ Ibid.

¹⁴ R. Cassingham, The Dvorak Keyboard – A Primer, (2014), <http://www.dvorak-keyboard.com/> accessed 24th April 2016.

Ergonomics Sub-Committee was now forwarding reviewed proposals to the HSC for potential funding consequent upon renegotiation with the Treasury for a financial uplift for human science research.¹⁵ The Sub-Committee also set up a working group to establish the need for ergonomics consultancies. The working group could not define the magnitude of the demand for a consultancy as an (unspecified) number of industrialists could not envisage a role or position for ergonomics in their enterprise.¹⁶ The report does not explain why the industrialists could not see a role for ergonomics. The issue of consultancies was to be re-visited by the DSIR RC.

The Ergonomics Sub-Committee operated until subsumed into the Human Sciences Research Sub-Committee in 1962, where all human science research proposals were to be processed. There is little further information on how the sub-Committee gathered research requirements or if it interacted with industry. For an institution which shaped the industrial ergonomics research programme it is strange that it does not feature in any practitioner history. Formed when the HSC was struggling to construct a balanced research programme the Sub-Committee provided a specialist forum for developing a robust ergonomics research programmes which, as I will show produced an extensive ergonomics knowledge base and launched the careers of future influential ergonomists. I will now discuss the HSC re-organisation.

4.3: Reorganising the HSC.

In response to the performance of the HSC, described in Section 3-3, in Spring 1959 the DSIR RC issued a policy paper on the internal management of human sciences. This recommended the transfer of Stansfield's Human Sciences Section to WSL to undertake and manage human science research, with a new Human Sciences Research Sub-Committee (Table 4-2) to manage the HSC research programme.¹⁷ These pragmatic decisions reflected the need for strategic planning and implementation of human sciences to be balanced with the reality of the workload that this would entail. The problem was that transferring Stansfield and his team removed all personnel from the centre who understood the totality of the human sciences programme and who

¹⁵ TNA DSIR 17/689. Minutes of Ninth Meeting of the Human Sciences Committee, 7th July 1959. HSC-120.

¹⁶ TNA AY 28/8. Report on the Working Group on Consultancy Services in Ergonomics. HSC / E – 12, January 1961.

¹⁷ TNA DSIR 17/689. Identifying research requirements in the human sciences suitable for DSIR contracts. Internal memorandum 7/43/2/9, 15th April 1959.

could immediately advise formally or informally on policy matters.¹⁸ The HSC, with a new membership and reporting directly to the RC, would become an advisory body to consider policy requirements in the light of industrial needs.

Name	Affiliation
H. Briggs (Chair).*	Personnel Division, Unilever.
S. H. Clarke.	Director Warren Springs.
Prof. G. C. Drew.*	Department of Psychology, UCL.
Prof. D. V. Glass.	London School of Economics.
Prof. N. C. Hunt.	Department of Organisation of Industry and Commerce, University of Edinburgh.
D. A. Oliver.	BISRA.
S. A. Robinson.*	National Union of Boot and Shoe Operatives.
R. G. Stansfield.*	WSL.

Table 4-2. Initial Membership of the Human Sciences Research Sub-Committee.¹⁹ * indicates previous member of HSC.

The Human Sciences Research Sub-Committee was to advise “the Steering Committee of the Warren Spring Laboratory, and the Director, on the Laboratory’s research in the field of human sciences”²⁰ so taking over the definition and management of the research programme. The appointment of D.V. Glass deserves especial mention.²¹ He was a member of the ‘Gaitskell Group’ of scientific advisors which had been formed by Marcus Brumwell²² following the 1956 general election. This included Blackett, Bronowski, Lockspeiser and James Callaghan and was charged with developing a new science policy for the Labour Party. Glass also contributed to the development of Wilson’s ‘White Heat’ speech.²³

¹⁸ J.Hughes, *Doing Diaries: David Martin, The Royal Society and Scientific London*, *Notes and Records of the Royal Society of London*, (2012), 66, 273 - 294 for a discussion on the importance of informal meetings in policy formulation and decision making.

¹⁹ Ibid.

²⁰ AY 28/7. Human Sciences sub –committee WSSC/HSR – A (59)1 14th October 1959.

²¹ M. J. Wise, David Victor Glass 2 January 1912 – 23 September 1978, *Biographical Memoirs of Fellows of the Royal Society*, 1983, 29, 201 - 225.

²² Brumwell founded the Design Research Unit which provided many displays for the Festival of Britain. He was a lifelong socialist.

²³ Horner, (1993). The role of Blackett in the “Gaitskell Group” is discussed in M. Kirby, Blackett in the ‘White Heat’ of the Scientific Revolution: Industrial Modernisation under the Labour Governments, 1964-1970, *Journal of the Operational Research Society*, (1999), 50, 985-993.

Member	Affiliation
L. T. Wright (Chair).*	Amalgamated Weavers Association and the Cotton Board.
H. Briggs.*	Personnel Division, Unilever.
Professor G.C. Drew.*	Department of Psychology, UCL.
E. Fletcher.*	Head of TUCPD.
Professor D. V. Glass.	LSE.
Professor M. Gluckman.	Dean of the Faculty of Economics and Social Science, The University of Manchester.
D. A. Oliver.	BISRA.
Professor J. Drever.*	Department of Psychology, Edinburgh.
C. G. Williams.	Shell Research Ltd.
A. B. Cherns (Secretary).	DSIR HQ.

Table 4-3. Initial Membership of the new Human Sciences Committee.²⁴ *indicates member of previous HSC.

By way of comparison the membership of the new HSC is given in Table 4-3, with four individuals sitting on both committees, ensuring good communications. The new secretary, A.B. Cherns, graduated from Cambridge in psychology and held several research posts before joining the DSIR Headquarters Division. He later became the first secretary to the SSRC and then Professor of Social Science at Loughborough.²⁵ His interests were the role of social science in government policy and sociotechnics: the application of social sciences to social affairs to effect efficient social action.²⁶ Cherns saw commonality between ergonomics and sociotechnics in that both strove to produce efficient human action, either individually or collectively.²⁷

The DSIR RC provided the HSC with an interim grant of £60,000 for FY 1960/61 to allow new research to be funded. They also directed that the HSC should produce a report on the scientific and productivity value of the work funded by both the joint DSIR / MSC committees and the HSC to act as supporting evidence for any future Treasury submission.²⁸ Cherns probably wrote the paper, which was a balanced and

²⁴ TNA AY 28/7. Relations of the sub-committee with other parts of the DSIR. WSSSC/HSR – (59) 3rd September 1959.

²⁵ J. Schmidt. In Memorandum of Albert Bernard Cherns – (1921 – 1987). *Isa bulletin* Spring (1987), 31.

²⁶ For a detailed description of sociotechnics see *Social Engineering*, eds, A. Podgórecski, J. Alexander and R. Shields. Ottawa, Carleton Press, 1996.

²⁷ A. Cherns, The Social Setting of Ergonomic Problems, *Ergonomics*, (1962), 5, 275 - 278.

²⁸ TNA DSIR 17/691. Evaluation of Human Science Research. HSC – 132. 22nd March 1960.

coherent account of research and consultancy work undertaken by the different committees and addressed the impact that the research had made within industry and academia. It closed with the proposal that DSIR should provide adequate funding for human science research, £400,000 over four years, or approximately 0.25% of their research expenditure (see Chapter 2). The DSIR RC accepted the findings and the need for DSIR to fund human sciences research for the next four years.²⁹

DSIR had now put in place a human science research management structure which should have allowed the Headquarters Human Science staff to concentrate on internal DSIR human science research at WSL. The Human Sciences Research Sub-Committee would take on the management of the external academic research programme whose strategic direction would be set by the HSC. I will now discuss how this research shaped ergonomics in the UK.

4.4: The HSC Ergonomics Research Programme - 1960 to 1965.

The progress of the human science research programme was reported in *Investigations Supported by the Human Sciences Committee*³⁰ which were issued bi-annually, free, to industry and academia. Research programmes were ordered institutionally and gave the programme aims, progress over the previous six months, future work and any publications. It also provided contact details for the lead investigator and, occasionally, co-workers. It is unclear how *Investigations* was developed and published; one possibility is that it was the outcome of discussions between the HSC and the DSIR Industry and Information Departments regarding research exploitation.³¹ The ergonomics studies, by institution, are given in Table 4-4.

Institution	Investigation	Purpose	Date
Aberdeen University.	Development of techniques of automatic instruction for scientific and industrial use.	The implementation of continuous self-assessment during self-paced learning.	01-10-61 to 31-09-64
Belfast, Queens.	Perceptual adaptation and perceptual motor learning.	The effects of visual distortion and perceptual motor learning on task performance.	01-09-65 to 31-08-68

²⁹ TNA DSIR 46/39. Notes of a Research Council Meeting held on 10th November 1960.

³⁰ DSIR. *Investigations Supported by the Human Sciences Committee*. Issues 1 – 10, November 1960 – September / October 1965. The final booklet in my possession is for October 1965 and was issued under the aegis of the SRC.

³¹ TNA DSIR 17/684. Training in Ergonomics HSC – 28 17th April 1958.

Birmingham College of Advanced Technology.	The acquisition of high speed skills.	Characteristics of learning and maximum performance using different presentation material.	Transferred from Cranfield
	Human factors problems in changing industrial systems.	Minimising the impact of emergent properties of new technology.	01-10-65 to 30-09-68
Birmingham University.	Principles of Batch Production.	Define economic and psychological aspects of batch production to achieve maximum productivity.	01-04-60 to 31-07-62
	Machine control by "semi-skilled" operators.	Investigation of human abilities and characteristics in relation to machine control requirements.	01-10-61 to 30-09-63.
	Hand injuries in industry.	The use of hand injury avoidance strategies to design machines.	01-04-62 to 31-03-65
	Factors influencing industrial skills.	Understanding the reactions of operators to machine originated signals.	01-04-62 to 31-03-64
	Simulation of cognitive processes by means of electronic computer programmes.	An attempt to build a mathematical model of cognition.	01-10-62 to 30-09-65
	Some effects of technological change.	Study of the impact of the introduction of new technology.	01-10-65 to 30-09-68
Bristol University.	The complexity of industrial tasks.	Studies of the relationships between task complexity and performance and working efficiency.	01-08-60 to 31-07-65
	An investigation of engineering drawing comprehension.	Investigations into how comprehension can be enhanced.	16-09-63 to 15-09-65
	Analysis of control skills.	An understanding of the interactions of factors which dictate control skills in an industrial setting.	01-10-64 to 30-09-66
	Sensori-motor co-ordination in touch and sight.	Mechanisms used by the central nervous system to control and integrate touch and sight.	01-09-65 to 31-08-67

Brunel College of Technology.	Subjective judgement in inspection and quality control.	Understanding the conditions which influence workplace judgement.	01-10-59 to 30-09-62
	The learning of process control skills.	Strategies for enhanced learning.	01-01-61 to 31-12-62
	Group decision and individual judgement.	Understanding the processes at arriving at a judgement.	01-09-62 to 31-08-64
Cambridge University.	Development of special devices for research and for matching machines to men.	Development of special devices for use in industry or psychological research.	01-10-58 to 30-09-62
	Human discrimination processes.	Use of information theory to explain discrimination processes.	01-04-60 to 31-03-61
	Development of special devices for behavioural research.	Development of techniques for psychological research which can be used in other branches of sciences and industry.	01-10-62 to 30-09-64
Cranfield University.	The acquisition of high speed skills.	Characterising learning and maximum performance as dictated by different media.	01-10-62 to 30-09-65
Dundee University.	Studies of process control in the manufacture of complex chemical compounds.	Experiments to understand how skill is performed, if it can be predicted and be trained.	01-01-64 to 31-12-66
Durham University.	The continued fixation of visual patterns.	An understanding of the factors underlying visual satiation.	01-10-61 to 30-09-64
	Development of features of space perception.	How spatial information is processed by people with attenuated or distorted sensory input.	01-09-62 to 31-08-63
	The performance of manipulative and inspection tasks under tungsten and fluorescent light.	How different light sources affect work performance.	01-01-63 to 31-12-65
Enfield College of Technology.	Study of the use of teaching machines and programmed learning for training industrial operatives.	The application of programmed learning.	01-09-64 to 31-08-67
Hull University.	Some perceptual or intellectual skills likely to become of increasing importance with the growth of automation in industry.	An understanding and characterisation of skills required with the advent of automation.	01-03-63 to 28-02-66

	The effects of associative variables on the free recall of verbal material.	Understanding factors underlying short term recall of verbal material.	01-10-64 to 30-09-67
University College, Keele.	Information processing in mechanisms of pattern recognition.	An understanding of the mechanisms underlying the recognition of patterns in the written word.	01-01-62 to 31-12-66
Leeds University.	Training by motor guidance.	An investigation of the efficiency of different forms of action guidance compared to other training techniques.	01-10-62 to 30-09-65
UCL.	Training of skilled operators.	The application of the "Activity Method" of learning to complex manual tasks.	01-01-59 to 31-12-62
	Manual skill and physiological efficiency.	To establish the most efficient rates of exerting force in muscular tasks.	01-10-59 – 30-09-62
	Speed and accuracy on decision making.	Building and validating a model of decision making.	01-09-63 to 31-08-66
	Studies in the training of adult workers.	Development of methods to train or re-train the older worker.	01-01-64 to 31-08-67
Loughborough University.	Studies of dynamic anthropometry.	See below.	01-01-62 to 31-12-65
	The study of tactual discrimination in relation to inspection tasks in industry.	An understanding of the most tactual part of the hand and how this can be used in inspection tasks.	01-10-63 to 01-10-66
	The study of motion patterns during the execution of skilled movements.	Development of techniques for visualising dynamic movements in workers.	01-10-63 to 01-10-66
University of Newcastle.	Perception in conditions of intrasensory and intersensory stimulation.	To shed further light on the mechanisms of perception.	01-09-64 to 31-08-66
University of Nottingham.	Some perceptual or intellectual skills likely to become of increasing importance with the growth of automation in industry.	An understanding of the cognitive demands of automation.	Transferred from Hull 01-09-64 to 31-08-67
Oxford University.	Plant operator skills and automation.	An understanding of acquisition of control skills.	01-10-61 to 30-09-62
	Thought and decision in control skills.	Development of a computer simulation of human control behaviour.	01-10-62 to 30-09-64

	Application of programmed learning techniques to the teaching of engineering Procedure Agreement.	Further studies on the use of programmed learning.	01-01-64 to 31-12-65
	Short and long term information storage by human subjects.	Understanding memory decay and retrieval criteria on the retention of verbal criteria.	01-01-65 to 31-12-67
Reading University.	Plant operator skills and automation.	See above.	01-01-59 to 31-03-61
	Presentation of information in skill situations.	Understanding the central control of skilled movements.	01-10-62 to 30-09-65
Sheffield University.	Perceptual motor relationships in skilled performances.	The use of automatic trainers and teaching machines.	01-10-60 – 30-09-63
	Auto-instructional methods in industry.	Development and use of teaching machines.	01-10-63 to 30-09-67
Southampton University.	An investigation of the effects of associative variables on the free recall of verbal material.	Transferred from Hull.	01-09-65 to 30-09-67
Welsh College of Advanced Technology.	The complexity of industrial tasks.	See entry for Bristol.	16-09-63 to 15-09-66
	Field research into operator performance in relation to (a) breaks, (b) pacing.	Examine the relationships between task demands and performance that affect working efficiency.	01-09-64 to 31-08-66

Table 4-4. Ergonomic Studies Supported by the Human Sciences Committee 1959 – 1967.³²

Investigations provides a rich picture of programme development. The 1961 report shows that of the 48 research programmes nine (19%) were ergonomics based and seven (15%) were basic research, mainly vision studies. These proportions remained constant up to 1965 when there were 95 research programmes. In terms of institutional funding, in 1961 ten universities including Birmingham, Loughborough and Imperial College, London were receiving funding. By 1965 this had risen to eighteen, with centres such as Queens Belfast and Birmingham College of Advanced of Technology now being funded.

³² DSIR. *Investigations Supported by the Human Sciences Committee*. Issues 1 – 10, November 1960 – September / October 1965.

This expansive research programme launched the careers of many world-renowned ergonomists, two notable examples being R. J. Beishon and John Annett.³³ Beishon researched control skills at Bristol (see page 149). In 1970 he was appointed as the Head of the Operational Analysis Group at Sussex,³⁴ and then joined the Open University as the first Professor in the Open Systems Department where he led studies on humans in industrial systems. Annett studied perceptual motor relationship in skilled performance at Sheffield (see page 152). He moved to the Psychology Department at Hull where he developed, and pioneered, the use of hierarchical task analysis which is “a way of understanding intelligent, and unintelligent, human behaviour in a complex environment.”³⁵ It has since become a key research tool for studying the human in complex working environments, such as nuclear power plants.³⁶ Annett was the inaugural Professor of Psychology at Warwick.

Further analysis of Table 4-4 shows how the programme developed over time. The 1960s was a time when computers and micro-processors were becoming more prevalent in industrial processes, replacing old skills, but in the early part of that decade they were still to make an impact in industrial processes.³⁷ Consequently, in 1961 the majority of the studies were concerned with the human skill aspects of production engineering. For example, Murrell and Spencer investigated the relationship between task complexity and working efficiency from a human-centric position, but were not examining the underlying cognitive, workload or fatigue issues.

By 1965 attention was directed to the ergonomic aspects of technological change, especially the growing presence of computer mediated automation at the workplace and the use of computers as teaching machines. As Bainbridge points out, “the classic aim of automation is to replace human manual control, planning and problem solving by automatic devices and computers,” but continues that even highly automated

³³ Others included Neville Moray who was Professor of Psychology at Surrey and Lianne Bainbridge who first identified and coined the term “irony of automation”. This refers to ways in which automation of industrial processes may expand rather than eliminate problems for the human operator. See L. Bainbridge, Ironies of Automation, *Automatica*, (1983), 19, 775 - 779.

³⁴ R J Beishon, Letter to *New Scientist* 18th March 1971.

³⁵ J. Annett, Reflections on Task Analysis, *Psychological Sciences and Clinical Psychology* (2014), <http://hciresearchforall.net>. accessed 26th September 2016.

³⁶ For a study of the use and significance of HTA see J. Annett, Hierarchical Task Analysis, in D. Diaper and N. A. Stanton (eds.), *Handbook of Task Analysis in Human – Computer Interaction*. Mahwah NJ, Lawrence Erlbaum, 2003, pp 67 - 82.

³⁷ For a discussion on the changing concepts of the meaning of work see McIvor (2013), pp 43 - 73.

systems still require human supervision.³⁸ In the US, Eliot Noyes working at IBM pioneered the application of human engineering to the design of the human machine interface of the early computers.³⁹ Although much of his early work was concerned with shape and colour of the interface, by the early 1960s Noyes came to appreciate that computers also stimulated the human sensory system and that human attributes such as speed and sequence of thought and attention would become increasingly important in dictating interface design and the usability of computer-controlled systems.⁴⁰ In the UK, the work of Broadbent and his team at the APU, discussed earlier, was seeking to understand the processes underpinning these attributes. What this also indicates is a convergence of ergonomics with cybernetics. Cybernetics had, since the mid-1940s sought to produce models of human cognitive performance,⁴¹ now ergonomists were trying to understand the cognitive issues underlying the use of computers. They were also taking steps to actively demonstrate that computers would replace humans in the work environment.

Crossman and his team, which included Bainbridge, were researching plant skills and automation and demonstrated how the perceptual systems, such as gaze, were used to control human information intake and determine courses of action to control complex processes.⁴² E. Nigel Corlett at the Engineering Production Department at Birmingham was studying the impact of the introduction of computers at the work place as a model for the effects of technological change on worker skills, and those of Singleton at Cranfield and Aston on the acquisition of high speed skills. These, and other contemporary studies funded by the HSC were moving ergonomics toward investigating humans in complex systems and were ushering in the understanding of the human in a systems engineering context, a point I shall return to later. The research into human responses in computer-controlled systems opened the field of human reliability and safety to ergonomics, eventually allowing the science to make significant contributions to the design and operation of Sizewell B and other nuclear

³⁸ Bainbridge, (1983).

³⁹ J. Harwood. *The Interface: IBM and the Transformation of Corporate Design, 1945 – 1976*. Minneapolis, University of Minnesota Press, 2011, pp 9 - 28 and 73 - 78.

⁴⁰ Ibid, pp.86 - 87, 91.

⁴¹ Pickering, (2011).

⁴² E. R. F. W. Crossman, J. E. Cooke and R. J. Beishon, Visual Attention and the Sampling of Displayed Information in Process Control, in E. Edwards and F.P. Lees (eds.), *Human Operator in Process Control*, London: Taylor & Francis, 1974, pp 25 - 50.

power stations.⁴³ Further discussion of this step in the development of ergonomics falls outside the timeframe of this thesis, but indicates an area for future work.

The ergonomics element of the human science research programme provided seed corn funding for the development of departments at Loughborough, Birmingham, Aston and UWIST. Singleton at Aston, for example, was funded to investigate emergent human factors problems in the design of new industrial systems.⁴⁴ This research was undertaken by secondees from the Motor Industry Research Association and Machine Tool Industry Research Association, the aim being to train them as ergonomists, so they could then use their knowledge in the RAs, providing both formal education and a route for research exploitation. Both RAs, during the latter part of the 1960s, had robust ergonomic capabilities.

So far, I have analysed the breadth of the ergonomics element of the human science research programme, and have identified how it shaped ergonomics, its role in capability development and training future ergonomists. Work which merits an in-depth analysis is the Studies in Dynamic Anthropometry undertaken by Floyd at Loughborough. This attracted long term funding to develop methodologies which were used in civilian applications, particularly building regulations and established a national and internationally recognised capability.

Anthropometry is the measurement of the dimensions of the human body to permit an understanding and visualisation of natural variability in size and shape both within, and across, populations.⁴⁵ Originally developed by anthropologists to validate racial typologies,⁴⁶ from the early twentieth century onwards it was used to determine growth, form and structure in populations which were related to nutritional and

⁴³ The ergonomic contributions to the development of Sizewell B power station fall outside the time scale of this thesis, but is an area ripe for future research. For a review of the ergonomic work undertaken for Sizewell B see D.J.C. Whitfield, Ergonomics in the Design and Operation of Sizewell 'B' Nuclear Power Station, *Ergonomics*, (1995), 38, 455 - 461.

⁴⁴ See D. Whitfield, Human Skill as a Determinate of Allocation of Function in W. T. Singleton, R. S. Easterby and D. Whitfield (eds.), *The Human Operator in Complex Systems*. London, Taylor and Francis, London, 1967, pp 54 - 60.

⁴⁵ The key book on the topic is S. Pheasant and C. Haselgrave, *Bodyspace: Anthropometry, Ergonomics and the Design of Work*. Basingstoke, Taylor and Francis, 2005.

⁴⁶ There is an extensive literature on anthropologists use of anthropometry. Two papers which give a useful insight into the use, and need for precision in measurement are F. Lundgren, The Politics of Participation: Francis Galton's Anthropometric Laboratory and the Making of Civic Selves. *British Journal of the History of Science*, (2013), 46, 445 - 466. and A. Morris-Reich, Anthropology, Standardization and Measurement: Rudolf Martin and Anthropometric Photography. *British Journal of the History of Science*. (2013), 46, 487 - 516.

vitamin deficiencies,⁴⁷ and to define and standardise garment size ranges.⁴⁸ Up to the late 1950s the UK anthropometric capability resided at RAFIAM.

In the early 1960s the key anthropometric data source was Henry Dreyfuss's *The Measure of Man*.⁴⁹ Drawn mainly from military anthropometric studies Dreyfuss's innovation was to present the data in both a tabular form and as a dimensional chart overlaid on a drawing of a human figure (Figure 4-1). Whilst this aided the visualisation of human dimensions there was a problem. Anthropometric data was gathered from static nude subjects in standing and seated postures, but work is dynamic. Workers adopt different postures to interact with their equipment and may be clad in bulky clothing. This changes body dimensions and reduces functional reach, how far forward or upward a limb can be extended, and range of motion, the arc of movement around a joint. Floyd's study was aimed at making dynamic anthropometric measurements to understand how clothing and natural obstructions impacted on body size, posture, reach and range of motion.

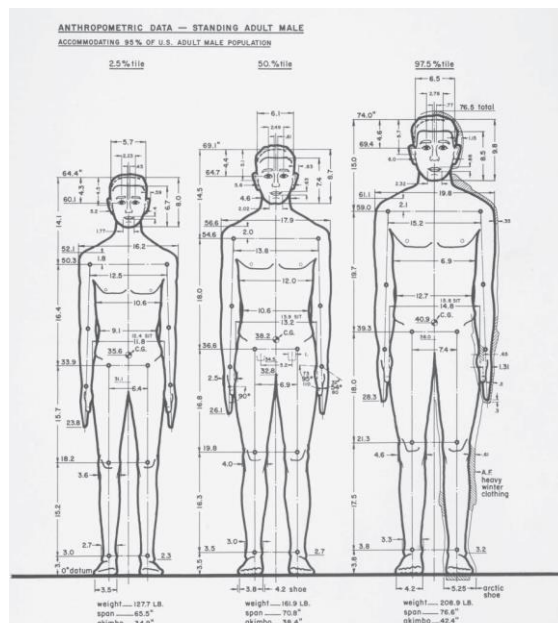


Figure 4-1. Visualisation of Anthropometric Data.⁵⁰

⁴⁷ There is a very extensive literature on nutrition, body growth and anthropometry. One of the more recent and comprehensive studies of the topic is *Handbook of Anthropometry*. Ed. V. R. Preedy. New York, Springer 2012. This provides a thorough review of anthropometric methodologies and the clinical and non-clinical uses of the technique.

⁴⁸ See for example Gibson and Harrison, (1984), pp. 220 - 221.

⁴⁹ H. Dreyfuss, *The Measure of Man: Human Factors in Design*. New York, Whitney Library of Design, 1960.

⁵⁰ Ibid.



Figure 4-2. Measuring the functional reach of a wheelchair user.⁵¹

Using the experimental apparatus in Figure 4-2 Floyd recorded postures and limb lengths and angles of schoolchildren, clerical workers, the elderly and disabled seated at chairs and tables of different heights and designs, and attempting to negotiate apertures or stairs. This provided the first comprehensive set of dynamic anthropometric data and was rapidly exploited. The study of children's anthropometry was used by the British Standards Institute to verify and revise previous standards for school furniture.⁵² Work on anthropometry and stair size was incorporated into architecture standards,⁵³ and the dimensions and reach distances of elderly women formed the basis of BS 4467, *Anthropometric and ergonomic recommendations for dimensions in designing for the elderly* which was published in 1969.⁵⁴ This unique anthropometry capability was used by civil agencies, such as the fire and police

⁵¹ Unattributed, Ergonomics in action—3. The Department of Ergonomics and Cybernetics, Loughborough University of Technology 1971. *Applied Ergonomics*, (1971), 2, 44 - 55.

⁵² W.F. Floyd and J. Ward, Anthropometric and Physiological Considerations in Schools, Office and Factory. *Ergonomics*, (1969), 12, 132 - 139. This provides a detailed description of the work undertaken for the Human Science Committee grant and the British Standards that the work informed.

⁵³ J. Ward and B. Beadling, Technical Study, Circulation 4. Optimum Dimensions for Domestic Stairways, *The Architects Journal*, (1970), 25th Feb.

⁵⁴ J. Ward and N. Kirk, Anthropometry of Elderly Women, *Ergonomics*, (1967), 10, 17 - 24.

services, for the design of protective clothing and exists today as an internationally renowned centre of excellence.⁵⁵

As discussed later in this chapter, one of the legacies from the work at WSL was Steve Griew's *Design of Work for the Disabled*.⁵⁶ This document was, possibly, the first attempt to demonstrate how ergonomics could be used to help the disabled to return to work. Floyd's study of dynamic anthropometry provided a method of establishing the space requirements, and dynamic reach envelope of a wheelchair user.⁵⁷ This latter study, funded by the Royal British Institute of Architects,⁵⁸ used the techniques and methodologies developed under DSIR funding.

The use of Floyd's data in British Standards was an important step in the institutionalisation of ergonomics. As Sumner and Gooday have pointed out, standards and standardisation confer uniformity and stability on technological systems⁵⁹ and, as Russell adds, are an important ingredient of innovation.⁶⁰ Much of the literature on standardisation has concentrated on technologies such as electrical systems and computers,⁶¹ the derivation and use of human science based standards have largely been ignored by scholars. Floyd's studies represent an early case of the development of human based standards for civilian use.⁶² Subsequently, ergonomists and ergonomic information have made significant contributions to standards in such diverse areas as design of agricultural equipment and control room ergonomics.⁶³ Stewart has provided a detailed practitioner's discussion on the contribution of UK ergonomists to the development of international standards for human computer

⁵⁵ For recent work see A. E. Masson, S. Hignett and D. E. Gyi, Anthropometric Study to Understand Body Size and Shape for Plus Size People at Work. *Procedia Manufacturing*, (2015), 3, 5647 - 5654.

⁵⁶ S.Griew, Design of Work for the Disabled, *Ergonomics in Industry*, No.3, London, HMSO, 1963.

⁵⁷ W. F. Floyd, L. Guttman, C. Wycliffe Noble, K. R. Parkes and J. Ward, A Study of the Space Requirements of Wheelchair Users, *Paraplegia*, (1966), 4, 24 – 37.

⁵⁸ For Floyd and the ergonomics department links to architecture see Chapter 6.

⁵⁹ J. Sumner and G. Gooday, Introduction: Does Standardisation Make Things Standard? *History of Technology*, (2008), 28, 1 - 13.

⁶⁰ A. L. Russell, "Industrial Legislation": Consensus Standardisation in the Second and Third Industrial Revolutions. *Enterprise and Society*, (2009), 10, 661 - 674.

⁶¹ Sumner and Gooday, (2008).

⁶² Military standards for clothing and workspace had been used since the end of World War 2 in both the UK and the US.

⁶³ Waterson and Sell, (2006), p. 780.

interfaces.⁶⁴ This also draws out the tensions that still existed between computer engineers and ergonomists over the need for human standards.

Floyd's development and use of anthropometry is also a demonstration of one of the characteristics of ergonomics: the modification of existing methodologies rather than the development of new techniques. Floyd had appropriated and modified anthropological techniques to address ergonomic problems. I have already drawn attention to Rodger's questioning if ergonomics had any distinctive methods.⁶⁵ The answer is that the distinctiveness he sought was the innovative thought to adapt methodologies from other disciplines to help answer objective questions. This is not the only example: as I discuss later, Singleton adapted systems engineering techniques to include the human element.

DSIR had had management responsibility for industrial human science research since 1950, but this association ended on March 31 1965, when the department was officially dissolved. As discussed in Section 1-3, closure had been recommended by the Cabinet Secretary, Sir Burke Trend, following his review of the civil service and governance of scientific research.⁶⁶ Trend had recommended that DSIR should be replaced by a Science Research Council, a National Institute for Research into Nuclear Science and an Industrial Research and Development Authority.⁶⁷ The latter body was not formed: in its place, Wilson's Labour administration established the Ministry of Technology (Min Tech).⁶⁸ This new ministry would take responsibility for the industrial research and development programmes, which included ergonomics, and activities managed by DSIR.

When DSIR closed, forty two funded human science research projects were still active.⁶⁹ Their management was transferred to either the Science Research Council (SRC) or the Social Science Research Council (SSRC). The foreword to the 1968 issue of *Research Supported by the SSRC* shows that 25 of the HSC projects had been transferred.⁷⁰ This document reveals that new ergonomics research was not being

⁶⁴ T. Stewart, Ergonomic User Interface Standards: Are They More Trouble Than They Are Worth? *Ergonomics*, (2000), 43, 1030 - 1044.

⁶⁵ Rodger, (1959).

⁶⁶ Vig, (1968) pp 50 - 52.

⁶⁷ *Report of the Committee of Enquiry into the Organisation of Civil Science*, Cmnd 2171, 1963-1964.

⁶⁸ Coopey, (1993).

⁶⁹ Investigations supported by the Human Sciences Committee, Issue no 9.

⁷⁰ *Research supported by the SSRC*, HMSO, 1968.

funded by the SSRC. Although a psychology committee had been established under Drever, its remit was to cover the social aspects of delinquency, developmental and occupational psychology – which was selection and training.⁷¹ Ergonomics would be managed by the SRC under the general heading of engineering psychology. Min Tech continued to support ergonomics through an ergonomics desk officer, Hilary Clay. Her role appears to have been administrative: there are no recorded ergonomics conferences arranged by Min Tech. When Min Tech was merged into the Department of Trade and Industry in 1970, government funding for industrial ergonomics was slowly ended.⁷²

In this section I have described how the HSC ergonomics research was dynamic and responsive. It was very low-value, was not tied to a specific technology and, by funding the development of researchers and academic departments, played a key role in the institutionalisation of ergonomics. It was also developed and delivered at a time when DSIR was undergoing internal changes in management. The programme was a powerful shaping influence on ergonomics, moving from quantifying the physiological and psychological impact of work to systems engineering, human reliability and human standards. This is best shown by the work of Crossman and others on the human aspects of computer interaction and Floyd's work on dynamic anthropometry, which had a significant influence on the derivation of human standards. Whilst this external research programme (i.e. delivered by academia) was being developed, DSIR was also attempting to establish its own human science research programme at WSL and this is the subject of the next section.

4. 5: Human Sciences at the Warren Spring Laboratory.

The proposal to construct WSL at Stevenage (Figure 4-3) was made in Jephcott's 1956 review of DSIR, which concluded that the Fuel Research Station at Greenwich should be closed and its work transferred to a new laboratory complex at Stevenage.⁷³ Mineral processing and chemical engineering research facilities were also included in

⁷¹ TNA EY 1/1. Working Party on the Division of Responsibility for Psychology among the Medical Research Council, Science Research Council and Social Science Research Council. HB 12/01. 21st January 1966.

⁷² Corlett and Stapleton, (2001), p. 1271. There are no official records in the Department of Trade and Industry archive to explain the reasons.

⁷³ TNA AY 24/30. Ministry of Technology. Warren Spring Laboratory. Its Origins, Terms of Reference, Achievements and Current Research Programme. March 1969.

the complex, which was officially opened in 1959. Industry were offered the use of the facilities on a repayment basis,⁷⁴ which was another change in DSIR business practices brought about by the 1956 *Scientific and Industrial Research Act*.

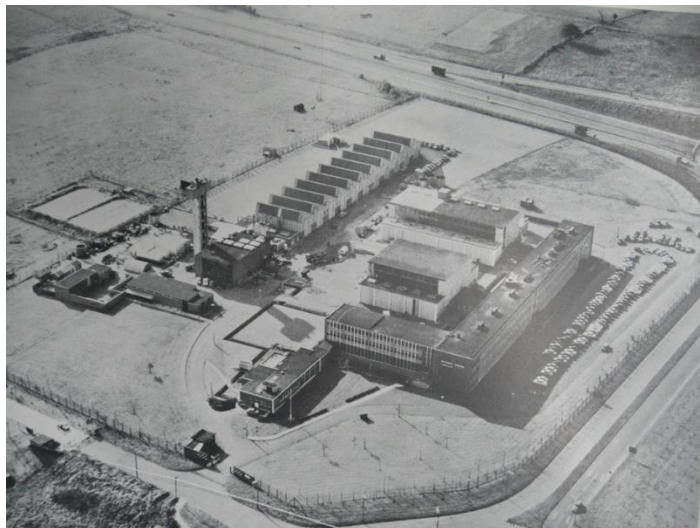


Figure 4-3. Warren Spring Laboratory in 1967.⁷⁵ The A1 runs to the North of the site.

The Human Science Group was in the main building on the right.

The Human Science Group, which comprised Stansfield, D. J. Gerhard, a psychologist, and Miss D. Butterworth, an experimental officer, moved to Stevenage in summer 1959.⁷⁶ Six vacant scientific posts were also transferred. The Group set about defining a research programme based on proposals gathered internally, from the HSC and the Ministry of Labour. The programme was ambitious beyond their physical capabilities, the tabled proposals are annotated by an unknown reviewer with “no explanation of derivation or priority” and “all this with six vacancies!”⁷⁷ It identified eleven research areas, which included ergonomics and liaison and information services,⁷⁸ and proposed a study of keyboard design and its impact on office automation, and a register of human sciences research and information with

⁷⁴ Ibid.

⁷⁵ Ibid.

⁷⁶ TNA DSIR 17/683. Ergonomics Sub-Committee. Introduction, Membership and Terms of Reference. HSC / E-2. 20th November 1958.

⁷⁷ TNA AY 28/7. Proposed programme of work for the laboratory WSSC/HSR (59), 8th September 1959.

⁷⁸ The other work areas were accident causation, work study, industrial sociology, study of management of scientific research, scientific manpower, human factors in offices, human factors in distributive trades, management problems and development of recovering equipment.

initial emphasis on human relations.⁷⁹ This was further revised to five research areas and thirty seven items suitable for study.⁸⁰ Three topics were identified as immediate work for the Human Sciences team – the keyboard study – and two others to be let as extra-mural contracts.⁸¹ The research plan was accepted but the inability to fill the vacancies meant that work was delayed. The team did commence development of a weekly *Index of Current Research in the Human Sciences* which addressed management science and was distributed to the RAs and industry. The purpose of the human science capability was soon modified by the RC's response to Fletcher's criticisms of DSIR at the Ergonomics in Industry Conference (Section 3.6).

Fletcher had been highly critical of what he saw as the trivial human science activities undertaken at WSL and the miserly sums of money expended by DSIR on ergonomics. Melville, who chaired the session where Fletcher made these criticisms, admitted that the DSIR contribution was small, but that money would be found if the need for more research was identified.⁸² The post-conference DSIR Research Council (DSIR RC) minutes noted Fletcher's criticisms and, rather than discuss the agenda item on extra-mural funding allocations to WSL, debated the role of the Human Science Group. The DSIR RC directed that more scientists should be recruited into the group, the research programme should be started as soon as possible and "that the projects undertaken by the staff of the WSL should be, in the main, of a type that requires the facilities of a laboratory."⁸³ The DSIR RC further directed that only ergonomics research should be undertaken as it was "specific, objective and required the use of a laboratory. It had a well-defined application to industry ... and since many small industries could not afford to employ an ergonomist this was a field suited to a Government laboratory."⁸⁴ S.H. Clarke, the Director of WSL, was instructed to

⁷⁹ TNA AY 28/7. Proposed programme of work for the laboratory WSSC/HSR (59), 8th September 1959.

⁸⁰ TNA AY 28/7. Proposed programme of work for the laboratory WSSC/HSR (59), 10th December 1959. The research areas were Studies relating to Individual Efficiency (which included ergonomics), Internal Problems of Industrial Undertaking, Industry and Commerce in Relation to the Community, General Problems of society and Development of Techniques.

⁸¹ TNA AY 28/8. Report of the Human Sciences Research Sub-Committee. WSSC 15 (1960) undated. The others were the study of the place, structure and function of the Work Study department in firms, placed with Imperial College, London. Study of the supply, place and status in industry of either apprentices or technicians, transition from school to work, placed with the Department of Social Anthropology and Sociology, Manchester.

⁸² Proceedings of the Ergonomics in Industry conference. September 1960, p 184.

⁸³ Ibid.

⁸⁴ Ibid.

seek Treasury permission to recruit at least a Senior Principal Scientific Officer (SPSO) to lead the unit.⁸⁵ These decisions were made without prior consultation with the HSC or WSL management.

The DSIR RC's decisions were poorly received by Clarke, who had spoken of the importance of the multi-disciplinary approach adopted by the Human Science Group at the Ergonomics in Industry meeting.⁸⁶ He complained to S.H. Knox, who, as head of Information Department, had responsibility for human science within DSIR, that this was a retrograde step as it would split ergonomics and human relations away from each other.⁸⁷ Knox told Clarke to comply with the DSIR RC's direction and apply for Treasury permission to recruit an SPSO.⁸⁸ He believed that Clarke was "advised by a Principal Scientific Officer who is a first class information officer, well versed in what other research workers are doing but unable to concentrate constructively on development of a part of a spectrum."⁸⁹ This was, of course, Stansfield.

Greenall, head of Grants Division, supported Clarke's position, believing that concentrating solely on ergonomics would not be in the best interests of UK industry. Greenall's stance was that that DSIR should continue to fund internal human relations studies as this would provide a coherent approach to understanding the worker in their working environment. The DSIR RC ignored Greenall's comments and re-affirmed that the WSL research programme should be directed at ergonomics.⁹⁰ They restated their aim of increasing staffing levels to develop a viable and productive unit, noting that J.G. Fox, a physiologist, and F. Gaebler, a sociologist had recently been recruited,⁹¹ which had filled 25% of the scientific vacancies. To bolster the unit £37,000 would be allocated for FY 1961 - 1965, for expenditure on extra-departmental contracts in the human sciences.

⁸⁵ The most junior grade in the Scientific Civil Service was Scientific Assistant (later Assistant Scientific Officer). Entry into this grade was usually direct from school with the entrant having at least 5 "O" levels. The grades then rose to Scientific Officer, usually initial entry for university trained scientists, to Higher, Senior and Principle Scientific Officer. An SPSO would typically be a leader of a group of teams and could be expected to take a senior role within a government department.

⁸⁶ S. H. Clarke, A Contribution. *Proceedings of the Conference on Ergonomics in Industry 27 – 29 September 1960*. London, HMSO, 1961, 173 - 176.

⁸⁷ TNA AY 28/6. Letter Clarke to Knox undated.

⁸⁸ TNA AY 28/6. Letter Lee to Clarke. Research in Human Sciences WS 1/3/1, 30th January 1961.

⁸⁹ *Ibid.*

⁹⁰ TNA AY 28/7. Decision of the Research Council of the Warren Spring Laboratory Human Sciences Programme. Unauthored and undated WSSC / HBR (61) 2.

⁹¹ For Fox's subsequent career see Chapter 6.

The DSIR RC had made a pragmatic decision supported by an erroneous assumption. DSIR research undertaken at the RAs was directed at the development of new industrial technologies and processes which would increase shop floor productivity and efficiency. Ergonomics addressed industrial workforce productivity and efficiency and would be more aligned to, and support, the DSIR technology research programme. Human relations research had a more tenuous link to the DSIR core programme, and the HSC sponsored human relations research in academia could be drawn upon as necessary. The erroneous assumption was that an SPSO and more scientific staff could be readily recruited. With the degree level course in ergonomics not due to commence until 1962 (see Chapter 6), new recruits for WSL would either come from academic departments, existing ergonomics units at, for example, Thorn EMI, BISRA and British Rail, or new graduates in physiology and psychology. WSL would need to offer a conducive working environment which would be the start, or extension, of the scientists' career. In the absence of an existing scientific reputation for excellence the group would need a highly qualified and respected SPSO to develop a research strategy and programme and attract new recruits. The inability to fill this vacancy was one of the causes of the demise of the WSL capability.

The DSIR RC also considered whether WSL should provide an industrial consultancy service.⁹² As this would require more staff, and there was an unquantifiable demand, the notion was rejected. Instead they directed that since ergonomic topics of greatest interest to industry could be readily listed, and that an expert in each category could be identified, WSL should issue a series of monographs aimed at engineers.⁹³ The twelve-volume *Ergonomics for Industry* was critical in making ergonomic concepts and ideas readily accessible to an industrial, trade union and academic audience, their impact is discussed below.

These decisions were badly received by the Human Sciences Research Sub-Committee, who saw them as a vote of no confidence.⁹⁴ They supported the idea of an ergonomics consultancy service but accused the DSIR RC of having a narrow interpretation of ergonomics, and of ignoring the fact that translation of ergonomics

⁹² TNA AY 28/7. Decision of the Research Council of the Warren Spring Laboratory Human Sciences Programme. Unattributed and undated WSSC / HBR (61) 2.

⁹³ Ibid.

⁹⁴ TNA AY 28/7. Notes of a Meeting of the Human Science Research Sub-Committee of the Warren Spring Laboratory Steering Committee at Charles House 2nd February 1961.

principles into an industrial setting needed a multi-disciplinary approach. Glass observed that “if WSL concentrated on ergonomics then ... not a single Government department would be looking at human sciences as a whole,” which echoed Greenall’s earlier observation.⁹⁵ Council’s paper was rejected with the request that it be amended to include Glass’s observations and concerns.⁹⁶ In addition, the “present Sub-Committee had been appointed on the basis of the members’ competence to offer advice in the field of human sciences generally; it did not consider itself competent to act as an “ergonomics” sub-committee.”⁹⁷ All future meetings were postponed sine die.

Underlying this dissent was a discontent amongst those managing the human science research programme. The HSC had proposed that a social scientist or psychologist should be promoted to the DSIR RC as the HSC was the only strategic committee without professional representation at that level. The proposal was rejected.⁹⁸ The HSC also presented the DSIR RC with a paper making the case for a Human Sciences Research Association,⁹⁹ which was well received, but not acted upon. To some, it seemed that the DSIR RC did not trust or value their work or judgement.

The Warren Spring Laboratory Steering Committee¹⁰⁰ endorsed the decision to concentrate on ergonomics and directed that the Human Sciences Research Sub-Committee should not be dissolved.¹⁰¹ Previous members were requested to remain in post, most accepting the offer, and an ergonomist, Weiner from the MRC, and two industrialists with an appreciation ergonomics, W.H. Larke, the General Manager of Stewarts and Lloyds, and S. Jackson, the Deputy Controller of Ordnance Factories, were recruited.

Establishing an ergonomics capability at WSL should have been an important step in the institutionalisation of a government-based ergonomics capability. Rentetzi has

⁹⁵ Ibid.

⁹⁶ TNA AY 28/7. Decision of the Research Council of the Warren Spring Laboratory Human Sciences Programme. Unattributed and undated WSSC / HBR (61) 2.

⁹⁷ Ibid.

⁹⁸ TNA DSIR 46/40. Minutes of the Meeting of Council held on 8th December 1960, unreferenced.

⁹⁹ TNA DSIR 17/691. Developing the Social and Human Sciences: Need for a Human Sciences Research Council 22nd May 1960, HSC - 133. The paper was to be the starting point for the discussions resulting in the formation of the Hayworth Committee (see later).

¹⁰⁰ Membership of this committee was Sir Harry Jephcott, S. H. Clarke, R. Holroyd, Sir Harry Melville and D. A. Oliver.

¹⁰¹ TNA AY 28/6. Human Sciences Research Sub-Committee WS 1/3/1, 26th October 1961.

drawn attention to the importance of the physical presence of a laboratory in providing legitimacy to a science.¹⁰² Such a physical presence should provide a rallying point for practitioners, help highlight areas of new research, provide a potential consultancy service and future employment opportunities. The WSL ergonomics capability could have been a positive signal to industry and the unions of DSIR's attitudes to the science, but it closed within seven years of formation. Clarke proposed establishing a "balanced and viable team ... composed of scientists and engineers, and ... the aim should be to work to a Group of about 34, including eight scientific staff with four of each discipline."¹⁰³ This would be achieved by 1964 when it was "hoped that there would be calls for repayment work."¹⁰⁴

The proposed work programme, which was not derived from existing research, is given in Table 4-5. It is unclear who derived this: it wasn't Stansfield, as he had been sent on sabbatical leave to the LSE in late 1960 and was now Reader in Industrial Sociology at the Northampton College of Advance Technology.¹⁰⁵ Why he resigned is unclear. His departure robbed DSIR of the sole member of staff who understood the origins and totality of the human science research programme. He was also an extremely well-connected civil servant who could have promoted collaborative and professional networks with other institutions.

Topic	Starting
Use and Co-ordination of Hands and Feet	1961/62
Examination of the Mechanisation of Industrial Skills, with a View to Determining the Best Aspects Left to the Human Operator.	1963/64
The Accuracy of Visual Perception of Changing Displays	1963/64
The Posture of the Operator with Relation to Accuracy of Control and Fatigue	1963/64
Advisory Work and Co-ordination of Extra Mural Activities in Studies Made on Behalf of Other Departments	1961/62

Table 4-5. Outline WSL Human Sciences Research Programme.¹⁰⁶

Clarke wasn't advised by Stansfield's successor either: no one had been appointed. The Treasury finally agreed to the appointment of a senior scientist post in June

¹⁰² Rentetzi, (2005).

¹⁰³ TNA AY 28/6. Warren Spring Laboratory Steering Committee, Human Sciences WSSC (46) 1961.

¹⁰⁴ Ibid. p.2.

¹⁰⁵ TNA AY 40/6. Detailed Research Programme 1963/64. WSSC 61, 18th July 1962.

¹⁰⁶ Ibid. pp. 3 - 4.

1962.¹⁰⁷ A civil service trawl identified six potential candidates to lead the team, but ultimately no one was appointed – not that this mattered, as the other vacancies remained unfilled.¹⁰⁸ Laboratory staffing levels rarely rose above eight and work did not arrive. The single noteworthy study was for the DSIR Committee for Research on Dental Materials and Equipment,¹⁰⁹ which redesigned the dentist's chair, drills and probes and developed a suitable workstation. There is some evidence that WSL was also referring requests for work received from industry to Loughborough University and, latterly, Aston.¹¹⁰ By late 1964 the ergonomics capability had only two employees, but an internal review agreed that research should continue.¹¹¹ In late 1966, J. Wardley-Smith, the Director of WSL recommended that the capability was too small to function effectively and should close. Funds would then be directed, presumably through the research councils, to sustain existing capabilities at Loughborough and Aston.¹¹² The WSL ergonomics unit formally closed in 1968.¹¹³ Clarke believed that the capability had failed because it could not attract a suitably qualified team leader with a strong scientific reputation. He reasoned that without such a figure, graduates would not perceive WSL as a place to start their career.¹¹⁴

Another reason for the subsequent failure of WSL was the inability to achieve a critical mass of researchers. Servos, in his study of 'research schools', points to the importance of communities of scientists who can exchange papers, potential research areas, attend conferences and meet formally or informally to discuss their science.¹¹⁵ The issue for the WSL capability was that being unable to recruit staff meant that they were unable to network effectively with the rest of the DSIR and other scientific

¹⁰⁷ TNA AY 40/6. Warren Spring Laboratory Steering Committee. Minutes of 8th Meeting, WSSC Minutes 8, 18th July 1962.

¹⁰⁸ Ibid.

¹⁰⁹ TNA AY 40/9. Warren Spring Laboratory Steering Committee. Design of Dental Equipment on Ergonomic Principles. WSSC 75 (1963) 6th December 1963.

¹¹⁰ TNA AY 28/191. Special Ad hoc Meeting of the Interdepartmental Committee on Human and Social Problems of Technological Progress. November 22nd 1966.

¹¹¹ TNA AY 40/11. Future of Research in Human sciences at Warren Spring Laboratory. WSSC 83, 8th December 1964.

¹¹² TNA AY 28/191. Ministry of Technology. Special ad hoc meeting of the inter-departmental committee of human and social problems of technological progress. 22nd November 1966 to discuss ergonomics research.

¹¹³ TNA AY 24/30. Ministry of Technology. Warren Spring Laboratory. Its Origins, Terms of Reference, Achievements and Current Research Programme. March 1969.

¹¹⁴ TNA AY 28/191. Ministry of Technology. Special ad hoc meeting of the inter-departmental committee of human and social problems of technological progress. 22nd November 1966 to discuss ergonomics research.

¹¹⁵ J. W. Servos, Research Schools and Their Histories, *Osiris*, (1993), 8, 2 - 15.

communities, there were too few staff and too many groups with which to interface and interact. In short, the ergonomics capability failed to reach a critical mass in numbers which would have permitted its survival.

The ergonomics capability at WSL was initially formed as a human science research capability, following the 1960 Ergonomics in Industry conference, in which DSIR support for ergonomics was heavily criticised by the TUC. Although it was initially conceived as a human science capability, the DSIR RC quickly decided that the capability should concentrate on ergonomics. Although this was met with some hostility, both internally and from the various DSIR research management committees, the decision to concentrate on ergonomics research was upheld. The problem was the capability was unable to attract staff or work which resulted in its subsequent closure. Had the capability succeeded it would have provided a government based civilian ergonomics research capability,¹¹⁶ which could have made a further contribution to the growth of ergonomics. It may have also provided a conduit for information exchange between industry and the academic ergonomic communities.

4.6: The Legacy of WSL.

Whilst the ergonomics capability at WSL did not develop as a research facility it did, however, produce two influential pieces of ergonomics literature. The bibliography of ergonomic research, *Ergonomic Abstracts* and the 12 volume *Ergonomics for Industry*. I will now describe these publications and their contribution to ergonomics.

Searchable abstract and index databases are commonplace entities. Web of Knowledge and Google Scholar are extensively used by academics, scientists and many other user groups.¹¹⁷ Like textbooks, abstracting systems can be viewed as codifying knowledge and making it readily available on a worldwide basis. J.G. Fox started *Ergonomics Abstracts* for WSL in 1963. They were issued quarterly in conjunction with Tufts University, which was funded by the US Office of Naval Research to undertake a human engineering abstracting service for the US military,

¹¹⁶ The government was funding military ergonomics capabilities.

¹¹⁷ See A. Öchsner, *Introduction to Scientific Publishing*, Heidelberg, New York, Dordrecht and London, Springer, 2013. Abstract and Index Databases (Web of Knowledge, Scopus, Google Scholar), pp. 31 - 46.

industry and academia.¹¹⁸ It is unclear how this collaboration was formed, or if *Ergonomics Abstracts* was started by Fox's initiative or as an extension of *Index of Current Research in the Human Sciences* (see above). *Ergonomic Abstracts* comprised individual report title, abstract and reference, organised into functional headings such as input channels, body measurements and interface design. Information was harvested from journals, conference proceedings and textbooks from around the world.¹¹⁹ *Ergonomic Abstracts* were freely available worldwide to industry, academia and trades unions, and were also published in *Ergonomics*. Fox moved to Birmingham in 1965, where, with E. Nigel Corlett, he established the Ergonomics Information Analysis Centre,¹²⁰ which continues to publish the abstracts through EBSCO, a US library services company. There are few, if any, citations regarding the importance of *Ergonomic Abstracts* to the development of ergonomics, but its longevity points to its utility and importance.

The other piece of major ergonomics literature were the 12 volume *Ergonomics for Industry* booklets. These were produced following the RC's direction that a series of monographs on ergonomic topics authored by experts in the field should be produced by WSL.¹²¹ Details on how the authors were identified and contacted, how a leading graphics designer, Ken Garland, became involved in designing the booklets, and who in WSL managed their development, remain elusive. *Ergonomics for Industry* was issued free, other DSIR publications cost three shillings and sixpence, and bulk orders were received from the TUC, individual industrial concerns, universities, technical colleges and trade associations.¹²² Distribution numbers were high: 10,000 copies of Broadbent's *Noise in Industry* were issued in its first year of publication.¹²³ Figures for others in the series are not known but Min Tech sanctioned reprinting "to bring the

¹¹⁸ Human Factors Engineering Bibliographic Series Volume 2, 1960 – 1964 Literature. *Human Factors Engineering Information Analysis Centre*. Tufts University, October 1966.

¹¹⁹ Abstracting Service, *Ergonomics*, (1965), 8, 111 - 132.

¹²⁰ J.G. Fox, Ergonomics and Information Systems, *Aslib Proceedings*, (1972), 24,178-186.

¹²¹ TNA AY 28/7. Decision of the Research Council of the Warren Spring Laboratory Human Sciences Programme. Unattributed and undated WSSC / HBR (61) 2.

¹²² TNA Lab 10/2222. Notes from Ergonomics in Industry Meeting 21st January 1965.

¹²³ Ibid.

stocks of each booklet up to 3000.”¹²⁴ The booklets also appeared in a slightly revised form in *Applied Ergonomics*¹²⁵ and Shackel’s textbook *Applied Ergonomics*.¹²⁶

The volume titles are given in Table 4-6. It will be noted that the books were mainly written by ergonomists who have featured throughout this thesis, the exceptions being Paul Branton and James Longmore. Branton was a psychologist employed by the Furniture Industry RA where he investigated the implementation of ergonomics into furniture design. In 1969, he was appointed as Head of Ergonomics at the British Railways Board.¹²⁷ Longmore worked at the Building Research Station and was a Fellow of the Illuminating Engineering Society.¹²⁸

Title	Author
1 The Industrial Use of Ergonomics.	W.T. Singleton.
2: Instruments and People.	Brian Shackel and David Whitfield.
3. Design of Work for the Disabled.	Steve Griew.
4: Inspection and Human Efficiency.	Ron Belbin.
5. Ergonomics versus Accidents.	Reg Sell.
6. Noise in Industry.	Don Broadbent.
7. Men, Machines and Controls.	Keith Provins.
8. Thermal Comfort in Industry.	Ron Fox.
9. Lighting of Workplaces.	James Longmore.
10. Seating in Industry.	Paul Branton.
11. Layout of Work Spaces.	John Chris Jones.
12. Current Trends Towards Systems Design.	W.T. Singleton.

Table 4-6. Ergonomics in Industry.

¹²⁴ TNA Lab 10/2222. Letter Clay to Larsen, 29th January 1965.

¹²⁵ The booklets were published in Volumes 1 and 2 of *Applied Ergonomics* in 1970 and 1971.

¹²⁶ B. Shackel. *Applied Ergonomics*. Guildford, International Publishing Company, 1974.

¹²⁷ Chartered Institute of Ergonomics and Human Factors, Paul Branton Award, (2017), <http://www.ergonomics.org.uk/awards/paul-branton-award/> accessed 16th April 2016.

¹²⁸ J. Longmore, Lighting of Workplaces, *Ergonomics for Industry No 9*. DSIR.

The booklets were less than 30 pages in length and had a cover (Figure 4-4) designed by Ken Garland Associates.¹²⁹ The design of the head and shoulders of a man surmounted by a linear and circular scale indicates that the series was about measuring humans but also set the series apart from other DSIR publications which had a uniform monochrome unillustrated cover. Except for Singleton's and Griew's studies, content was a review of the current state of knowledge from which guidelines were developed, either for the design of the working environment or advice on how to measure the physical elements of the workplace and interpret the results. There was also a list of recommended references.

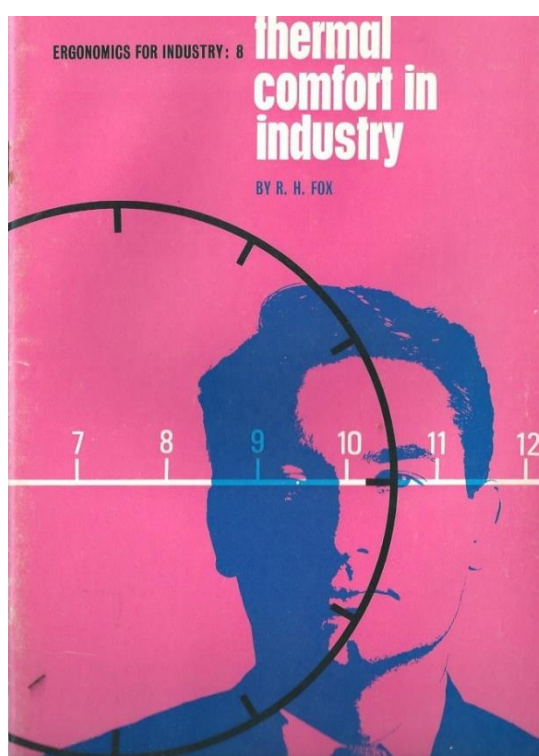


Figure 4-4. Generic covers for Ergonomics in Industry.

Garland used eye-catching and informative illustrations to deliver information in a comprehensible fashion to the readers. In *Instruments and People*, the activation of a switch is shown from both the perspective of the operator and that of a screen or dial (Figure 4-5). This reinforced the text, which noted that there was more to activating a switch than the physiological processes underlying the movement of a finger. There were issues of decision making, anticipation and outcome expectation. Another

¹²⁹ Unattributed, Ken Garland, (2014), <http://www.kengarland.co.uk> accessed 30 March 2015. Garland was responsible for some of the more striking graphic designs in the mid 1960 including the iconic Galt Toys posters.

example is the method of providing a comparative impression of the intensity of noise (Figure 4-6). Here intensity is related visually to everyday sounds ranging from a whisper to an operating hydraulic press. Accessibility of the scientific message was enhanced by the authors using plain text. Fox in *Thermal Comfort in Industry* states that “resting metabolic heat is produced at a rate equivalent to the power consumption of a 60 watt lightbulb.”¹³⁰ The physiological textbook definition would be that basal (resting) metabolic rate is 50 Watts per metre squared, but the former definition, by invoking an analogy would be more readily appreciated by an engineer or designer.



Figure 4-5. Operating a switch from the perspective of a dial.

¹³⁰ R.H. Fox, *Thermal Comfort in Industry, Ergonomics for Industry No.8*, DSIR, HMSO, 1965.

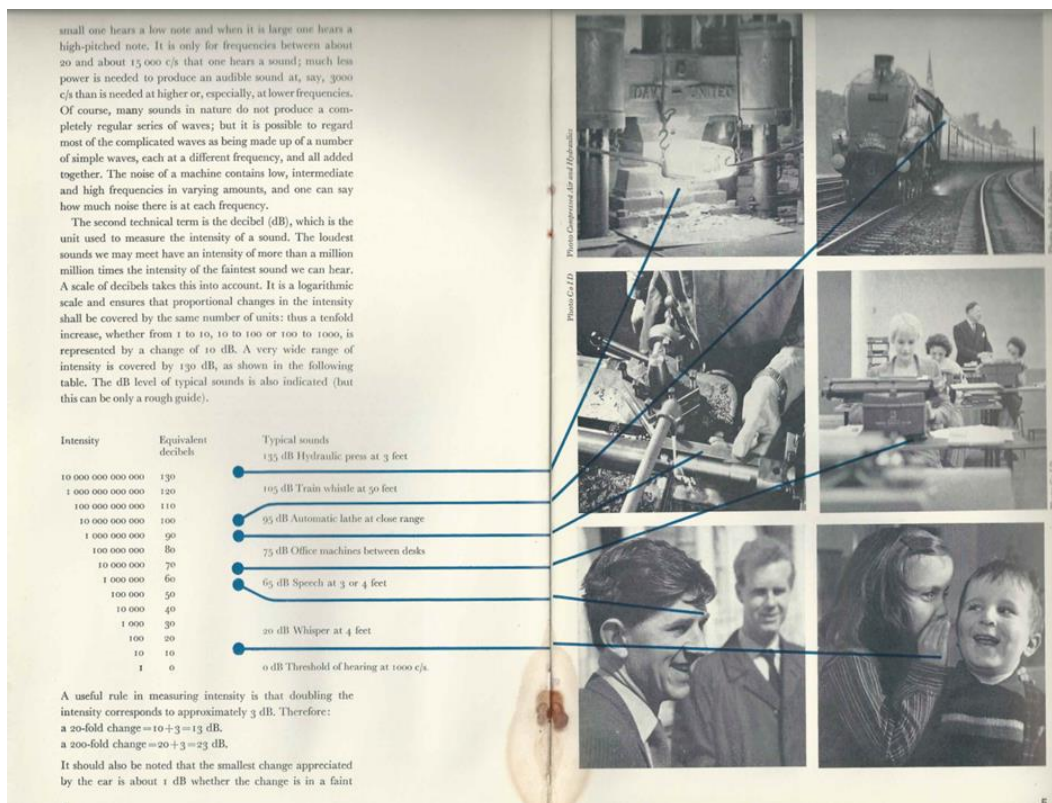


Figure 4-6. Relating noise intensity to everyday sounds.

Griew's and Singleton's booklets differed from other volumes in that they addressed emerging ergonomics issues and indicated new areas of research. Griew, who worked with Murrell at Bristol, had previously been employed in the Ministry of Labour Industrial Rehabilitation Unit. The Ministry of Labour's *Services for the Disabled*, published in 1961, explained the provisions made for rehabilitation but contained little guidance on employers' responsibilities, or how to accommodate a disabled worker at the workplace.¹³¹ *Design of Work for the Disabled*¹³² was produced to help amplify the Ministry of Labour's paper, provide guidance and demonstrate to employers that disabled people did not necessarily have restricted productivity and could be gainfully employed in tasks which provided them with job satisfaction.

Griew proposed that the best means to allow the disabled worker the opportunity to enter meaningful employment would be by 'fitting the job to the disabled worker,' a clever play on words as 'fitting the job to the worker' had gained currency within

¹³¹ *Services for the Disabled: An Account of the Services Provided for the Disabled by Government Departments, Local Authorities and Voluntary organisations in the United Kingdom. Standing Committee on the Rehabilitation and Resettlement of Disabled Persons. 2nd Edition. London, HMSO 1961.*

¹³² S.Griew, (1963).

industry. He proposed that with over 660,000 registered disabled persons in the UK in 1962, appropriate and inexpensive application of ergonomics could bring some back into employment, so increasing the effectiveness of the labour force. The introduction of raised conveyor belts, for example would prevent bending and stooping and so increase the scope of a task for disabled workers, but could also reduce the prevalence of back injury in the rest of the workforce. He also gave an examples where industrial concerns had made simple and inexpensive ergonomic modifications to machinery, so allowing disabled workers to remain in productive employment.

Up to this point disability research had been directed towards rehabilitation rather than accommodation at the workplace. Griew proposed ergonomics as a tool that could assist return to work, and help maintain productivity and dignity of the disabled: a powerful political message. As discussed in Chapter 3, Floyd's anthropometric study of the disabled provided data which aided the accommodation of wheelchair users at the workplace. This remains a significant area of research for ergonomics.¹³³

Singleton's *The Industrial Use of Ergonomics*¹³⁴ discussed the employment of ergonomists and was published shortly after Loughborough and Birmingham universities had started offering degree courses in ergonomics (see Chapter 6). The CIP (HF), IEC and HSC had been tasked with increasing the number of trained human scientists, including ergonomists, who could help industry apply human science research. University Grants Committee funding restrictions had prevented this objective being met until the CATs were established in the late 1950s. Now, with the arrival of ergonomists on the job market, guidance was needed on their employment.

Following some background information on the development and the application of ergonomics Singleton set about recommending where, organisationally, an ergonomist should be placed to provide maximum benefit to the business enterprise. He rejected placing ergonomists in medical or personnel departments, as in both cases there would be insufficient appreciation of the contribution of ergonomics. His

¹³³ See, for example, R. E. Sims, R. Marshall, S. J. Summerskill, D. E. Gyi and K. Case, Supporting Older and Disabled People's Needs in Product, Environment and Service Design, *International Journal of Business, Humanities and Technology*, (2012), 2, 212 - 220. See also, B. Branowski, L. Pacholski, M. Rychlik, M. Zablocki and P. Pohl, Studies on a New Concept of 3D Data Integration about Reaches and Forces of a Disabled Person on a Wheelchair (CAD Methods in Car and Market Ergonomics), *Human Factors and Ergonomics in Manufacturing and Service Industries*, (2013), 23, 255 - 266.

¹³⁴ W.T. Singleton, *The Industrial Use of Ergonomics. Ergonomics for Industry: No. 1* London, HMSO, 1962

preferred option would be placing them in a design and production engineering department, a work study department or an operational research department, which was where Sell had been employed in 1954 (see Section 2.8). His reasoning was that in these departments there would be more common areas of interest and a more fruitful exchange of ideas and concepts. An important pre-requisite was that the department head, or other senior person should understand the contribution an ergonomist and ergonomics could make to an enterprise. In many respects Singleton had provided a cogent answer to Bogod's question discussed in Chapter 3 – "what is an ergonomist?" and "where would he fit in the organisation?" It is difficult to determine if Singleton's advice on placement was heeded, as single ergonomists employed in industry, and who appear in the ERS membership lists, rarely gave an address which includes their department.

Singleton's *Current Trends Towards Systems Design* set out to "summarise the systems philosophy developed and taught ... by the author", noting that "systems design (is) a very new technique, which is not well understood even by many specialists in the field of ergonomics."¹³⁵ Singleton's aim was to persuade designers and engineers to "escape from the dominance of hardware technology and to design, not machines, but systems which include hardware and human operators."¹³⁶

Systems design was developed by the Bell Telephone Company in the 1940s as a methodology for designing and managing telephone networks by specifying the architecture, components, interfaces and data requirements of a system.¹³⁷ The technique did not, however, provide a way of representing and understanding human performance in a complex human machine system. From the late 1940s onwards, US researchers investigated ways of situating human factors within a systems design construct to rectify this shortfall.¹³⁸ The key US worker in the field was Robert Gagne who attempted, with a degree of success, to define how human attributes such

¹³⁵ W.T. Singleton, *Current Trends Towards Systems Design*, *Ergonomics for Industry: No. 12*, DSIR, HMSO, 1966.

¹³⁶ *Ibid.*

¹³⁷ K. J. Schlager, *Systems Engineering – Key to Modern Development*. IRE Transactions on Engineering Management, (1956), 3, 64 - 66.

¹³⁸ W.T. Singleton, A Review of "Psychological Principles of Systems Development". *Ergonomics*, (1964), 7, 345 - 350.

as limitations in performance, team selection and training could be situated within a systems design framework.¹³⁹

Singleton developed his philosophy of the human in systems design during his visit to the US as a member of the team led by Murrell to gather information for EPA 335 – “*Fitting the Job to the Worker.*” This allowed him to meet leading workers in the field and observe, at first hand the close working relationship between psychologists and engineers.¹⁴⁰ He matured his concepts whilst at Cranfield University, teaching ergonomics and systems design to engineering students, and continued this work at Aston.¹⁴¹ Singleton’s book was intended to show how he had extended Gagne’s work and how it could be applied in British industry.

He started by describing the individual aspects of the systems design process, explaining, for example, how to set objectives for a new system. He then explained how to allocate functions either to a machine or a human using the Fitts list,¹⁴² a process familiar to engineers and designers. He then continued to step through the different steps in the process as shown in Figure 4.7. The integration of ergonomic activities and products is represented within the hatched area. It will be noted that Singleton uses ‘human factors’¹⁴³ rather than ergonomics in the title to the figure, but indicates elsewhere in the text that he is using the terms interchangeably. Singleton then introduced the need for the development of personnel to be part of a systems design team, mapping the territory where an ergonomist should have primacy within an industrial engineering and / or design framework.

¹³⁹ R. M. Gagne (ed), *Psychological Principles in Systems Development*. New York: Holt, Rinehart and Winston, 1962.

¹⁴⁰ Edwards, (1995).

¹⁴¹ Ibid.

¹⁴² Fitts, (1947). The Fitts List is a method of codifying the relative advantages of the human and machine in categories such as speed, consistency and reasoning. The engineer or designer, based on his interpretation of the list could then allocate tasks to the operator or machine.

¹⁴³ See Introduction.

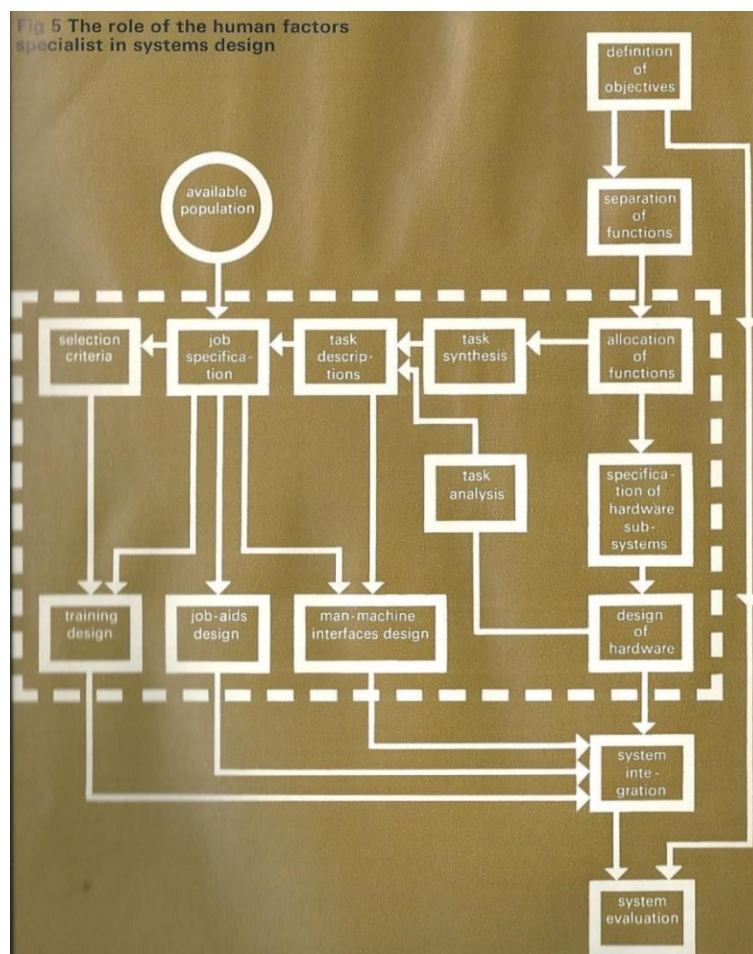


Figure 4-7. The Role of the Human Factors Specialist in Systems Design.

Current Trends Towards Systems Design marks a significant point in the development of ergonomics in the UK. Singleton championed the systems approach as it allowed the industrial ergonomist to “survive in this chaotic competitive situation”¹⁴⁴ alongside work study practitioners, designers and engineers. The porosity of the boundary between human factors (ergonomics) and engineering activities, with the feedback and feed-forward information flow loops represents the need for a continual dialogue between engineers and ergonomists. In addition to being a block diagram for the mechanics of system engineering it is a visualisation of how ergonomists and engineers could work together.

Ergonomics in Industry was an integrated series of books on the implementation and philosophy of ergonomics aimed primarily at an industrial audience. It covered

¹⁴⁴ W.T Singleton. Preface, in W.T. Singleton, R. S. Easterby and D. C. Whitfield (eds). *Proceedings of the Conference on The Human Operator in Complex Systems*, London, Taylor and Francis, 1967. Singleton was appointed as Head of Psychology at Aston in 1964.

conventional themes in ergonomics and provided a glimpse of the future directions for the discipline. As with *Ergonomic Abstracts*, there is no hard information to show if these volumes were influential in enhancing the use, or understanding, of ergonomics, the only metric being the number of booklets issued. It has been shown that the books of Griew and Singleton's *Current Trends Towards Systems Design* did act as catalysts for future research and opened new areas for ergonomics to make a significant contribution. What cannot be denied is that collectively they brought together and codified ergonomics knowledge into a single series, and in a way that was visually exciting and using language which was comprehensible to the non-ergonomist. It is also the case that they acted as a lasting showcase for DSIR human science research.

4.7: Conclusions.

The first part of this thesis has chronicled the genesis, rise and fall in government support for industrial human sciences as viewed through the prism of ergonomics. The aim has been to show how a low-value, non-medical human science research programme was developed and managed, and how this in turn institutionalised the science of ergonomics. I have shown how government interest arose from the notion of using human science research to increase individual and group productivity across industry, in order to ameliorate the 1947 balance of payments deficit. This notion of human science research aiding productivity persisted despite changes in the Labour and Conservative parties' political concept of productivity, from curing economic ills to fuelling the consumerism boom. Over time, however, the nature and content of the human science research programme evolved in line with changes in the meaning of work. This is seen by comparing Tables 2-5, 2-7 and 4-4, which list the research programmes of CIP (HF), IEC and the HSC respectively. Research direction moved from the problem of productivity and the ageing worker (Table 2-5), through the redesign of individual and collective workplaces (Table 2-7), to the cognitive issues of human-computer interaction and computer simulation for training (Table 4-4). This transition reflected the changing nature of work; the shift from heavy manual to light work and the introduction of new technology at the work place, such as automation and mechanisation. This comparison also reveals the growing base of academic institutes which, by the middle 1960s, were capable of undertaking ergonomics research, the study of the worker in his working environment. Most of these studies were undertaken in academic institutions which did not have an ergonomics

department, e.g. Hull, or which would form a capability during the 1970s, e.g. UCL. These observations lead to two conclusions. The research programme played a role in institutionalising ergonomics, by nurturing the science within extant departments, and by providing an impetus to the subsequent formation of a sub-capability, a small number of researchers undertaking ergonomics studies within, for example, a psychology department. Secondly, ergonomics was a geographically distributed science. It was practised across multiple academic institutions, but without any apparent inter-site research co-ordination. Institutions were undertaking research that contributed to the overall ergonomics knowledge, but they were shaping the science to their own research imperatives. This theme is developed further in Chapter 6.

I have introduced in these chapters the cast of actors and institutions who influenced the development of ergonomics. Schuster, although an adherent to human relations studies developed a logical and enduring framework which permitted human relations and human engineering to be accommodated in the overarching term human science, but which allowed a differentiation between the two sciences. Bartlett and the MRC established specialist laboratories which provided venues in which human engineering and ergonomics research could be undertaken. Workers at these laboratories also generated basic physiological and psychological knowledge which would be used to address workplace problems. Although both Schuster and Bartlett contributed to the development of ergonomics, their personal relationship was tempestuous. I have argued that the root cause of these tensions was Bartlett's unsuccessful attempt to advance industrial psychology over human relations studies as the principal, perhaps even sole, scientific method for studying man in his working environment. The effect of Bartlett's activities was to define the space which ergonomics could fill.

Stansfield, from DSIR, and Fletcher, from the TUCPD, played significant roles in the strategic management and direction of the human science research programme. Stansfield provided secretarial and strategic support to both the MRC / DSIR and DSIR research committees, although I have suggested that his inability to help the HSC develop a strategic vision hampered the development of a balanced human science research programme. This negative observation needs to be counterbalanced with his role with the EPA, where he played a significant part in raising both the national and international profile of ergonomics.

Fletcher was a firm believer in the importance of human science as a lever which could be used in negotiations between employers and employees. He sat on most of the government human science research committees and was also Deputy Chair of the EPA. He was highly critical of DSIR's management and funding of human science research, and it was his comments at the 1960 conference which resulted in the RC making a series of hasty decisions regarding the management and direction of human science research in DSIR. So, for ergonomics, this cast of actors, outside the ERS, each made important contributions to the shape and direction of the science.

Institutionally DSIR played a key role in the growth of ergonomics through its management of the research programme. The executive decision to move the Headquarters Human Science capability to WSL was expected to result in an ergonomics research capability accessible to RAs and industry. Although the capability did not fulfil expectations it was responsible for the production of two key pieces of ergonomic literature. *Ergonomic Abstracts* and the twelve-volume *Ergonomics for Industry* served to codify and share ergonomics knowledge amongst human scientists, engineers, designers and trade unionists. In addition, much of the information appearing in these publications was drawn from DSIR sponsored research, indicating the quality, applicability, of the work supported by the department.

A notable feature of the narrative in these chapters is that institutionally the ERS played a secondary role in developing and shaping of ergonomics. Ergonomists, such as Murrell, Singleton and Floyd, who feature in this narrative as shaping the science, were acting as individuals with clear agendas. This will be further amplified in Part 2 of this thesis. The ERS, however, appears to have been a passive body without a clear or distinctive agenda. This could be attributed to factors such as a lack of communication or limited resources. Whatever the root cause, the well-publicised schisms that existed between physiologists and psychologists would have served to exacerbate the situation. As I show in Part 2 of this thesis, the ERS would start to take a slightly more pro-active stance in outside engagement.

Finally, there is an emerging 'working worlds' framework which encompasses ergonomics. The evidence from Part 1 of this thesis would indicate that ergonomics

did not emerge from an industrial ‘working world’, as evoked by Agar,¹⁴⁵ but came from problems arising in a productivity ‘working world.’ There were exceptions in the “industrial” working world where a local form of ergonomics did emerge. Thorn EMI established an ergonomics capability to ensure that their products, particularly early computers and consumer items, were “user friendly”¹⁴⁶: ergonomics again shaped by local factors. Here the capability was being used to enhance both engineering and design. This is, of course, a further piece of evidence for proposing that ergonomics was a “distributed science.” This theme will be pursued in the next part of this thesis.

These chapters have shown for the first time how this low value non-medical human science research programme, which developed from a set of studies undertaken by the CRP, into a dynamic programme which contributed to the growth and institutionalisation of ergonomics. In the second part of this thesis I will start by discussing how the TUC interacted with the ERS and sought to influence government policy on ergonomics. In the final chapter I will examine the development of ergonomics academic departments in two UK universities. This will also include a review of both academic degree awarding and non-degree awarding courses delivered through these universities, and via an employers’ association, before drawing the thesis to a conclusion.

¹⁴⁵ Agar, (2012), pp.180-183.

¹⁴⁶ Unattributed, The Psychological Research Laboratory 1954 to 1965. Now named EMI Ergonomics Laboratory. EMI Electronics CP.5518.

Part 2: Chapter 5: We Should Have a Say in the Research - The TUC and Ergonomics.

5.1: Introduction.

Part 1 of this thesis has shown how ergonomics was developed and shaped by the government funded human science research programme. It has also identified the key actors and institutions who contributed to the genesis and growth of the science. My aim in Part 2 is to show how ergonomics was further shaped through support to the TUC and other government departments political goals. I will also discuss the development of academic departments which delivered formal degree and non-degree-awarding courses in ergonomics. I will additionally consider the case where non-degree-awarding ergonomics education was delivered through an employers' association. In the previous chapter I have shown how the TUC was becoming increasingly critical of the efforts made by DSIR to promote ergonomics within the UK. Their basic criticisms were that too little was being spent on research and insufficient effort made to increase ergonomics training in academia. Such criticisms resulted in DSIR eventually forming the ergonomics capability at WSL.

The TUC had always regarded workers' health and safety as one of its highest priorities and had actively supported the IHRB studies.¹ During the post-war years they expanded its interest in human and management science. Whilst management science, which included work study, was enthusiastically embraced by government, the TUC was concerned with the possible negative impact that the implementation of work study information could have on work conditions, industrial relations and pay bargaining. It was against this background that the TUC's interest in ergonomics as a science which could potentially benefit union members emerged.

Here I will examine some of the activities that the TUC undertook to interact with, and promote, ergonomics and ergonomists. I will explain the nature of the TUC's interest in the science and how it interacted with the ERS to develop a series of seminars to educate middle ranking union officials and shop stewards. Woven into the narrative will be two instances where the TUC sought to influence central government departments, other than DSIR, to give greater prominence to ergonomics. These vignettes, in addition to demonstrating TUC attitudes and aspirations for ergonomics,

¹ A. J. McIvor, (1987).

will provide an insight into how government departments viewed ergonomics. Towards the end of the 1960s, the TUC gave lesser prominence to ergonomics compared to human relations research, and I will discuss the reasons for this shift in emphasis. In summary, this chapter will show, through the prism of ergonomics, how the TUC addressed and considered science and technology.

5.2: The TUC Conference Series - 1959 to 1965.

The TUC Scientific Advisory Committee's (TUCSAC) interest in ergonomics stemmed from Schuster's 1950 presentation on the work of CIP (HF). Impressed, they concluded that the TUC needed more information on human factors, and that their members would benefit from such knowledge.² Further, any future research should not simply address increasing productivity through individual efficiency, but should also include the human cost of the introduction of new technology or working practices imposed through the implementation of work study. Although the TUCSAC instructed union members to propose topics to help shape research, proposals were not forthcoming.

Senior TUC officials, such as Jack Tanner and Lewis Wright, sat on CIP (HF) and the IEC, but made few positive contributions to defining research programmes. This attitude changed during the late 1950s with an unattributed TUC Production Department (TUCPD) paper stated that "current and future human research was likely to have an important bearing on work conditions and industrial relations"³ and that the TUC should take an active role in setting the research agenda. It continued that "poorly designed machines and workplaces [result in], waste of resources and loss of output [i.e. productivity] and not least their impact on wage rates and earning opportunities."⁴ In debating the paper the TUCSAC directed that, for the first time, a session on human sciences should be included in their forthcoming conference on *Trade Unions and Industrial Research*.⁵ Vincent Tewson, the TUC General Secretary, wrote to Murrell inviting him, as a researcher, and not as an ERS member, to present

² TUC Annual Report, 1951, pp. 262 - 263.

<http://www.unionhistory.info/britainatwork/emuweb/objects/nofdigi/tuc/imagedisplay.php?irn=6012698&refable=ecatalogue&refirn=6012583> . Membership included Jack Tanner, P.M.S. Blackett, J.H.C. Tippett, statistician and, later, Assistant Director of the Shirley Institute and Sir Robert Watson-Watt.

³ BUSCA 26/4821. Trades Union Congress. Human Factors in Workplace and Machine Design. Prod Cttee 4/3 1st May 1958.

⁴ Ibid.

⁵ Ibid.

on ergonomics.⁶ Murrell had come to the attention of the TUC through his work with the EPA and his studies into the employment of aged worker where he had sought TUC assistance in gaining access to shop floor workers.

The meeting attracted 73 senior TUC officers from 35 unions. Papers were given on industrial research by Jacob Bronowski, then Director of the National Coal Board Coal Research Establishment, and by representatives from the steel and building industries. Murrell's presentation, 'Man and his Work', defined ergonomics as the inter-disciplinary study of man in his working environment.⁷ He then described his studies on the employment of the older worker. These had shown that labourers were on average 10 years older than skilled workers and, as they aged, workers were moved from skilled to menial duties, with reduced earnings and the hidden loss of experience at the workplace. Murrell argued for a better understanding of the design of the job and the nature of the task, leading to improved design of machinery so making it easier for the older worker to use.⁸ He concluded by assuring the audience that "there is no concrete evidence to show that the application of time and motion study causes workers to become prematurely aged, but that the increased tempo resulting from time and motion study creates problems for older workers."⁹

Murrell had provided a comprehensible definition of ergonomics, which was in stark contrast to Weiner's attempts a year later at the Ergonomics in Industry conference (Chapter 3). He also addressed the TUC's concerns regarding employment of the older worker and the use of work study.¹⁰ The criticism of work study was that the time allowance for human fatigue took no account of mental or physical capability, age or of increasing fatigue over a working day, the underlying science was vague.¹¹ Murrell offered the possibility that ergonomics could be married with work study to provide a rational basis for job redesign, making the technique more acceptable to the TUC and its membership.

⁶ BUSCA DM 26/4821. Letter Tewson to Murrell 23rd April 1958. The TUC regularly held one day seminars on Industrial Research.

⁷ BUSCA 26/4821. Trades Union Congress. Production Memorandum 20. Undated.

⁸ Ibid

⁹ Ibid.

¹⁰ See D. Hall, *Working Lives*. London, Transworld, 2014. This contains oral transcripts from workers in industries such as cotton, coal mining, ship building and iron and steel and gives their views and experiences of the application of work study in the work place from the mid-1950s to the early 1970s.

¹¹ W. Baldamus, *Efficiency and Effort: An Analysis of Industrial Administration*, London, Tavistock, (1961), 45 - 46.

Murrell was invited to attend the TUCSAC meeting in May 1959 to discuss future ergonomics research, following which he was invited to join the committee.¹² This represented the first occasion in which an ergonomist held an executive position in a major political institution. He could now advise the TUC directly on ergonomics and produce information papers as required. There is no evidence suggesting that Murrell had a direct influence, but it was at this point that Fletcher, as secretary of the TUCPD, became more vocal in pressuring DSIR to support and nurture ergonomics. Further TUC internal ergonomics conferences were held without ERS involvement. A ‘One Day Conference in Ergonomics’ was held at TUC Headquarters in 1963.¹³ Murrell provided an overview of ergonomics before Shackel, from Thorn EMI, spoke on ergonomic experimentation. Singleton contributed to the debate on work study and ergonomics by pointing out the distinctions between the methodologies.¹⁴ He explained that work study practitioners were interested in the actions of the workers in task performance. They used comparative methodologies which evaluated the effects of an intervention, which although relatively cheap to apply, produced results which did not bear scrutiny. In short, work study was mechanistic and subjective. Ergonomics was based on measurement and establishing limits of human performance and, so, was objective.¹⁵ I have previously discussed how ergonomists had been unable to effectively explain the concept of ergonomics and its relationship to work study, here Singleton had succinctly made that distinction.

The 1965 TUC conference, ‘The Worker and his Job’, was held at Cranfield. As before, expert ergonomists reviewed work in their field. Welford, for example, spoke on ergonomics and automation whilst Sell described the work of the ergonomics unit at BISRA. There were also papers from the Chief Inspector of Factories on safety and ergonomics and Dr S.A. Roach, from the London School of Hygiene and Tropical Medicine, on environmental effects on human performance.¹⁶ The presentation of ergonomics alongside safety and environmental health aspects of the factory, would effectively demonstrate to the audience that ergonomics was not an isolated science: it

¹² BUSCA 26/4821. Letter Fletcher to Murrell 11th November 1958.

¹³ MRC.MSS.292B/571.89/4. Letter Fletcher to Murrell. PF/IM/207. 13th November 1962.

¹⁴ MRC.MSS.292B/571.89/4. Trades Union Congress. TUC Production Department. TUC Conference papers No. 3 Ergonomics. March 1963.

¹⁵ *Ibid.*

¹⁶ MRC.MSS.292B/571.89/5. Proposed conference agenda on “The Worker and His Job - Ergonomics”. Undated.

needed to be seen as part of an arsenal of sciences which could be deployed to ameliorate stress and error at the workplace. The TUCPD considered the conference had been a success and that it had stimulated a greater interest in ergonomics amongst affiliated unions. The meeting report concluded that a further conference could be held within a year.¹⁷

The conferences proved popular with the target audience, between 30 and 40 union officials attended the 1963 and 1965 events. Meeting duration increased from a single presentation to a dedicated two-day conference, with the content changing from a general paper to a structured agenda which situated ergonomics with other workplace sciences. These were also the only regular ergonomics meeting series that were directed at a single audience group, middle to senior ranking union officials. This provided an environment in which ergonomists and union officials could meet and exchange ideas and knowledge and afforded the TUC the opportunity to shape the ergonomics agenda to suit their needs. It is unclear how much influence this had on ergonomics practitioners, as few, if any, who took part in these or subsequent conferences have written of their experiences. The conferences did, however, spur the TUC General Council to lobby government departments to give greater importance to ergonomics, as discussed in the next section.

5.3: Government Lobbying by the TUC – More Ergonomics Courses?

In spring 1962 the TUCSAC tasked Dr. R. Murray, their Medical Advisor, to produce a paper identifying ergonomic developments as they affected the worker.¹⁸ He provided a simple overview of the state of ergonomics research and training and proposed that the TUCSAC should consider if there should be an increase in ergonomics training for industry and how industrial research knowledge could be exploited.¹⁹ Murrell also wrote a practitioner's perspective paper, the *Future Development of Ergonomics*.²⁰ This proposed that the development of ergonomics needed senior figures in industry and government to show a more positive attitude towards the science and that ergonomics training was required for Trades Union members to help them understand, interpret and implement information.²¹ He

¹⁷ MRC.MSS.292B/571.89/5. Extract from Minutes of Scientific Advisory Committee. 6th May 1965.

¹⁸ MRC.MSS.292B/571.87/4. Ergonomics in Industry. Sc Adv Ctee 2/3 5th April 1962.

¹⁹ MRC.MSS.292B/571.87/4. Ergonomics in Industry. Sc Adv Ctee 2/3 Appendix 5th April 1962.

²⁰ MRC.MSS.292B/571.87/4. Extract from Minutes of Science Advisory Council. Undated.

²¹ MRC.MSS.292B/571.87/4. Memorandum on the Development of Ergonomics. 1962.

identified a critical pre-requisite activity to underpin these proposals. Drawing attention to the low level of UK industrial ergonomics research, compared to other nations, he called for the founding of a UK research centre. This would research industrial ergonomic issues in close relations with both employers and employees' associations. He supported this notion by arguing that "It is of little use trying to sell ergonomics to workers or management until there is something really worth selling."²² He also suggested that the government should follow the lead of the US military by writing into their contracts that equipment "must be designed in accordance with good human factors principles"²³ and that there was a need for industrial ergonomics standards.

Murrell's call for an industrial ergonomics unit was an attempt to elicit support from the TUC for the establishment of a sub-Department of Ergonomics at the University of Bristol, which he would direct.²⁴ The TUCSAC chose to ignore his suggestion. Murray and Murrell's other recommendations were now consolidated and submitted to the TUC General Secretary, George Woodcock.²⁵ It was recommended that Woodcock should write to Viscount Hogg, the Secretary of State for Education and Science, suggesting that his department contact others responsible for running educational courses for managers, designers and work study practitioners, drawing attention to the need to increase the number of ergonomics lectures in the curricula.²⁶

Whether this was a reasonable, or indeed valid request to make is highly debatable. The BPC had already commenced courses in ergonomics, Loughborough University was running short courses in ergonomics and both Birmingham and Cranfield Universities were running work study courses which had strong ergonomics elements, (see Chapter 6). The numbers passing through these courses were however, typically ten to fifteen per course, which was less than the available places,²⁷ highlighting that the real issue was not availability of courses but the low numbers of industrial

²² Ibid.

²³ Ibid.

²⁴ BUSCA DM 26/4830. Proposal for the establishment of a sub-Department of Ergonomics (Human Factors in Industry) within the University of Bristol. 12th September 1961.

²⁵ MRC.MSS.292b.571.89/4. Ergonomics. Sc.Adv.Ctee 1/4. 10th January 1963.

²⁶ Ibid.

²⁷ Wade (1960).

attendees. This, in turn, may have been more a reflection of the number of suitable candidates for the existing courses.

Woodcock wrote to Hogg requesting that his department encourage the inclusion of ergonomics in training courses.²⁸ Hogg was broadly in favour, but there was a delay in actioning the request as departments tried to understand who should take the lead in implementing the request. The Department of Education and Science (DES), the Board of Trade, the Ministry of Labour and the Treasury all had an interest in ergonomics, but it was not central to their business and none had any suitable policy committees which could take ownership of the issue.²⁹ Eventually it fell to the Ministry of Labour who directed that the National Joint Advisory Council (NJAC) should action the request. Membership of the NJAC comprised the government, the TUC and the employers' associations, and was chaired by the Minister of Labour, Ray Gunter. Members included Sir Harry Douglass from the TUC General Council, Lord McCorquodale of Newton, director of the Bank of Scotland and Sir George Pollock, Chair of the British Employers Council (BEC). The NJAC advised the Minister of Labour on pay and working conditions and received regular briefings on the work of the DSIR human science panels.³⁰

The NJAC requested a paper on education in ergonomics, which should take account of the DES comments that “provision of education in ergonomics is at present outstripping the interest of, and the supply of students from industry.”³¹ The paper concluded that industry did not pay enough attention to ergonomics or to ergonomics training.³² It also noted that a major recommendation from the Fielden Report,³³ which had criticised the standard and quality of industrial design, particularly hand tools, had noted that this was “a field in which ergonomics is of outstanding

²⁸ TNA Lab 10/2222. Letter Woodcock to Hogg 30th April 1964.

²⁹ TNA Lab 10/2222. Flysheet note Merre to Stewart 24th July 1964.

³⁰ See, for example TNA FD 1/7580. File Note on NJAC Meeting, 25th January 1956. 1/2/56.

³¹ TNA Lab 10/2222. Letter Hickinbotham to Larsen. Ergonomics in Industry. 20/182. 1st October 1964.

³² TNA Lab 10/2222. Ministry of Labour. National Joint Advisory council. Ergonomics in Industry. NJC (64) 22. 13th Nov 1964.

³³ *Engineering design : report of a committee appointed by the Council for Scientific and Industrial Research to consider the present standing of mechanical engineering design*, London, HMSO, 1963. This examined the reasons for the decline in the UK's share of international trade in engineering goods. The main finding was that the decline could be traced to the poor design, reliability and performance of British goods compared to their foreign competitors. The main recommendation was that there should be an increase in the training and prestige of designers compared to engineers.

importance and that the main need is for industry to make more use of the resources now available ... by releasing more students for courses.”³⁴ The paper concluded that ergonomics was important, but could not agree on how to ensure that industry paid due attention to the science.

The inability to decide who should take responsibility for addressing the TUC request on ergonomic is highly illuminating. Murrell’s TUC paper had identified an absence of senior government figures supporting ergonomics.³⁵ Despite several government departments having an interest in ergonomics none of them saw the science as central to their enterprise. Although DSIR was the central lead agency for ergonomics and its exploitation, it was due for closure; and, as discussed in Chapter 4, although Min Tech, its successor organisation, took some interest in ergonomics, its focus lay with technology. The issue for ergonomics and the ERS was that, as with industry, there was no principal government authority for the science. Without such a focus, the problem of how to develop a powerful social network between the ERS, ergonomics practitioners and government was made more difficult.

The request for increased ergonomic content in government educational courses for industry had been transformed into how to stimulate industrial interest in ergonomics, which was still of importance to the TUC. The NJAC finally concluded that the Ministries of Labour, DES, Min Tech, DSIR, the Unions, and the BEC should meet to discuss how to stimulate industrial interest in ergonomics.³⁶ This meeting, held in early 1965, was almost inconclusive. The BEC disagreed that industry lacked awareness of ergonomics: it was that they were slow to adopt new techniques!³⁷ Suggestions for stimulating industrial interest, such as a conference or pamphlets on the benefits of ergonomics, were rejected as there were a considerable number of publicised ergonomics meetings and substantial literatures readily available.³⁸ With the meeting meandering to a close, Hilary Clay³⁹ from DSIR mentioned that there

³⁴ TNA Lab 10/2222. Ministry of Labour. National Joint Advisory council. Ergonomics in Industry. NJC (64) 22. 13th Nov 1964.

³⁵ MRC.MSS.292B/571.87/4. Memorandum on the Development of Ergonomics. 1962.

³⁶ TNA Lab 10/2222. Extract from the Minutes of the 88th Meeting of the NJAC. Item 5 Ergonomics in Industry, undated.

³⁷ TNA Lab 10/2222. Transcript of Ergonomics in Industry meeting. 21st January 1965.

³⁸ *Ibid.*

³⁹ Hilary Clay moved to Min Tech when DSIR closed and then onto the SSRC. Very little else is known of her work in government other than that reported in this thesis.

were “human factors clauses in Government contracts in the USA in which minimum ergonomic standards are set out. Broadly speaking, the clauses stated that at some stage an ergonomist should look at the work.”⁴⁰ It will be recalled that Murrell’s TUC paper had called for enforceable standards to be included in government contracts. The TUC request that that the DES should draw attention to the need to encourage the inclusion of ergonomics in training courses had now transformed into contract law: which was not what the TUC had requested. It is, however, instructive, to quickly trace the final steps as it reveals more about attitudes towards ergonomics.

H. Larson, the Ministry of Labour official in charge of the TUC request, now wrote to J. Petch at the Treasury Procurement Policy Committee (PPC). This had been established in September 1964 to seek ways to support civil research and development by the use of contracting policy and methods.⁴¹ Larson explained his Ministry’s role and asked if the PCC could advise on how ergonomic considerations could be included in future government contracts.⁴² Petch replied that as design criteria were already considered in the development of equipment there was no need to evoke ergonomics as a contract requirement.⁴³ The response clearly shows that in the minds of these Treasury officials there was no distinction between design and ergonomics, and no need for any standards. In Section 5-4 I will show how the Department of Transport had a very different perspective on ergonomics and the need for standards. The purpose of this section has been to follow the course of the government’s response to the TUC’s request to draw attention to those running educational courses for managers, designers and work study practitioners, of the need to increase the number of ergonomics lectures in the appropriate course curricula. This has shown, in some detail, how government departments responded to a request from the General Secretary of the TUC. Although this was a fairly trivial issue, the request was afforded a sustained level of bureaucratic support, indicating that both Douglas-Home’s Conservative, and Wilson’s Labour administration placed great importance on responding positively to lobbying from the TUC. This section has also shown the

⁴⁰ Ibid. These clauses had first been inserted into military equipment contracts in 1947. It should also be noted that the UK had no ergonomic standards for either civilian or military equipment at this time.

⁴¹ TNA T 320/568. Federation of British Industry. Report of a Working Party on Public Purchasing Policy July 1965.

⁴² TNA Lab 10/2222. Letter Larsen to Petch. 9th March 1965.

⁴³ Op. cit. (57).

magnitude of the sustained effort by the Ministry of Labour to provide a government response, even to the extent of enrolling support from the Treasury.

I have previously identified that the employers' federations did not have a single focal point for ergonomics. It is now clear that the same was true for central government. Following the passage of this request has shown that although the government departments involved, Ministry of Labour, DES and the Treasury, had an appreciation of the utility of ergonomics, they did not view 'championing' ergonomics as central to their business enterprise. Accordingly, they afforded the science a proportionate and appropriate level of support, but were not prepared to co-ordinate a pan-government policy for ergonomics. I now discuss the conferences arranged jointly by the TUC and the ERS. These differed from the series described in Section 5.3 as they were targeted at specific issues of interest to the TUC, and were to result in further lobbying of the government regarding ergonomics.

5.4: The TUC / ERS Conferences - 1965 to 1970.

Following the success of the 1965 Cranfield conference, the TUC had decided to continue the series of ergonomics conferences. In October 1965, David Whitfield, the Secretary of the ERS Industrial Section, wrote to Paul Fisher⁴⁴, the new secretary of the TUCPD, requesting a meeting to identify any areas of mutual collaboration.⁴⁵ This marked the start of a fruitful partnership between the two organisations. Here, I describe the conferences that were arranged, and how the outcome of one meeting resulted in the TUC again attempting to influence government policy on ergonomics. Finally, I will explore why, towards the end of the 1960s, the TUC's interest in ergonomics was overtaken by a more pressing interest in the social sciences. I will now review of the formation of the ERS Industrial Section.

During the 1950s, the ERS held regular visits to industrial sites such as Bradwell Nuclear Power Station.⁴⁶ Whilst these were well attended and may have provided the attendees with insights into industrial processes, these informal events did not appear to have been fruitful avenues for bringing ergonomics into the industrial base, or for helping ergonomists understand business practices. The ERS Industrial Section was

⁴⁴ There is no known biographical information regarding Paul Fisher.

⁴⁵ MRC.MSS.292B/571.87/4. Letter Whitfield to Fisher. 13th October 1965.

⁴⁶ BUSCA DM 26/4812. Ergonomics Research Society. Circular No. 30. Meeting at Unilever Factory, Purfleet. 19th May 1955. This advertised the meeting at Bradwell.

formed following a session on ergonomics consultancies for industry at the 1960 society conference.⁴⁷ The Industrial Section's aim was to formally engage with employers, employees and industrial scientists who were interested in, but not working on ergonomics.⁴⁸ This would be through regular meetings at companies' premises, and would permit the exchange of information and ideas between the groups and identify consultants to address specific issues, training and educational needs. The first meeting was held at Thomas and Baldwin steel works, followed by a Symposium on Industrial Design with the Industrial Design Society and a visit to Metrovick in Manchester.⁴⁹ Although meetings were well publicised, attendances were poor. It was the appointment of David Whitfield⁵⁰ and John Chris Jones⁵¹ as chair and co-chair respectively in 1965 which re-invigorated the section.

Whitfield wrote to the TUC suggesting that a meeting be arranged with members of the TUC, or individual unions to discuss ergonomics. This resulted in both Whitfield and Jones being invited to attend a TUCSAC meeting to discuss possible joint ventures.⁵² Whitfield proposed holding a series of meetings, targeted at key areas of interest to the TUC.⁵³ These would be open to union members, the ERS and industries associated with the meeting theme. Papers would be elicited from the represented groups giving a fully rounded agenda. The ERS suggested that an initial meeting should be on train or lorry cab design as "one result of such activity might be to persuade Government departments, both as employers and large scale buyers of machines to give more practical encouragement to ergonomics."⁵⁴

⁴⁷ BUSCA DM 26/4815. Letter Wallis to Edholm 6th May 1960.

⁴⁸ BUSCA DM 26/4815. Ergonomics Research Society. Proposed Industrial Section. 2nd June 1960.

⁴⁹ BUSCA DM 26/4815. Minutes of Meeting of Industrial Section Committee. 16th January 1961.

⁵⁰ BUSCA DM 26/4814. Ergonomics Research Society Council Minutes. 18th September 1963.

⁵¹ Jones read Engineering at Cambridge and worked on the selection of exhibits for the Festival of Britain. He moved to Metropolitan Vickers as a designer where he started a design course for engineers and established an ergonomics unit. From there he went to the University of Manchester Institute of Science and Technology where he ran the first graduate course in design technology and in 1970 published *Design Methods* where he explicitly linked ergonomics and design. In 1971, he became the first professor of design at the Open University.

⁵² MRC.MSS.292B/571.87/4. Letter Fisher to Whitfield 18th October 1965. Fletcher had moved to the West of England Engineering Association. Nothing is known of Fisher's background.

⁵³ MRC.MSS.292B/571.87/4. Ergonomics: Meeting with Representatives from the Ergonomics Research Society. Extract from Minutes of Sc. Adv. Ctee 4, 5th May 1966.

⁵⁴ *Ibid.*

Concerns had been raised over commercial vehicle cab design by the United Road Transport Union⁵⁵ who, with the Transport and General Workers Union, represented some 500,000 commercial vehicle drivers. Although cab design had been improved, there were many vehicles in service with poorly designed drivers' stations. Some drivers in these older vehicles had to use blocks of wood or half bricks as heel rests.⁵⁶ Both unions agreed that improvements in cab design had been made, but also believed that further enhancements, such as an adjustable driver's seat, were needed. Other concerns included the reduced strength of the cabs, consequent upon reductions in the thickness of metal, driver and passenger mounting and dismounting procedures, and the postures assumed when reversing vehicles (Figure 5-1). In the old-style cabs the driver had to adopt a half-sitting, half-standing posture whilst steering and controlling the accelerator because the window did not wind down. With improved visibility in the new-style cab, a much safer working posture could be adopted.⁵⁷



Figure 5-1. Reversing in old style and new style lorry cabs.⁵⁸

Seventy people attended the meeting: 31 senior trade union officials from nine unions, 30 ergonomists and nine senior designers from vehicle and cab equipment manufacturers.⁵⁹ Jones presented on the application of ergonomics to the design of lorry cabs, stressing that “design improvements would lead to greater safety, efficiency and comfort for drivers.”⁶⁰ There followed a series of presentations from

⁵⁵ MSS.292B/571.89/6. Letter Moore (General Secretary United Road Transport Union) to Woodcock. 22nd July 1966.

⁵⁶ MRC.MSS.292B/571.89/6. L.Smith. Driver's Cab Ergonomics, a Union View.

⁵⁷ J. B. Davey, Looking after the Lorry Driver, *Design*, April 1965.

⁵⁸ *Ibid.*

⁵⁹ MRC.MSS.292b.571.89/6. Trades Union Congress. Joint Meeting with Industrial Section. List of Attendees.

⁶⁰ *Ibid.*

senior design engineers from Ford Motors, Cox and Co⁶¹ and Leyland Motors. All conceded that considerably more could be done in the field of ergonomics. The Transport and General Workers Union gave their views on the positive changes that had occurred in cab design, and aspirations for the future. The closing discussion centred on concerns over the fragility of modern cabs, the lack of backboards to prevent loads slipping forward, and the resistance by drivers to the use of seat belts. The conference recommended the need for better cab design standards and the need to reduce noise and vibration. The positive responses from the meeting resulted in the TUC agreeing to request that Woodcock write to the Ministers of Transport (Barbara Castle) and Technology (Anthony Wedgwood Benn) bringing to their attention the recommendations of the meeting.⁶² Woodcock's letter was designed to encourage the government to put pressure on the manufacturers to introduce measures to improve cab safety.

He urged both Castle and Benn to persuade manufacturers to "take steps to include ergonomic principles in their products and to persuade user companies (and Government Departments) to insist that this be done."⁶³ It will be recalled that when the Ministry of Labour had made a similar request to the Treasury's PPC, the response had been that because design principles were included in government contracts, there was no requirement for ergonomics standards to be mandated. Castle responded by promising to include the ERS / TUC papers in a forthcoming meeting with manufacturers on vehicle safety.⁶⁴ Subsequently, W.E. Alexander from the Ministry of Transport wrote to the Society of Motor Manufacturers and Traders enquiring what work had been done in the field of ergonomics and vehicle design.⁶⁵ The Society replied that a considerable amount of work into vehicle ergonomics and safety had been undertaken and that cabs were "not as bad as may be thought by certain individuals in the Trades Union movement."⁶⁶

⁶¹ Cox and Co were the leading designers and manufactures of vehicle seats.

⁶² MRC.MSS.292B/571.89/6. Ergonomics of Drivers' Cabs: Views of the Unions. Extract from Sc.Adv.Ctee (4), 4th May 1967.

⁶³ MRC.MSS.292B/571.89/6. Letter Woodcock to Castle / Wedgewood Benn. 22nd June 1967.

⁶⁴ MRC.MSS.292B/571.89/6. Letter Castle to Woodcock. 21st July 1967.

⁶⁵ TNA MT 98/697. Letter Alexander to Woodbridge 23rd Jan 1968. There is no information regarding Alexander's position or responsibility within the Ministry of Transport.

⁶⁶ TNA MT 98/697. Letter Woodbridge to Alexander. 3rd April 1968.

Alexander was as keen as the TUC to see vehicle manufacturers make more effort to improve the ergonomics and safety of vehicle cabs, even proposing a British Standard on vehicle controls be developed.⁶⁷ He established an informal group drawn from the Ministries of Transport and the Environment and passenger transport authorities, supported by an ergonomist, Pat Ruffell-Smith.⁶⁸ Working in conjunction with the Motor Industries Research Association, the group developed guidelines for instrument layout, hand and foot control positioning and sizes, and number, colour and tone of visual and audio warning signals.⁶⁹ This was the first document that set out ergonomic standards for the construction of passenger vehicles, preceding the military ergonomics standard, *Human Factors for Designers of Naval Equipment*, published in 1971. It provided a code of practice for cab design which could form the basis of testable and verifiable standards and be built into future contracts. It also gave engineers and designers a set of clear design parameters, based upon ergonomic knowledge, which they could use in the development and construction of vehicle cabs, and also met the goal which Larson had attempted to achieve with the Treasury.

From the perspective of the both the TUC and the ERS, the conference was successful in that it aired the issue of cab safety and design and resulted in subsequent positive ministerial activity. The next meeting, on the design and operation of hand tools, was held at the Machine Tool Research Association in Macclesfield. Twenty union officials, an equal number of ergonomists, and six representatives from industry attended.⁷⁰ The meeting report marks a shift in TUC views on ergonomics: “delegates pointed out that strict observance of traditional demarcation lines could cause serious problems in industry. It was said that there was a need for re-thinking on both sides of industry. Several delegates referred to the human problems of change management and a general view was that changes would come about if both sides of industry had more confidence in the future.”⁷¹ The report continued that the high levels of unemployment and credit restrictions made all sides of industry reluctant to accept change. The concerns expressed by the delegates were more amenable to human

⁶⁷ TNA MT 98/697. Flysheet note by Alexander. 19th April 1968.

⁶⁸ TNA MT 102/361. Ergonomic Study into Driver’s Cab Design: Note of first meeting held on 23rd July 1969 at St. Christopher House. Ruffell-Smith was an independent ergonomist and had attended the first meeting of the ERS.

⁶⁹ TNA MT 102/361. Ergonomic Cab Study.

⁷⁰ MRC.MSS.292B/571.89/8. Circular letter Woodcock to Trades Unions. GW/CL/TD/216. 4th January 1968.

⁷¹ *Ibid.*

relations, than ergonomics, research. To understand this shift in interest towards social science it is necessary to examine the state of union and government relations during the late 1960s.

Williamson's study⁷² of the 1974 Bullock Report⁷³ charts the course of industrial democracy within the TUC during the 1960s. He points out that the 'post-war consensus' built around the operation of a mixed economy, development of the welfare state, full employment, close co-operation with unions and movement towards membership of the European Union, provided a stable environment in which a change in administration would do little to disturb policy continuity.⁷⁴ From this consensus industrial democracy, the action of consultation or active participation between unions and the government and/or employers to set policy was established. By the mid-1960s this consensus had started to unravel. This was partly a result of Conservative and Labour administrations seeking to impose a wage restraint policy to cushion the effects of a worsening financial climate. For both the MacMillan and Douglas-Home Conservative administrations, and Wilson's Labour government, wage restraint was seen as essential for full employment. Interfering with free collective bargaining was viewed by the TUC as challenging, or even limiting, how they had exercised industrial power.⁷⁵

The 1965 Royal Commission on Trade Unions and Employers Associations (the Donovan Commission) investigated the role of both trade unions and employers' associations in a modern industrial setting.⁷⁶ Amongst the conclusions was that the multi-union structure was complex and chaotic, with a duality of industrial relations.⁷⁷ There was a formal industry-wide collective bargaining process which was governed by agreed rules and an informal, local system in which collective bargaining was

⁷² A. Williamson, *The Bullock Report on Industrial Democracy and the Post-War Consensus*. *Contemporary British History*, (2016), 30, 119 - 149.

⁷³ *Report of the committee of inquiry on industrial democracy*. Cmnd 6706, London, HMSO, 1977.

⁷⁴ There is some debate concerning the validity of the concept of a post-war consensus, see for example B. Pimlott, *The Myth of Consensus*, in L. M. Smith (ed.) *The Making of Britain: Volume 5: Echoes of Greatness*, London, Macmillan, 1988.

⁷⁵ D. Barnes and E. Reid, *Governments and Trade Unions. The British Experience, 1964 – 79*. Heinemann, London, 1980. pp 40 – 41.

⁷⁶ *Royal Commission on Trade Unions and Employers' Associations*. Cmd 3623. London, HMSO, 1968. Multi-unionism is the condition where unions compete for the same group of workers. An emergent property from this situation is that collective bargaining is undertaken on a local rather than national level.

⁷⁷ *Ibid.*

undertaken without agreed rules. This informal system was more important and powerful and was in the hands of the local shop stewards⁷⁸ whose numbers almost doubled between 1961 to 1968, so shifting the locus of power to the shop floor, and engendering frictions between the leadership and the shop floor.⁷⁹

Donovan recommended union amalgamation to combat fragmented wage bargaining, and the appointment of full-time union officers to provide greater influence over shop stewards. The TUC was supportive of Donovan's proposals, but senior members in the government, particularly Castle, believed that it did not address the issue of the powerful position of the shop stewards. This resulted in Castle issuing *In Place of Strife*,⁸⁰ which contained proposals for improving industrial relations. The TUC strongly objected to three proposals, namely, granting power to the Secretary of State to impose a conciliation pause for unconstitutional strikes, the requirement for unions to ballot members in strikes which posed a serious threat to the economy and, in the case of inter-union disputes, the Secretary of State having the power to exclude unions from recognition and compel the employer to recognise and negotiate.⁸¹ The TUC saw these proposals as challenges to the structure of unions: challenges which ergonomics could not address.

By late 1969 the TUCSAC were concerned by the increased use of social science research as a basis for employers' labour policies. These included organisation theory, management structure and, what the paper calls, conflict situations.⁸² The TUC was clearly feeling disadvantaged by their poor knowledge of social science and called for greater engagement with social scientists. They also recognised "the possible contribution which social sciences could make to providing a basis for the self-regulation by workers of work situations."⁸³ The TUCSAC requested that Len Murray, then head of the TUC economics department and a council member of the SSRC, should present on the work of the committee.

⁷⁸ Barnes and Reid, 1980. Chapter 7. A Deep and Fundamental Split, pp 106 - 128.

⁷⁹ A. Booth and J. Melling, Workplace Cultures and Business Performance: British Labour Relations and Industrial Output in Comparative Perspective. In J. Melling and A. Booth (eds.). *Managing the Modern Workplace. Productivity, Politics and Workplace Culture in Post War Britain*. Aldershot, Ashgate, 2008, Chapter 1, Workplace Cultures and Business Performance: British Labour Relations and Industrial Output in Comparative Perspective, pp 1 - 26.

⁸⁰ *In Place of Strife: A Policy for Industrial Relations*. Cmnd.3888. HMSO, 1969.

⁸¹ Barnes and Reid, (1980). pp. 112 - 117.

⁸² MRC.MSS. 292B/572.1/4. Social Sciences in Industry. Sc.Adv.Ctee. 1/2, 7th October 1969.

⁸³ MRC.MSS. 292B/572.1/4. Minutes of Scientific Advisory Council. 7th October 1969.

The concept of an SSRC had first been proposed in the Clapham report of 1946⁸⁴, but had failed to gain government support.⁸⁵ There had also been attempts to establish a commission to assess the needs for a social science research council. In 1961 the HSC had observed in their bid to establish a Human Sciences RA, that for social science research, “provision is patchy, unco-ordinated and insufficient to cover the whole spectrum of human science.”⁸⁶ It was from discussions of this paper that in 1965 the DES formed the Heyworth Committee to establish the nature of social science research required, and the structure of an executive body which could manage such a programme.⁸⁷

In his presentation Murray argued that the TUC should refocus its research interest towards social sciences to ensure that their corporate level of understanding was comparable to that of the employers’ organisations, and seek to influence the research programmes identified by, and funded through the SSRC. The TUC should also launch a series of human relations seminars for their officials. He foresaw that social science research could support recruitment, restructuring of union management and collective bargaining, all of which were of critical importance to the TUC.⁸⁸ He revealed that the SSRC intended forming an Industrial Relations Research Unit at Warwick under Hugh Clegg to identify appropriate research to address the application of social science research to industrial relations.⁸⁹

Effectively, Murray was saying that here was a funded research body that was receptive to the future needs of the TUC. Further, Clegg’s research unit at Warwick provided an institution which could undertake and interpret research for the TUC. The

⁸⁴ *Report of the Committee for the Provision of Social and Economic Research*. Cmnd. 6868, London, HMSO, 1946.

⁸⁵ D. King, Creating a Funding Regime for Social Research in Britain: The Heyworth Committee on Social Studies and the Founding of the Social Science Research Council, *Minerva*, (1997), 35, 1 - 26. The committee was chaired by Lord Heyworth, ex-chairman of ICI and Unilever and included Sir Austin Bradford Hill, the epidemiologist and statistician and C.F. Carter, economist and vice - chancellor of Lancaster University.

⁸⁶ TNA DSIR 17/691. Developing the Social and Human Sciences: Need for a Human Sciences Research Council 22nd May 1960, HSC – 133.

⁸⁷ King, (1997).

⁸⁸ MRC.MSS. 292B/572.1/4. Minutes of Scientific Advisory Council. 7th October 1969.

⁸⁹ The Industrial Relations Research Unit was formed in 1970 under the leadership of Professor Hugh Clegg at Warwick. Clegg had been appointed to the Royal Commission on Trade Unions and Employers Associations in 1965 and, in 1967 was made Professor of Industrial Relations at Warwick. See W. Brown, Obituary: Professor Hugh Clegg, (1995), <http://www.independent.co.uk/news/people/obituary-professor-hugh-clegg-1525800.html> accessed 9th March 2017.

safety and welfare of the worker at the workplace was important, but the TUC was facing organisational changes which only social science research could address.

There were two more conferences but the contribution from the ERS was markedly reduced. ‘Ergonomics and the Office’ addressed office furniture, environment and interpretation of the legislation contained in the Shops and Railways Premises Act.⁹⁰ ERS participation was limited to providing a speaker for the question and answer session. ‘Influence of Ergonomics on Work Study’ addressed the measurement of fatigue and development of shift patterns but was dominated by work study presentations.⁹¹ After this the joint conferences ceased. Donald Anderson and Ted Lovesey, who served on the ERS Industrial Section, noted that from 1969 onwards the TUC’s interest focused on how ergonomics could aid job demarcation and wage bargaining, which was in line with the human science imperatives being pursued by the TUCSAC. The refusal of the ERS to become embroiled in these issues resulted in a cooling of relations.⁹²

The TUC’s interest in ergonomics education peaked during the mid-1960s as exemplified by the interest generated by the different conferences. These were targeted at specific areas of interest to the TUC and employers and attracted good support from members. However, from the late 1960s onwards the importance of these conferences, and the interest shown in ergonomics waned. The main reason for this was that the structural reorganisation and challenges of change management which the TUC and its members now faced were not amenable to solution by ergonomics. In addition, the SSRC were establishing a research unit at Warwick which would address structural and organisational issues that faced the TUC. It should be noted that the TUC did not lose interest in ergonomics as the TUC home web site still hosts a page on the subject.⁹³ The relationship between the TUC and the ERS benefited both sides. The TUC received education in the human sciences whilst the ERS learnt first-hand of the issues facing the TUC.

⁹⁰ *Offices, Shops and Railways Act, Chapter 41*. HMSO, London, 1963. The Act extended the health and safety legislation from heavy industry to the office environment

⁹¹ MRC.MSS.292B/571.89/3. Trades Union Congress. Technical Programme. Prod. Ctee. 2/6, 6th November 1969.

⁹² Email Lovesey / Edwards 10th November 2014 and Anderson / Edwards 16th November 2014.

⁹³ <https://www.tuc.org.uk/workplace-issues/health-and-safety/ergonomics> accessed 20th October 2016.

5.5: Conclusions.

This chapter has examined the relationship that existed between the TUC, ergonomics and ergonomists during the 1960s. There are few, if any studies of the TUC's attitudes towards science and technology or the internal bodies which were responsible for setting policy. Although my research is through the lens of ergonomics it is possible to build an understanding of how the TUCSAC initiated policy and the TUCPD implemented the directives. It is also possible to gain an impression of the breadth of the TUC's interests in science through examination of some of the peripheral details contained in the human science primary source material. There are, for example, TUCSAC discussions on proposed conferences on the use of computers in work study and OR,⁹⁴ on marine science, and on preparations for meeting with the government to discuss science policy.⁹⁵

Whilst this chapter has been concerned with the TUC and ergonomics, an insight into how other government departments viewed ergonomics has been gained from the lobbying case studies. I have shown how the Ministry of Labour, which had a more than passing interest in ergonomics, after much debate pursued the TUC's request for an increase in ergonomics educational courses. This eventually became a discussion with the Treasury on how ergonomics should be specified in government contracts. The Treasury, however, saw no requirements for specifications and saw no difference between design and ergonomics. In contrast, the Ministry of Transport saw a very real need for ergonomic standards. Lobbying of the Ministry of Transport by the TUC should be viewed as reinforcing, rather than influencing a policy decision. The requirement for ergonomic guidelines for cab design had already been decided, the TUC's intervention merely strengthened the Ministry's hand.

What also became clear from these case studies is once that DSIR closed there was no other government department or ministry which embraced primacy for ergonomics. The absence of a clear high-ranking 'champion' for ergonomics within government, meant that there was no obvious single point of contact. As with industry there were many departments, such as Transport, which had an interest in ergonomics: an

⁹⁴ MRC MSS292B.571.89/3. Joint TUC / ICL Seminar on Computers and Work Study, October 1969

⁹⁵ BUSCA DM 26/4818. Minutes of 5th Annual SAC Meeting 30th June 1969.

ergonomics unit for the railways had been established in the early 1960s.⁹⁶ This however, served a specific rather than a pan-government requirement. The observations from this chapter have shown that the ERS could have built a coherent cross-government network, but that would be a long, and irksome process as they attempted to identify and cultivate the appropriate desk officer in each Ministry. Through their links in the TUCSAC and the TUCPD, they built such a structure.

In this chapter I have examined the relationships between the TUC and ergonomics and have presented new information on the relationship of government departments towards ergonomics. The TUCSAC and TUCPD made repeated calls for more ergonomics courses to provide both formally trained ergonomists and to inform industry on the use and merits of ergonomics. In the next and final chapter, I will discuss the establishment of ergonomics departments in the university sector and the development of degree-awarding and non-degree-awarding courses, how the courses were structured and inter-related, and how this helped establish a supply of trained ergonomics practitioners.

⁹⁶ Files relating to its formation have not come to light but an appreciation of the work undertaken may be found in TNA MT 102/361 Working Group on Ergonomic study into Drivers' Cab Design.

Part 2 Chapter 6. We Need People who can Work with Industry – Academic and Non-Academic Ergonomics Education.

6.1: Introduction.

A consistent recommendation from the CRP, CIP (HF) and the IEC had been the need for formal training in human sciences, including ergonomics, to establish a cadre of scientists to work with industry to identify and solve human factors issues, and act as a conduit for research exploitation. In addition, both the TUC and employers' organisations were pressing the government and DSIR to establish non-credit-bearing short courses for middle ranking managers, designers and engineers to provide an understanding of ergonomic principles, and an appreciation of how they may be applied at the workplace. Despite this demand, the provision of such courses proved consistently problematic.

From the late 1950s onwards degree level courses and short non-credit-bearing ergonomics courses were established by newly created or existing academic departments and employers' associations. In this chapter I will review three case studies which trace the origins of these courses, identify the key actors and, where possible, who attended and the impact of the courses. From this I will demonstrate the inter-relationships that existed between degree level and non-credit-bearing short courses in ergonomics and how the latter contributed to the growth of the science.

The first two case studies will examine the development of degree and non-credit-bearing ergonomics courses at the universities of Loughborough and Birmingham. These case studies will show how the courses were shaped by factors which prevailed at those universities. The remaining case study will be the non-credit bearing short duration ergonomics courses provided by the West of England Engineering and Allied Employers' Association. This employers' association ran a series of short residential courses for engineers and designers which were delivered by Murrell, and others, during his tenure at Bristol. Whilst there is an extensive literature on the role and importance of formal (degree level) academic courses, non-credit bearing short courses have attracted little attention. This will be addressed in this chapter. Before continuing it is worth briefly considering the nature of formal and non-formal training or 'education' to aid the framing of the arguments in this chapter.

Educationalists characterise formal educational courses as being systematic and structured with sets of norms and rules, following a rather rigid curriculum, and attended by assessments resulting in recognised educational awards.¹ They characterise non-formal education as an approach where one, or more, of these characteristics are missing.² A non-credit-bearing short course, i.e. one that does not result in a formally recognised educational award, could therefore be interpreted as non-formal. Such a distinction is unhelpful in considering how ergonomics information was passed from one set of specialists to another – ergonomists to engineers – as this type of knowledge transfer does not conform to the definition of non-formal education above. These courses were endorsed by the universities and, therefore, institutionalised.

The literature review in Section 1-9 has highlighted the importance of academic degree awarding courses in the institutionalisation of science. Non-formal education literature has addressed topics such as its use to prepare school children for work,³ the learning of job related skills at the workplace⁴ or pedagogical techniques.⁵ It is also possible to include in this category Secord's study of artisan botanists of the century,⁶ and Gouyon's work on the use of museum exhibits and television to teach and communicate science.⁷ Studies of non-formal education address the case where knowledge is being transferred from 'experts' – the youth teacher or museum curator, for example – to non-specialist groups for general education. So, the film *Fitting the Job to the Worker* (Section 2.8) may be seen as non-formal education as it was aimed at, predominantly, non-specialist groups, such as shop floor workers. In the examples discussed in this chapter, the communication is between different specialist expert disciplinary groups: peer group transfer of knowledge between ergonomists and engineers. Further, the anticipated outcome was that the engineer would be able to use his new ergonomics knowledge in his work. From these considerations the use of the

¹ Eraut, (2000).

² Ibid.

³ See for example Kuchinke, (2013).

⁴ See for example Boud and Garrick, (1999).

⁵ C.A. Price, H-S Lee and K.Malatesta, Stereoscopy in Static Scientific Imagery in an Informal Education Setting: Does it Matter? *Journal of Science Education and Technology*, (2014), 23, 721 – 734.

⁶ A. Secord, Science in the Pub: Artisan Botany in Early Nineteenth Century Lancashire. *History of Science*, (1994), 32, 269 – 315.

⁷ J-B. Gouyon, Making Science at Home: Visual Displays of Space Science and Nuclear Physics at the Science Museum and on Television in Post War Britain. *History and Technology*, (2014), 30, 1 – 24.

term ‘non-formal’ to describe the short courses in ergonomics is inaccurate. I shall, instead, be using the term ‘non-credit-bearing’.

The first case study is the Department of Ergonomics and Cybernetics at Loughborough University. This was the UK’s first ergonomics department, and was founded in response to a recommendation of the 1956 White Paper on Technical Education.⁸ The second example is the ergonomics capability within the Department of Engineering Production at the University of Birmingham, which grew from the delivery of lectures in ergonomics to attendees at summer schools in engineering production techniques. In both cases, funding from the government human science research programme was key in the development of these capabilities.

6.2: The Department of Ergonomics and Cybernetics, Loughborough.

Loughborough College of Advanced Technology, latterly Loughborough University, was the first UK academic institution to offer degree-level courses in ergonomics. Practitioner histories have identified Floyd as the key actor in the enterprise,⁹ but I will show that it was the Principal Herbert Haselgrave, and the Head of Industrial Engineering, James France, who were the leading actors in establishing the department, whilst Floyd and others developed the courses.

The Loughborough Technical Institute was established in 1909 to provide education in science and engineering, building, commercial and domestic subjects and the arts.¹⁰ It rapidly developed a strong reputation in engineering and, during World War 2, ran training courses for military engineering cadets.¹¹ The post-war years saw a continued expansion of the engineering and applied science departments, and in 1953 Haselgrave (Figure 6-1) was appointed as Principal of Loughborough College.¹² He had obtained a first-class degree in the Mechanical Sciences Tripos at Cambridge, and joined Loughborough as a lecturer in 1936. He left in 1938 to become Principal of St Helens Technical College, where he built a reputation as a national figure in technical

⁸ *Technical Education*, Cmd 9703, London, HMSO 1956.

⁹ E.g. Waterson and Sell, (2006).

¹⁰ L. Cantor, *Loughborough University of Technology: Past and Present*. Loughborough, Loughborough University of Technology, 1990.

¹¹ *Ibid*, p. 92.

¹² *Ibid*, p.130.

education.¹³ Under Haselgrave, Loughborough College established a Department of Industrial Engineering and was granted CAT status, with the attendant funding for expansion and modernisation of facilities.¹⁴



Figure 6-1. Dr Herbert Haselgrave.¹⁵

Through his close connections with the DES, Haselgrave would have been aware of an imminent review of the status of the CATs and the possibility of Loughborough being granted university status.¹⁶ He would also have appreciated that to establish Loughborough in the academic arena it would be imperative to develop courses in new and emerging subjects. This would attract students, and create a potential revenue source by providing a service to other College departments, industry, and, potentially, other academic institutions. One such subject was ergonomics, and it appears that it was James France¹⁷, the Head of the Department of Industrial Engineering who first conceived the notion.

By 1958, France's Department was offering specialised postgraduate and diploma courses in production engineering which included lectures on ergonomics and

¹³ Unattributed, Herbert Haselgrave, (2014), <http://www.lboro.ac.uk/anniversary/pages/history-vicechancellors.html>, accessed 11 July 2014. Pages have now been removed.

¹⁴ Cantor, (1990), pp 130 – 137.

¹⁵ Ibid, p.131.

¹⁶ *Higher education: report of the Committee appointed by the Prime Minister under the Chairmanship of Lord Robbins 1961-63*, Cmnd. 2154, London, HMSO, 1963.

¹⁷ Biographical details of France's career have not come to light.

cybernetics.¹⁸ How France came to include ergonomics in his courses is unclear. Further, course notes have not come to light, but it is possible that Floyd delivered the lectures. During late summer 1959, France and Floyd met to discuss forming an ergonomics capability at Loughborough, which would both serve France's Department of Industrial Engineering and act as a consultancy to industry.¹⁹

In early 1960 Haselgrave proposed to the College governors the establishment of a Department of Ergonomics and Cybernetics.²⁰ Cyberneticists were seeking to develop machines which would act like humans, so placing cybernetics in an ergonomics department signals that Haselgrave was laying claims to both sciences, and providing an environment where practitioners could cross collaborate. There was also a strong link between engineering and cybernetics, particularly in their shared use of servo-mechanisms and feedback and feed-forward loops in both their teaching and research.

Haselgrave highlighted the role that ergonomics could play in workspace design and shop floor layout, and suggested a role in civic planning, so identifying a new area which the department could cultivate for the benefit of the College. He argued that "Loughborough ought to be at the forefront of advances to be made in any field relating to engineering."²¹ Establishing the department would give a competitive edge over other CATs and enhance the college's ability to attract finance from outside sources. Haselgrave wanted Floyd as Head of Department, bolstering his argument by stating that employing Floyd would attract more students.²² He concluded that "this development is necessary if the College is to establish itself to University equivalence."²³ The governors accepted his proposal.

In his discussions with France, Floyd had suggested that the potential curriculum would be lectures on human biology to full-time engineering students, with one- to five-day residential courses on ergonomics for higher managers and TUC officials.²⁴ Floyd was appointed as the Head of the Department in February 1960, and that July

¹⁸ LUA LCT/G/P3 Extended Agenda Governors Meeting. Post graduate Work In Ergonomics and Cybernetics, Agenda Item 7. 2nd Feb 1960.

¹⁹ BUSCA DM 26/4811. Letter Floyd to France 7th October 1959.

²⁰ It appears that Haselgrave decided on the department name.

²¹ LUA LCT/G/P3 Extended Agenda Governors Meeting. Post graduate Work In Ergonomics and Cybernetics, Agenda Item 7. 2nd Feb 1960.

²² Ibid.

²³ Ibid.

²⁴ BUSCA DM 26/4811. Letter Floyd to France 7th October 1959.

he presented his proposals for a one year full-time postgraduate course in Ergonomics and Cybernetics to the College Board of Studies (Figure 6-2).²⁵

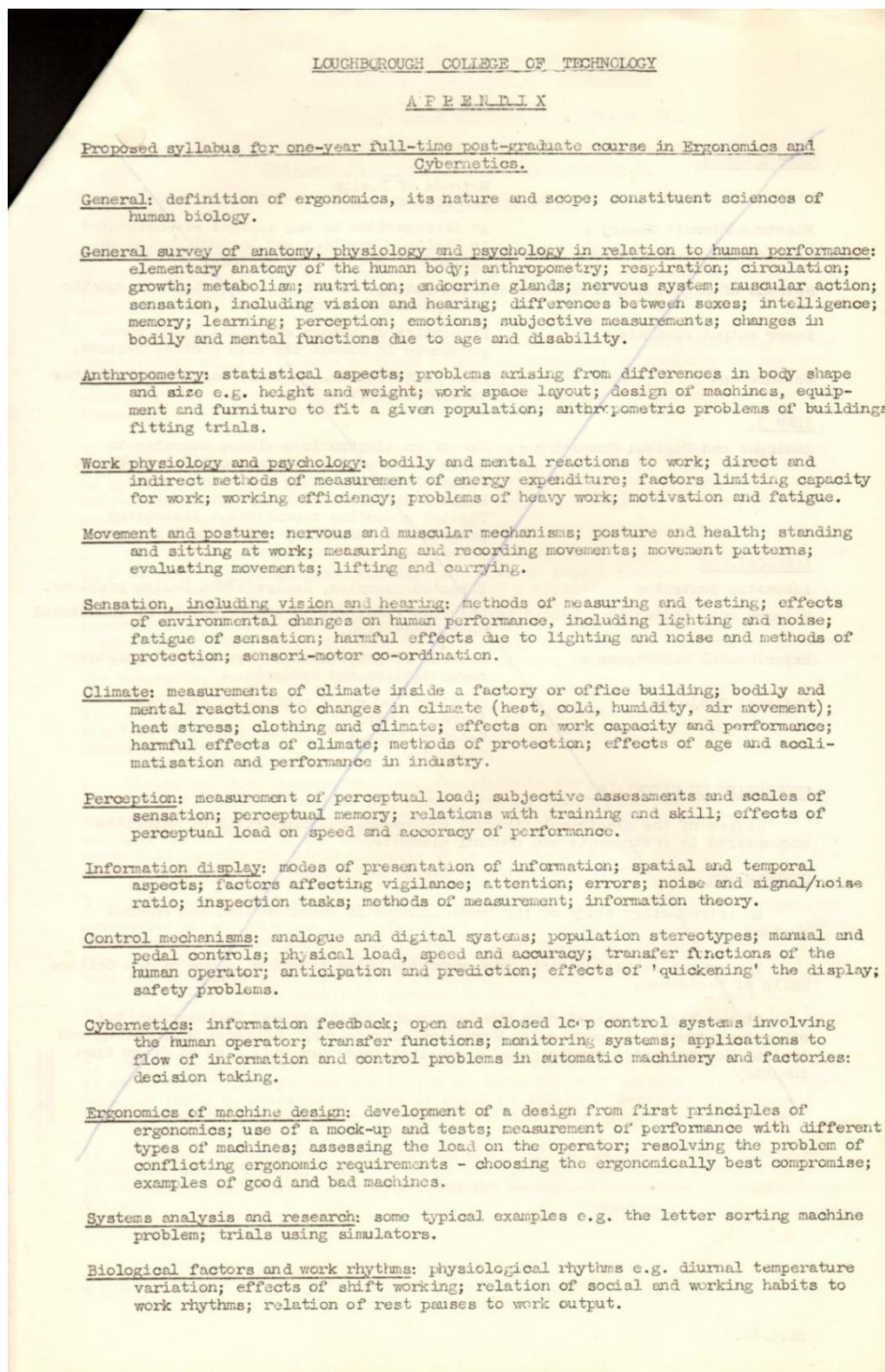


Figure 6-2. Floyd's Original Outline Syllabus.

²⁵ Email Clarke (Loughborough University Archivist) – Edwards 9th April 2013.

Designed “primarily for engineers or designers who are, or will be responsible for the design of systems,”²⁶ the aim was to “impart factual knowledge of ergonomics and to promote what might be called a biological way of thinking about man-machine problems.”²⁷ In presenting his syllabus Floyd stated that “the facilities and staff are likely to be available by January 1961, and that he expected to enrol from six to ten students for this course.”²⁸ Floyd’s problem was that there was no other academic degree level ergonomics syllabus which he could use to develop his own proposals. What he did was, effectively, list all the elements of physiology, psychology and anatomy which contributed, or were used, in ergonomic investigations.

The first staff members were Peter Stone, a psychologist from the Clothing and Equipment Physiological Research Establishment at Farnborough, and Elwyn Edwards, a psychologist from Bristol.²⁹ The Nuffield Foundation provided funding for four postgraduate studentships to attract “people with industrial experience plus some sort of academic qualification of a type which could include that obtained by good students sent by the TUC or individual unions to Ruskin College or LSE.”³⁰

Loughborough College of Technology								
: for Session JANUARY - MARCH 1961.								
Group One Year Course in Ergonomics & Cybernetics.								
or Student								
	9-0 to 10-0	10-0 to 11-0	11-0 to 12-0	1-30 to 2-30	2-30 to 3-30	3-30 to 4-30	4-30 to 5-30	Total
Monday	Psychol. Lecture. (E.E./P.S.) PS B9.	Seminar. (E.E./P.S.) BB4,2	Private Study.	Private Study.	Private Study.	Private Study.	Private Study.	
Tuesday	Physiol. Lect. (W.F.F.) C3	Tutorial (see List) L7	Tutorial L7	PRACTICAL PHYSIOLOGY (P.S. and W.F.F.)			LAB.	
Wednesday	Stat. Lecture (E.E.) CYBBERNETICS	Private Study.	Seminar (W.F.F.) BB4,1	Special Lecture or Demonstration OR Private Study. (P.S.)				
Thursday	Private Study.	Private Study.	Private Study.	LECTURE PRACTICAL STATISTICS (E.E. and W.F.F.)			LAB.	
Friday	Psychol. or Physiol. Lect. (E.E./P.S.)	Seminar (E.E.) EE	Seminar (W.F.F./P.S.)	PRACTICAL PSYCHOLOGY (E.E./P.S.)			LAB.	

Figure 6-3. Initial Timetable for Post Graduate Course in Ergonomics and Cybernetics.³¹

²⁶ Ibid.

²⁷ Ibid.

²⁸ Ibid.

²⁹ Peter Stone. Personal Recollections on the Genesis of an Educational Experiment. Unpublished.

³⁰ MRC.MSS 292b/571.87/4. Letter Fletcher to Roberts 30th September 1960. Neither Loughborough University nor the Nuffield archive has any information regarding the granting of these studentships.

³¹ Letter Stone- Edwards 15th May 2014.

By January 1961, three industry-based students had enrolled: Alan Lacy from Lyons, John Easterby from Associated Electrical Industries, and Graham Thompson from the British Motor Corporation (BMC). Thompson was taken on as part of a research programme on seating sponsored by BMC.³² The course syllabus was reshaped (Figure 6-3) and the academic staff increased when Stuart Kirk joined from the Royal Navy to teach psychology, and Bernard Chapman to lecture in cybernetics.

The new department was housed in the Engineering Department, so providing a physical presence for ergonomics and integrating it into the institutional fabric. Floyd had anticipated building a research team with little or no teaching,³³ but was quickly disabused of this idea when “Haselgrave informed us that one cannot survive as a purely research group in a teaching institution and therefore we must offer full-time courses.”³⁴ In an effort to bring industrial relevance to the course, increase income and raise the department’s profile, Floyd launched a three week Introductory Short Course in Ergonomics in 1961. This was “aimed specifically at engineers, designers, industrial medical officers, work study engineers, factory managers and all senior staff” and sought to “impart a general knowledge of the capabilities and limitations of human performance at industrial work tasks.”³⁵

The weekly timetables are given in Figures 6-4 to 6-6, and show that the teaching was shared between the existing staff and visiting lecturers. These included Tom Bedford, who lectured on thermal stress, and Shackel who lectured on the human-machine interface.³⁶ The attendee list from the first course³⁶ has not survived but a register from the 1963 course shows 11 senior and middle-ranking designers and works engineers from companies such as Wilkinson Sword, Ransome and Marles and Svensk Design Västerås, Sweden, hinting at the department may have already established an international reputation.³⁷

³² Letter Stone – Edwards 15 May 2014.

³³ Peter Stone. Personal Recollections on the Genesis of an Educational Experiment. Unpublished.

³⁴ Ibid.

³⁵ Letter Stone- Edwards 15th May 2014. Prospectus for Three Week Introductory Courses on Ergonomics. 1961.

³⁶ Other lecturers included Donald Broadbent, John Cotes, Director of the MRC Pneumoconiosis Research Unit and founder of the ERS Sub-committee on sports medicine, Sandy Lind, Head of the National Coal Board Ergonomics Unit and John Chris Jones.

³⁷ Letter Stone- Edwards 15th May 2014.

LOUGHBOROUGH COLLEGE OF TECHNOLOGY

Time Table for Session 6 March - 24 March 1961. Group 3rd week Introductory Course

Tutor _____ or Student _____

Day	Time	Topic / Activity	Notes
Monday	9.0 - 9.55	Introductory Lecture	WFP.
	10.15 - 11.10	Measuring human performances.	EE.
Tuesday	9.0 - 9.55	Auditory perception.	PS.
	11.15 - 12.10	Audiometry and noise measurement	PS.
Wednesday	9.0 - 9.55	Hearing and noise.	PS.
	11.15 - 12.10	Problems of movement and posture (1)	WFP.
Thursday	9.0 - 9.55	INDUSTRIAL VISIT. Messrs. Plastic Company.	PS.
	11.15 - 12.10	Problems of movement and posture (2)	WFP.
Friday	9.0 - 9.55	Case Study 2.	WFP.
	11.15 - 12.10	Case Study 1.	WFP.

Figure 6-4. Timetable for 1st Week of Inaugural Ergonomics Introductory Course.³⁸

³⁸ Letter Stone – Edwards 15 May 2014..

LOUGHBOROUGH COLLEGE OF TECHNOLOGY

Time Table for Session 6 March - 24 March 1963

Tutor _____ or Student _____

Group 2-Week Introductory Course on _____

Day	Date	9.0 - 9.55	10.15 - 11.10	11.15 - 12.10	2.0 - 3.0	3.0 - 4.0	4.0 - 5.0
Monday	March 11th	LECTURE. Communication through auditory and visual displays.	EX.	LECTURE. Problems of subjective assessment.	LECTURE. Ergonomics in the Iron and Steel Industry, by R. G. Sell, B.Sc. (British Iron & Steel Res. Assoc.)	EX.	LECTURE. Age and work.
Tuesday	March 12th	LECTURE. How hard can a man work? by June Grievie, B.Sc.	LECTURE. Some limitations of human performance.	PS.	DEMONSTRATION. Measurement of energy expenditure. June Grievie, B.Sc. (Host Office Physiological Unit)		
Wednesday	March 13th	LECTURE. Fatigue. PS.	LECTURE. Work piece layout. PS.	LECTURE. Speed, load and error in part-formance. EX.	LECTURE AND DISCUSSION. Ergonomics in the design of electronic equipment, by B. Shackel, M.A. (E.M.I. Ltd.)		
Thursday	March 14th	INDUSTRIAL VISIT. <i>Longhorough Cabinet.</i>		PS	INDUSTRIAL VISIT. <i>BR. Lactic.</i>		PS
Friday	March 15th		Case Study 3.	EX.	PRactical WORK. (1) Reaction times. (2) Accuracy of movement.		EX/PS.

Figure 6-5. Timetable for 2nd Week of Inaugural Ergonomics Introductory Course.³⁹

³⁹ Letter Stone – Edwards 15 May 2014.

LOUGHBOROUGH COLLEGE OF TECHNOLOGY
3rd WEEK.

Time Table for Session 6 March - 24 March 1961

Tutor _____ or Student _____

Group 3-Week Introductory Course

	8:30 to 9:00	9.0 - 9.55 9:00 to 9:40	10.15 - 11.10 10:00 to 11:00	11.15 - 12.10 11:00 to 12:00	2.0 - 7.0 1:30 to 2:30	3.0 - 4.0 2:30 to 3:30	4.0 - 5.0 3:30 to 4:30
Monday	March 20th	LECTURE. How hard should a man work? W.P.F.	PROJECT 1. Advisers: EE/PS/W.P.F.	LECTURE. Lighting and vision. W.P.F.	Project 1 (Cont.)	TUTORIAL	MEETING. EE/PS/W.P.F.
Tuesday	March 21st	LECTURE. Problems of vision (1) P.S.	LECTURE. Vigilance and inspection. EE.	LECTURE. Lighting and vision. W.P.F.	P R O J E C T 2. Advisers: EE/PS/W.P.F.		
Wednesday	March 22nd	LECTURE. Problems of vision (2) P.S.	PRACTICAL WORK. Experiments on vision and lighting. W.P.F.		LECTURE AND DISCUSSION "Some aspects of skill" by A.T.elfford, K.A. (Fellow of St. John's College Cambridge)		
Thursday	March 23rd		INDUSTRIAL VISIT.		INDUSTRIAL VISIT.		
Friday	March 24th		Discussion and criticism of projects.		FINAL SESSION Discussion and questions EE/PS/W.P.F.		

Figure 6-6. Timetable for 3rd Week of Inaugural Ergonomics Introductory Course.⁴⁰

⁴⁰ Letter Stone – Edwards 15 May 2014.

In addition to providing an income stream, launching the short course in ergonomics provided several benefits for the department. Courses were residential which meant that academics, engineers and designers could mix and meet informally to exchange knowledge and information. Demonstrations and practical sessions showed the calibre of the capability and facilities at Loughborough, advertising to industry that the department had the staff, equipment and understanding to undertake contract research work. The attendance of industry based students would help shape and inform the taught curricula through the identification of emerging ergonomic issues in industry.

The short courses also opened new areas of collaboration for the department. Of note was that with the Birmingham School of Architecture. Ron Croft, the senior design lecturer at the school had attended an Introductory Course to Ergonomics, and was so impressed that he invited Floyd to provide lectures on design and ergonomics, noise, anthropometry, vision and perception to students on the Bachelor's degree in Architecture.⁴¹ Floyd also provided external supervisors for final year projects, some of which were undertaken at Loughborough. The collaboration resulted in invitations to give lectures to Cheltenham School of Architecture, Royal College of Art, and the Edinburgh School of Architecture.⁴² As noted in Chapter 4, a major research area for Loughborough was dynamic anthropometry, and the development of building standards for the elderly and disabled. The links with the architecture establishments helped develop ergonomics research, particularly in the field of anthropometry, and opened new funding streams for the department.⁴³

One of the department's more prestigious engagements was the invitation to exhibit at the Boys and Girls Exhibition in 1964/65, where Stone presented to the children on 'Ergonomics – The Scientific Study of Human Work.' The Boys and Girls Exhibition, sponsored by the Daily Mail, was held annually at Olympia. The exhibition sought to satisfy its youthful audience's interest in sports, technology, cars, pop music and fashion. Stone's was not the first public lecture on ergonomics, Murrell had broadcast on ergonomics on the radio programme *At Home and Abroad* in 1959,⁴⁴ whilst Michael Farr, an ergonomics consultant, appeared on Rediffusion's *Design for Living*

⁴¹ Letter Stone- Edwards 15th May 2014.

⁴² Ibid.

⁴³ See Section 4.4. Part of the anthropometry studies were funded by the Royal Institute of Architects.

⁴⁴ BUSCA DM 26/4821. Extract from "At Home and Abroad". Home Service, March 1957.

television series discussing clothing ergonomics.⁴⁵ The Loughborough stand is shown at Figure 6-7 where examples of the extra-mural work that the department had attracted may be seen. The study into golf swing was for the Golf Society of Great Britain whilst measurement of pedal thrust came from the BMC contract.



Figure 6-7. The Loughborough College of Technology Stand at the Boys and Girls Exhibition at Olympia in 1964/65.⁴⁶

Following the Robbins report into Higher Education, Loughborough was granted degree awarding powers in 1964. Initially, the department offered a four-year Bachelor of Technology (B.Tech) in Ergonomics and Cybernetics course. This attracted sixteen students.⁴⁷ In 1967 the course was reduced to three years and renamed Bachelor of Science (BSc) in Ergonomics. Cybernetics was removed from the title, as Chapman had left and was not replaced. Despite best efforts, cybernetics did not flourish at Loughborough. Attempts had been made to run week-long courses from 1962 onwards, but these attracted little interest.⁴⁸

By 1971 the department offered three postgraduate courses, an ergonomics course which extended and deepened the content of the taught BSc. Ergonomics for Architecture and Building Services which covered spatial environment, toxicity,

⁴⁵ Victoria and Albert Museum, Archive of Art and Design (ADD) AAD 7/94 – 1989. MF (DI) News August 1965.

⁴⁶ Letter Stone- Edwards 15th May 2014.

⁴⁷ Unattributed, Ergonomics in Action 3. The Department of Ergonomics and Cybernetics, Loughborough University of Technology. *Applied Ergonomics*. 1971, 2, 44 - 55.

⁴⁸ Letter Stone- Edwards 15th May 2014.

sociological considerations of the built space and windowless buildings, and a human biology course which included anthropometry, nutrition and biomechanics.⁴⁹ Floyd had also developed a multi-disciplinary teaching staff, which included Ernest Hamley, a physiologist from UCL, whose main interests included the muscular effects of exercise and manual handling, and John Atha, a biomechanician from the University of Wisconsin.⁵⁰ Both developed strong links with the Loughborough sports science group, enabling techniques such as motion analysis to be further refined as a tool for ergonomics analysis. By 1971, the department had an annual intake of twenty undergraduate and postgraduate students: within five years, this figure had tripled.⁵¹

The Ergonomics Department was established in anticipation of Loughborough being granted university status. The impetus came not from human scientists, but from senior engineering trained figures in the College, Haselgrave and France, who appreciated the political, academic and financial benefits to be gained by establishing the department. Floyd, for his part, grew the department based on a strong outreach programme to other establishments and by organising short non-degree awarding courses aimed at engineers and designers. This outreach programme was critical in establishing an academic network with other institutions. This enabled the exchange of knowledge, techniques and students between the ergonomics department and other academic departments, such as architecture at Cheltenham and, through the short course education programme, industry, building a network of actors with a professional interest in ergonomics. It also appears to have opened new research funding opportunities for the department. The formation of the Ergonomics Department created an institutional environment where the science could flourish, or as Lenoir puts it, “the translation and insertion of that style of work into service roles within the existing intuitional context as part of a disciplinary programme promoted by an institutional builder.”⁵² In this case, the institutional builders were Haselgrave, France, Floyd and his team.

⁴⁹ P. Stone and S. Kirk. Obituaries: Professor William Frederic Floyd. *News@lboro*. 2005, p 11.

⁵⁰ *Ibid*.

⁵¹ Unattributed, Human Sciences 1960 – 1981 Twenty One Years. Loughborough University.

⁵² Lenoir, (1997), p. 61.

6.3: The Department of Engineering Production and Ergonomics, Birmingham.

The previous section considered the case where a new capability was developed to meet institutional political, academic and financial goals. At Birmingham, ergonomics was initially taught as part of short-duration non-credit-bearing courses, and was subsequently developed to be an integral part of degrees awarded by the Department of Engineering Production. I will examine the development and structure of the Birmingham course and show how ergonomics was shaped locally. This section also offers an exploration of the regional responses to the call for enhanced productivity in post-war Britain.

Engineering Production is defined as “the planning, organising and control of manufacturing industry, more specifically, with the production engineering and production management functions.”⁵³ The professional body, the Institution of Production Engineers, was formed in 1921 in response to the “unprecedented demand for the supply of armaments (which) entailed a complete revision of methods of production.”⁵⁴ It grew rapidly in the inter-war years, attracting membership from academics and industrialists alike, established a network of local branches and published its own journal, *The Production Engineer*.⁵⁵ Now renamed the Institution of Engineering and Technology, it has a worldwide membership of 167,000 and, in addition to setting engineering standards, accredits university courses and has an outreach programme to schools and colleges to provide career guidance.⁵⁶

The Engineering Production Department at Birmingham was formed in 1945 when the James Lucas Company endowed a personal Chair,⁵⁷ with T. U. Matthew (Figure 6-8) appointed in 1948 as its first professor.⁵⁸ Matthew graduated in engineering from

⁵³ N. Dudley, Engineering Production in Theory and Practice, *Production Engineer*, (1964), 43, 84 - 87.

⁵⁴ Unattributed, The Institution of Production Engineering: a Brief History, *Production Engineer*, (1947), 26, 145 - 147.

⁵⁵ Ibid.

⁵⁶ The Institution of Engineering Technology, The IET Story, <http://www.theiet.org/about/video.cfm>, accessed 12th November 2016.

⁵⁷ N. Dudley. Introduction of a B.Sc. Honours Course in Engineering Production in the University of Birmingham. *Production Engineer*, (1962), 41, 424 – 425. See also TNA BT 194/16. Proposals affecting the development of the Department of Engineering Production and the Creation of a Midland Advisory Council on Industrial Productivity 25th June 1948. This provides a short discourse on the formation of the department, the work it would undertake and how it fitted into the academic framework at Birmingham.

⁵⁸ N. Dudley, Obituary Dr T U Matthew. *Nature*, (1962), 195, 4837, p. 121.

King's College, Cambridge, and had been a production engineering consultant before coming to Birmingham.⁵⁹ He believed that his graduates not only needed to understand and be capable of implementing the principles of engineering production, they also needed to appreciate and apply disciplines outside their core area, such as operational research and human factors.⁶⁰ This, he believed, would make his students both more distinctive and employable.



Figure 6-8. Professor T. U. Matthew.⁶¹

On his appointment Matthew wrote to the University Vice Chancellor, Raymond Priestley, suggesting that the University, the Birmingham Chamber of Commerce, FBI and Trade Unions should form the Midland Advisory Council on Industrial Productivity.⁶² He argued that this body could provide local industrial groups with assistance in “education, training and research and for the application of Engineering Production methods, on a voluntary co-operative basis.”⁶³ Further, a “joint organisation of this type ... will lead to closer co-operation between university departments and Midland industries, both from the standpoint of the application of science in industry and of the development of new methods of production and

⁵⁹ Ibid.

⁶⁰ Ibid.

⁶¹ T.U. Matthew, *The Engineer and the Automatic Factory – a Challenge to the University*, *Journal of the Institution of Production Engineers*, (1955), 34, 582 - 588.

⁶² MRC.MSS.292/571.7/1. Committee on Industrial Productivity. Midland Advisory Council on Productivity. C.I.P. (48) 19 11th May 1948. Annex B p. 2.

⁶³ Ibid.

industrial organisation.”⁶⁴ The Council was not the first such body. A Manchester Joint Research Council had been established in 1944 with the aim of exploiting academic research into local industry, but did not seek to undertake research with industry.⁶⁵ Priestley was fully supportive and wrote to Tizard, the Chair of CIP (see Section 2.6), asking if he would be prepared to appoint a member to sit on the Council.⁶⁶ Schuster and Solly Zuckerman were nominated to fulfil this role.⁶⁷

Matthew proposed that the Council be supported by an Advisory Panel drawn from the staff of Midland’s universities, industries, and RAs, such as British Cast Iron RA which was in Alvechurch.⁶⁸ This would provide “an immense resource capable of being brought to bear on the immediate problems of increasing industrial productivity.”⁶⁹ Such a Council would place his department, and the University, in a position of influence within Midlands industry. It could also serve as a vehicle to establish Engineering Production as a technique to address the productivity drive in the UK, and, potentially, develop student secondments and employment opportunities for graduates. The relationship with industry was not universally smooth. The Iron Foundries Trade Association told its members to have nothing to do with the Council as it was “working in an underground way towards nationalisation of the foundries.”⁷⁰ Matthew also wanted an underpinning research programme to support his vision of Engineering Production as a multi-discipline science.

Matthew was advised by Alexander King, from the Lord President’s Office, to write to Schuster asking if CIP (HF) would be prepared to fund a human science research programme.⁷¹ In the letter Matthew pointed out that he needed such a programme to allow the department to employ men of research fellow status. He continued that he was “most grateful for ... your suggestion to Mr Stedeford ... to endow a Research Fellowship.”⁷² Stedeford was the chairman of Tube Industries (TI) which had a

⁶⁴ Ibid, p. 3.

⁶⁵ TNA BT 195/6. Letter Blaker (Treasury) to Johnson (Scottish Home Office) 1st December 1948. The Manchester council was chaired by Sir Raymond Streate, who sat on the CIP main council. This was co-chaired by Stopford. Other members included Blackett and Polyani. The Manchester Joint Research Council, 1948. EA/62. RB/2/42/05 8th Nov 1948.

⁶⁶ MRC.MSS.292/571.7/1 letter Priestley to Tizard 15th April 1948.

⁶⁷ MRC.MSS.292/571.7/1. C.I.P (48) 3rd Meeting 12th May 1948.

⁶⁸ MRC.MSS.292/571.7/1 letter Priestley to Tizard 15th April 1948. Annex B. p 3

⁶⁹ Ibid.

⁷⁰ TNA BT 195/6. Letter Belson (Secretary of the Council) to Blaker 20th Jan 1949.

⁷¹ MSS.292/571.7/1. Letter Matthew to Schuster. C.I.P. 48 (23) 21st July 1948.

⁷² Ibid. There is no record of Schuster’s recommendation or how it was elicited.

Research and Development Department at Walsall Airport.⁷³ This would appear to be the first interaction of TI with the department, as I discuss below they were to later provide a fellowship in ergonomics.

Matthew's proposal contained what he termed three basic and seven other projects.⁷⁴ He estimated that each project would take two years to complete and cost between £5,000 and £6,000. Although they addressed issues that the government considered important in alleviating the productivity crisis, e.g. dissemination of information, they lacked substance. King's review identified that some would be best carried out in government, whilst others were inappropriate as Matthew's department did not have the requisite skill to address them. Further, they were written in such general terms that it was difficult to understand what he intended. King rejected all the proposals.⁷⁵

The proposals were a statement of Matthew's aspiration for a multi discipline teaching and research capability within the department. In his opinion "progress in scientific management, in human relations in industry and in planning for a major increase in industrial productivity must be based on a wide programme of research of this nature, preferably carried out ... by a team within a university department."⁷⁶ The bid had included informatics, operational research, engineering productivity, economics, human factors and design. Matthew understood that these disciplines were inter-related, for example incentives have a strong economic basis, but human relations studies would identify the social impact of the type of inducements. Matthew

⁷³ D. Melford, P. Duncumb, M. Stowell and B. Graham, Tube Investments Group Research Laboratory, Hinxton Hall (1954 -88). *Notes and Records of the Royal Society*. <http://rsnr.royalsocietypublishing.org/content/64/3/287.article-info> accessed 25th June 2013. Murrell formed the first industrial based ergonomics unit at the Walsall facility in 1952, with the remit to research customer complaints and production problems.

⁷⁴ The basic projects were the classification and dissemination of scientific information to reduce the time lag between scientific discovery and its application in a civil setting. The characterisation of the productivity levels attainable in the basic industries using advanced technological methods. An examination of economic and other factors affecting the industrial use of natural resources, and the extent to which the resources were taken from within or outside existing industrial areas. The seven other projects were; Investigations of the accuracy of work measurement; the accuracy of job evaluation methods; the relative effects of different incentive applied to various categories of industrial workers; the effects of the design of tools on human energy expenditure and operating fatigue; the effect of training operators on the accuracy and output of various types of skilled and unskilled work; the accuracy of manual control of machine tools and semi-automatic machinery; the effect of design of products on the economics of production.

⁷⁵ MSS.292/571.7/1. University Research Projects. C.I.P (48) 24 27th July 1948.

⁷⁶ MSS.292/571.7/1. Letter Matthew to Schuster. C.I.P. 48 (23) 21st July 1948. p 3.

had been unsuccessful in establishing a research programme, but he was now developing short courses in Engineering Production which included ergonomics.

In 1949 Matthew instigated operational research and work study summer schools for business executives.⁷⁷ These were replaced in 1950 by residential courses⁷⁸ where lecturers included Owen Wansborough-Jones, Chief Scientist to the Ministry of Supply, Sir Charles Goodeve and P.M.S. Blackett.⁷⁹ Specialist lectures were on market research, linear programming and human factors and productivity. These were not given by members of the ERS, but by Charles Oakley, who was a lecturer in management studies at Glasgow.⁸⁰

The 1950/51 syllabus included lectures on selection and training, operational analysis and principles of motion study. Students were also required to attend lectures on physiology, occupational health and experimental psychology.⁸¹ The 1951/52 syllabus stated that “attention is given to the human factor in industry; the physical and psychological environment of work; and the development of the personnel management functions.”⁸² The latter syllabus shows that rather than the human sciences being an adjunct to the course – ‘attend lectures on physiology’ – human factors was being woven into the syllabus to become a major contributor. This change in emphasis could have been the result of Matthew hosting the 1951 ERS conference.

Matthew had been elected to the ERS in 1950⁸³ and early in the planning for the 1951 Symposium on Human Factors in Equipment Design⁸⁴ he invited the Society to hold the meeting at Birmingham.⁸⁵ Hosting the symposium, which was opened by the Director of DSIR, Lockspeiser, would engender an association between engineering production and ergonomics at Birmingham amongst industrialists and academics. It could help establish potentially prestigious contacts within those organisations.

⁷⁷ Kirby, 2003, p. 370.

⁷⁸ K. B. Haley, War and Peace: The First 25 Years of OR in Great Britain, *Operational Research*, (2002), 50, 82 - 88.

⁷⁹ R. T. Eddison, Operational Research Course at Birmingham University, *Operational Research Society*, (1953), 4, 77 – 80.

⁸⁰ Dr Charles Oakley, CBE, JP, LDD, *Contact*. May 1977.

⁸¹ Email Birmingham University Special Collections – Edwards 11 April 2014.

⁸² *Ibid.*

⁸³ Unattributed, ERS Membership list 1951/52.

⁸⁴ W. F. Floyd and A. T. Welford, *Symposium on Human Factors in Equipment Design*, London, H.K. Lewis, 1954.

⁸⁵ Edholm and Murrell (1973).

Following the symposium Matthew started developing an ergonomics capability by employing W. D. Seymour, an occupational psychologist, who had worked for the NIIP and IHRB before the war, to provide lectures on the residential courses.⁸⁶ He then persuaded Seymour to apply, successfully, for a TI Fellowship to study the nature and acquisition of industrial skills. Through his links to the APU Seymour borrowed and adapted experimental equipment, thereby cementing professional and academic links with Cambridge, further growing the department's network. In 1954, the TI Fellowship ended, but funding was secured from the IEC to allow the work to continue and recruit staff to support Seymour.⁸⁷

Matthew left Birmingham in 1955 to become Production Director at TI and was replaced as Head of Engineering Production by Norman Dudley.⁸⁸ Dudley had joined the department in 1952 and was appointed to the Lucas Chair in 1959.⁸⁹ Matthew made important contributions to the development of both engineering production and ergonomics at Birmingham. His concept of engineering production being supported by complementary or enabling sciences resulted in a partially successful attempt to develop both courses and a research programme to support this notion. He developed, for the time, innovative curricula which included operational research, work study, physiology and psychology. He appreciated the inter-relationship between engineering production and ergonomics which was exemplified when, in 1957, he endowed the department with the TI Fellowship in industrial ergonomics.⁹⁰ The first person to hold this award was E. Nigel Corlett.

Corlett (Figure 6-9; overleaf) gained a BSc in Engineering from Loughborough and was initially employed by Servis as Head of Design and Development.⁹¹ His interest in ergonomics had been kindled by a visit to a DSIR productivity exhibition in 1953⁹²

⁸⁶ W. D. Seymour, William Douglas Seymour. *Occupational Psychology Through Autobiography: Journal of Occupational Psychology*, (1979) ,52, 241 - 253.

⁸⁷ STAN B100. HF (IE) (53) 13. Application for Conditional Aid Funds for Factors Affecting Individual Efficiency from The Department of Engineering Production, Birmingham University. 23rd June 1953. Matthew submitted 3 proposals which were poorly received, attracting comments such as "overly ambitious and poorly defined .. not clearly thought through proposal". Even when re-submitted aside from Seymour's work the views ranged from "vague" to "doubtful of the worth of the work."

⁸⁸ Email Corlett – Edwards. 30 December 2011.

⁸⁹ Norman Dudley, Engineering Production Research, *The Production Engineer*. (1960), 39, 195 - 209.

⁹⁰ Ibid.

⁹¹ Email Corlett – Edwards. 30 December 2011.

⁹² Ibid.

and he became a regular attendee at ERS conferences.⁹³ He left Servis in 1957 to undertake a PhD at Birmingham in the human factors of machine control. He also lectured on ergonomics to the postgraduate engineering production courses and to the short courses on engineering. Corlett and Dudley would now carry forward Matthew's vision and grow an ergonomics capability at Birmingham which enabled Engineering Production.



Figure 6-9. E Nigel Corlett.⁹⁴

Up until the early 1960's the terms of the Lucas Chair precluded the department from introducing a first degree in engineering production. In addition, the Institution of Production Engineers believed that there was insufficient worldwide research to provide an academic basis for a degree course.⁹⁵ In 1962, however, Dudley announced the introduction of a BSc honours course in Engineering Production at Birmingham, claiming, as justification, the existence of a "substantial body of knowledge that could properly be treated at undergraduate level."⁹⁶ Nottingham had just launched a similar degree course and established a Department of Production Engineering.⁹⁷ Dudley's move, like that of France and Haselgrave at Loughborough,

⁹³ Edholm and Murrell, (1973) p. 18.

⁹⁴ E.N. Corlett, The factory and its people, *Production Engineer*, (1974), 53, 377 - 382.

⁹⁵ Norman Dudley, Introduction of a B.Sc. Honours Course in Engineering Production in the University of Birmingham, *Production Engineer*, (1962), 47, 424 - 425.

⁹⁶ *Ibid.* He does not explain where, or how this body of knowledge arose.

⁹⁷ *Ibid.*

was to ensure that Birmingham could compete for students and funding. Dudley argued that through the development of this knowledge, and the contribution of both ergonomics and operational research as supporting specialities production engineering could now be recognised as a discipline – the embodiment of Matthew’s vision for engineering production. Dudley wrote, “Production engineering has often been referred to as a meeting place of many disciplines; if so, there would be no case to be made for the introduction of a first degree. The emergence of ergonomics, concerned with the interaction of psychological, physiological, technical and economic forces, mainly at the level of the individual process, and of operational research, concerned with the interaction of technical, economic and social and other forces, mainly at the overall planning level have, in large measure, shown that to the production engineer the division between production technology and production management is an artificial one. Production engineering can now be seen ... as a discipline in its own right, supported by studies in many contributing fields, but itself primarily concerned with using and co-ordinating these forces in quest of efficient production.”⁹⁸

Dudley does not show how he came to conclude that engineering production was a ‘discipline’ but highlights that it is underpinned by complementary subjects such as ergonomics and OR. By implication, the complementary disciplines were being shaped at Birmingham to meet the requirements of engineering production. This is supported by analysing Corlett’s early research output. Studies included an analysis of the factors which affected the consistency of handwheel setting,⁹⁹ how semi-skilled operators controlled the use of drills¹⁰⁰ and the performance of arc-welding.¹⁰¹ These were directed at answering specific ergonomics questions regarding human control of movement in engineering production tasks. At Birmingham, ergonomics was directed at solving Engineering Production problems.

In describing the syllabus (Table 6-1; overleaf) Dudley wrote that “The first year of the course comprises mainly appropriate basic science subjects, the second year mainly science applied to various aspects of production, and the third year

⁹⁸ Ibid.

⁹⁹ E. N. Corlett, The Accuracy of Setting of Machine Tools by Means of Handwheels and Dials. *Ergonomics*, (1961), 4, 53 - 62.

¹⁰⁰ E. N. Corlett, Human Factors in Machine Control, *Ergonomics*, (1962), 5, 217 - 227.

¹⁰¹ E. N. Corlett and J. W. Goodhand, A Preliminary Investigation of Human Factors Problems in Semi-Automatic Arc Welding. 1. The Effect of Limiting the Field of Vision on Tracking Performance with Various Shaped Tracks. *International Journal of Production Research*, (1965), 4, 115 - 189.

concentrates particularly on those subjects which demonstrate the interaction of the many factors involved in the planning and control of production processes and of manufacturing systems.”¹⁰² The second year syllabus also included physiology, work analysis and experimental psychology. Students were expected to have an understanding of the underpinning disciplines of physiology and psychology before they were taught ergonomics.

First Year	Second year	Third Year
Mathematics	Mathematics	Analytical Method
Physics	Statistics	Control Theory
Electrical Engineering	Metrology	Engineering Production Analysis
Mechanical Engineering	Electronics	Control of Production
Chemistry	Production Engineering Science	Ergonomics
Metallurgy	Chemical Processes	Industrial Sociology
Engineering Drawing	Metalworking Processes	Industrial Legislation
Engineering Production	Production Organisation	
Industrial Economics	Costing and accounting	
	Physiology	
	Work Analysis	
	Experimental Psychology	

Table 6-1. Initial Course Structure for BSc in Engineering Production at Birmingham.

Dudley proposed that an MSc in Industrial Ergonomics should be offered, with Corlett as senior lecturer.¹⁰³ This first ran in Autumn 1963 with seven students and continued until the 1980s when Corlett moved to Nottingham. The first timetable is shown in Table 6-2, overleaf. Lectures were given by Corlett, Dudley and a physiologist, Ben Davies. An analysis of the Master’s and Doctoral theses reflected the applied nature of the course, titles included work place design and operator performance, operator response in conveyor based work and the ergonomics of a hot rolling mill.¹⁰⁴

¹⁰² Dudley, (1962).

¹⁰³ Email Corlett – Edwards. 30 December 2011.

¹⁰⁴Ibid.

Autumn Term	Spring and Summer Terms
Workplace and Equipment design	Ergonomics and the working environment.
Models of human performance and their applications	Industrial Health practice
Industrial Sociology	Ergonomics of Industrial Inspection
Measurement and Evaluation of Human Industrial Performance	Industrial Sociology
Quantitative Methods	The Human Operator in Process control
Engineering Production	Quantitative Methods
Technology for non-engineers	Work design and Organisation
Professional Ergonomics studies	Engineering Production
	Advanced Ergonomic options
	Professional Ergonomics studies

Table 6-2. Initial Course Structure for MSc in Industrial Ergonomics at Birmingham.¹⁰⁵

Approximately ten students graduated annually with either a Master's degree or a doctoral award. It has not been possible to trace the later career of most of these students but two progressed to have international careers. Gavriel Salvendy, the current Professor of Industrial Engineering at Purdue and the founding editor of the *International Journal on Human – Computer Interaction*, graduated in 1965. He was the first ergonomist to be elected to the US National Academy of Engineering,¹⁰⁶ and is also the author of the *Handbook of Human Factors and Ergonomics*¹⁰⁷ which is considered a key ergonomics text. C. G. Drury, the Chair of the Department of Industrial Engineering at the University of Buffalo graduated the following year. A prolific author of papers on human factors in industrial engineering, he won both the ERS Bartlett medal and the Fitts award from the Human Factors and Ergonomics Society for his contribution to ergonomics.¹⁰⁸ Both have continued to combine ergonomics and production engineering in their teaching and research.

The department attracted finance from sources such as the Welding Institute, which funded studies into the ergonomics of spot welding. The SRC provided grants to study

¹⁰⁵ Ibid.

¹⁰⁶ Unattributed, Synopsis Gavriel Salvendy (2008), <https://engineering.purdue.edu/~salvendy> accessed 10th August 2014.

¹⁰⁷ G. Salvendy. *Handbook of Human Factors and Ergonomics*. Hoboken, Wiley, 2012.

¹⁰⁸ Unattributed, Colin G. Drury, (2005), <http://www.eng.buffalo.edu/~drury> accessed 10th August 2014.

computer models for noise prediction and optimisation of control layout for vertical boring machines. The SSRC sponsored studies into the effectiveness of changes in industry and learning and the control of limb movement.¹⁰⁹ Corlett also set out to raise the international profile of the department and to cement its central position in ergonomics in the UK by hosting the 1967 IEA conference.

I have previously described how the ERS declined to be involved in the formation of the IEA, and, to improve relationships the UK was invited to host the 1967 conference.¹¹⁰ Initially five venues were considered: London, Loughborough, Cambridge, Cranfield and UWIST.¹¹¹ Thomas Cook, the conference organisers, proposed that the chosen venue should be capable of hosting up to 1,000 delegates. This eliminated UWIST, and Birmingham was added. Thomas Cook then rejected Birmingham, suggesting that foreign visitors would view it as “the grimy centre of British industry” and would stay away.¹¹² Corlett wrote to the ERS pointing out that Thomas Cook had approached the University to host World Cup footballers: he could not understand why the setting was deemed suitable for international footballers but not academics!¹¹³ He closed by noting that Dortmund had hosted the previous conference and its reputation as a grimy industrial centre was worse than Birmingham’s.¹¹⁴ Birmingham was reinstated and was ultimately given the honour of hosting the conference.¹¹⁵ By dint of his efforts, Corlett had successfully raised the profile of the department to an international level and given students the opportunity to interact with leading ergonomists.

Corlett also sought to cement Birmingham’s position by managing the production of *Ergonomics Abstracts*. As explained earlier, WSL had produced *Ergonomics Abstracts* in conjunction with Tufts University,¹¹⁶ but the closure of WSL threatened the service’s future. Corlett, clearly aware of this issue, obtained, in 1969, a grant from the Office for Scientific and Technical Information¹¹⁷ to form, with J.G. Fox,

¹⁰⁹ MSc Course Syllabus undated.

¹¹⁰ BUSCA DM 26/4815. Minutes of the Ergonomics Research Society Council Meeting 6th April 1964.

¹¹¹ BUSCA DM 26/4817. Letter Floyd to Jones 11th February 1964.

¹¹² BUSCA DM 26/4826. Letter Corlett to Sell undated.

¹¹³ Ibid.

¹¹⁴ Ibid.

¹¹⁵ BUSCA DM 26/4815. Minutes of the Ergonomics Research Council meeting 5th April 1965.

¹¹⁶ An example of the Abstracts can be found at Abstracting Service, *Ergonomics*, (1965), 8, 111 - 132.

¹¹⁷ The Office for Scientific and Technical Information was part of the Department of Education.

who had arrived from WSL, the Ergonomics Information Analysis Centre.¹¹⁸ This would provide “appropriate information for research workers and practitioners in ergonomics and the evaluation of methods of communicating research in this area.”¹¹⁹ Collaboration with Tufts was maintained to “ensure that both centres will be able to sustain a claim to virtually world-wide coverage of the appropriate literature in their information stores.”¹²⁰ It was, and remains, the largest repository of ergonomics knowledge¹²¹ and further cemented Birmingham’s significant position in ergonomics both nationally and internationally.

The department continued to flourish during the 1970s, as did Corlett’s career. In 1980 he moved to Nottingham to become Cripps Professor of Production Engineering.¹²² The Birmingham capability is enduring and today researches cognition and simulation and training technologies,¹²³ remaining in the Engineering Department. The vision for the capability belonged to Matthew, who saw engineering production as a discipline which was supported by information and methodologies from complementary sciences such as OR and ergonomics. He also understood the need to establish a research programme in those sciences to provide the knowledge that was tailored to the needs of engineering production at Birmingham.

Matthew’s vision was continued by Dudley and Corlett, who further shaped ergonomics, as delivered at Birmingham, to meet the needs of the Engineering Production Department. This concept of ergonomics and engineering production was exported to the US through the subsequent careers of their students, Salvendy and Drury. These case studies have demonstrated that ergonomics as practised at both Loughborough and Birmingham was shaped by local factors. At both centres, however, the development of course structure was dependent upon the inter-relationships between formal degree-level and residential non-credit-bearing courses. This section has considered the case where non-credit bearing ergonomics courses

¹¹⁸ BUSCA DM 26/4830. Letter Fox to Edholm E/IC/2/1/3/2 dated 23rd January 1969. Fox had managed the abstraction service at Warren Spring and was now employed by Birmingham.

¹¹⁹ Ibid.

¹²⁰ Ibid.

¹²¹ <http://www.tandf.co.uk/journals/pdf/ergonomics/teab-demo.pdf> accessed 11th January 2016.

¹²² Email Corlett – Edwards. 30 December 2011.

¹²³ The ergonomics capability is now part of the School of Electronic, Electrical and Systems Engineering. For examples of recent work see Chris Baber, Distributed Cognition at the Crime Scene. *AI and Society*, (2010), 25, 423 – 432. Robert J. Stone, The (Human) Science of Medical Virtual Learning Environments, *Philosophical Transactions of the Royal Society B*, (2011), 366, 276 - 285.

were offered by academic institutions. In the next section the case is considered where a non-credit-bearing course was offered by a non-academic provider.

6.4: The West of England Engineering and Allied Employers' Association Ergonomic Courses for Industry.

Short courses in ergonomics were provided by non-academic institutions from the early 1960s. Attention has also been drawn to the BPC "Fitting the Job to the Worker" courses (Section 2.9), and it is known that the TUC also provided in-house ergonomics lectures separate from those described in Chapter 5. Information on these courses is either limited or non-existent. In comparison, the Murrell archive has shed some light on the ergonomics courses provided by the West of England Engineering and Allied Employers' Association based in Bristol.

The West of England Engineering and Allied Employers' Association was one of many local committees founded by the Engineering Employers Federation in the 1920s.¹²⁴ In 1953 a Department of Work Study and Staff was established under G. P. Wade¹²⁵ to "assist companies in the efforts they are making to achieve greater efficiency and higher productivity."¹²⁶ The following year work study courses commenced as an educational training services to local industries.¹²⁷ In 1957, Murrell approached Wade suggesting that a pilot course in ergonomics, which would be aimed specifically at designers and middle managers, should be launched. Wade, who had been taking an interest in the development of ergonomics, accepted the proposal and suggested that in order not to "frighten off managers unfamiliar with the term ergonomics"¹²⁸ the course be titled 'The Design of Equipment for Human Use.' Courses were residential, lasted two weeks with lecture rooms and laboratory space being made available on the Association's premises.¹²⁹ Courses were advertised in

¹²⁴ The Employers' Federation of Engineering Associations was established in 1896 and in 1918 merged with the National Employers' Federation, being called the Engineering and Allied Employers' National Federation. It retained this title until 1961, when it reverted to the Engineering Employers' Federation (EEF). The EEF "helps to foster enterprise and innovation, keeping businesses safe, compliant and future-focused ... providing essential business support and training, championing our industry within government in the UK and in Europe. Our business support services cover human resources and employment law, productivity improvement, research and intelligence, health, safety and environmental issues." The Engineering Employers' Federation, <http://www.eef.org.uk/> accessed 18th December 2014.

¹²⁵ It is not known if other branches also established such departments. Nothing is known about Wade.

¹²⁶ Wade, (1960).

¹²⁷ Ibid.

¹²⁸ Ibid, p.14.

¹²⁹ Ibid, p. 154.

trade journals and cost £40 in 1958.¹³⁰ The curriculum for the fifth course (Figure 6-10) was a blend of lectures in basic ergonomics and work study techniques. There were also lectures on statistics and practical experimentation, which were included to encourage the attendees to be sufficiently confident to use ergonomics and work study techniques in the workplace. The course aimed to provide attendees with a working knowledge of ergonomics and its application. Additionally, it aimed to show how ergonomics interacted with other disciplines, such as work study. Wade believed that qualified designers should first take a course in method study (which is the systematic study of the work process) and, after a period of practice, should then take a course in ergonomics.¹³¹

ENGINEERING EMPLOYEES' WEST OF ENGLAND ASSOCIATION DEPARTMENT OF WORK STUDY & STAFF TRAINING.		The Design of Equipment for Human Use - Course No: 5.	
PROGRAMME.		PROGRAMME - Ctd.	
FIRST WEEK.		SECOND WEEK.	
MONDAY, 21st November.		MONDAY, 28th November.	
9.30 - 10.30.	Introduction to the Course.	9.30 - 10.30	The Human Factor in Equipment Design.
10.45 - 12.15.	The Human Being as a Receiver and Processor of Information I.	10.45 - 12.15	The Working Environment. Lighting & Colour I.
1.45 - 3.15	Anthropometry, Seating & Manual Weight Lifting.	1.45 - 3.15	The Working Environment. Lighting & Colour II.
3.30 - 5.00	The Need to Experiment & problems of experimenting on Human Performance.	3.30 - 5.00	The Use of Statistics III.
TUESDAY, 22nd November.		TUESDAY, 29th November.	
9.00 - 10.30	The Human Being as a Receiver & Processor of Information II.	9.00 - 10.30	The Layout of Equipment.
10.45 - 12.15	Body Structure & the limits of limb movement.	10.45 - 12.15	Ergonomics in the Electronics Industry.
1.45 - 3.15	Display of Information I.	1.45 - 3.15	Experimental Work.
3.30 - 5.00		3.30 - 5.00	
WEDNESDAY, 23rd November.		WEDNESDAY, 30th November.	
9.00 - 10.30	The Use of Statistics I.	9.00 - 10.30	The Working Environment - Radiant Heat and Noise.
10.45 - 12.15	The Body as a Heat Engine & the problem of Physical Fatigue.	10.45 - 12.15	Fitting the Man to the Job.
1.45 - 3.15	Planning Experiments.	1.45 - 3.15	The Application of Ergonomics I.
3.30 - 5.00		3.30 - 5.00	Physiology & Anthropometry. Experimental Work.
THURSDAY, 24th November.		THURSDAY, 1st December.	
9.00 - 10.30	Use of Statistics II.	9.00 - 10.30	Load, Speed and Stress.
10.45 - 12.15	Display of Information II.	10.45 - 12.15	Fatigue - fact or fiction?
1.45 - 3.15	Control Design.	1.45 - 3.15	Ergonomics and Automation.
3.30 - 5.00	Experimental Work.	3.30 - 5.00	The Effect of Ageing on Performance.
5.00 - 6.30	The Contribution of Motion Study to Equipment Design.	FRIDAY, 2nd December.	
FRIDAY, 25th November.		9.00 - 10.30	The relations of the Designer with Managers and Workpeople.
9.00 - 10.30	Experimental Work.	10.45 - 12.15	The Application of Ergonomics, II, Psychology.
10.45 - 12.15	Human Problems of Inspection.	1.45 - 3.00	Discussion on Practical Exercises, and Closing Discussion.
1.45 - 4.00	Experimental Work.	3.15 - 4.00	

Figure 6-10. Design of Equipment for Human Use Curriculum for Course 5.¹³²

Most, if not all visiting lecturers were ERS members or well known to Murrell (Figure 6-11). Edholm lectured on physical strength, Shackel on workplace design, and Welford on ergonomics and automation. Birren was a visiting lecturer at Cambridge at the time.¹³³ This range of nationally and internationally renowned

¹³⁰ BUSCA DM 26/4821. An Appreciation Course on Designing Equipment for Human Use. 1958.

¹³¹ Wade, (1960), p.154.

¹³² BUSCA DM 26/4821. Design of Equipment for Human Use Curriculum for Course 5.

¹³³ BUSCA DM 2648/21. Letter Birren to Murrell 24th October 1960. James E Birren is widely recognised as one the leading US researcher in gerontology, a synopsis of his career is in J. E. Birren, How Do I Think I Got Here, LLI review. University of Southern Maine, Fall 2006, pp. 90 – 97.

speakers gave a degree of legitimacy to the course and exposed the attendees to ergonomics being researched and practised in centres of excellence.

KEY TO LECTURERS.		
EG.	F.I. de la P. Garforth.	Dept. of Work Study & Staff Training, Engineering Employers' Association.
EG.	Dr. S.Griew.	Lecturer in Psychology, University of Bristol.
EG.	H.Murrell.	Research Fellow in Psychology, University of Bristol.
EG.	G.F. Wade.	Dept. of Work Study & Staff Training, Engineering Employers' Association.
VISITING LECTURERS.		
JEB.	Dr. J.E. Birren.	Head of the Section on Ageing, Nat. Institute of Mental Health, Bethesda, U.S.A.
OGE.	Dr. O.G. Edholm.	Head of Dept. of Human Physiology, Medical Research Council, Harpenden.
JIG.	Mrs. J.I. Grieve.	Physiological Unit, P.O. Research Station, London.
EP.	Dr. K. Provins.	Medical Research Council, Unit for Research on Climate & Working Efficiency, Dept. of Human Anatomy, Oxford.
AR.	A. Rodger.	Reader in Industrial Psychology, Birbeck College, University of London.
ES.	B. Sheckel.	Research Psychologist, E.M.I., Electronics, Feltham, Middx.
IPT.	J.F. Thomas.	Dept. of Management & Production Engineering, Brunel College of Technology, London.
DW.	D. Wallis.	Senior Psychologist's Division, Manpower Dept., Admiralty, London.
EW.	A.T. Welford.	Lecturer in Psychology, University of Cambridge.

Figure 6-11. Lecturers for Course 5 of Design of Equipment for Human Use.¹³⁴

Course attendees (Table 6-3 and Figure 6-12) seem to have been drawn from industries across the country. Both the Rover Company and Westinghouse provided continued support, which I suggest is indicative of the quality of the course, and the importance that both companies attributed to ergonomics. In addition, the broad appeal of the course is indicated by the range of other industries who funded their employees to attend. These included the confectioners J. S. Fry, car component manufacturers Coopers Mechanical Joints,¹³⁵ and toolmakers James Archdale.¹³⁶ Most, if not all, of these companies have not left an archive, making it problematic to determine why they funded personnel attending these courses. Attendance implies

¹³⁴ BUSCA DM 2648/21. Attendee lists for Courses 5 and 6.

¹³⁵ Grace's Guide to British Industrial History, Who's Who in the Motor Industry, http://www.gracesguide.co.uk/1953_Who's_Who_in_the_Motor_Industry:_Companies_C accessed 16 November 2016

¹³⁶ Grace's Guide to British Industrial History, James Archdale and Co, http://www.gracesguide.co.uk/James_Archdale_and_Co accessed 16th November 2016

that they perceived the worth of a member of staff with an appreciation of ergonomics.

Name	Company	Job Description
Philip Banks	Rover Company, Solihull	Deputy Research Engineer
Raymond Coker	BISRA, London	Human Factors Section
George Finbow	James Archdale, Worcester	Senior Designer
Raymond Gray	AEI, Manchester	Industrial Designer
Horace Guest	Rubery, Owen, Darlaston	Project Engineer
Brian Hawkin	U.K. A.E.A, Aldermaston	Engineer
D. G. Pinchon	British American Tobacco, Southampton	Work Study Engineer
B. U. Powell	British Cellophane, Bridgewater	Deputy Development Engineer
Peter Robinson	Westinghouse, Chippenham	Not Known
Graham Thompson	Austin Motors, Longbridge	Production Development Engineer

Table 6-3. Course 5 of Design of Equipment for Human Use, Attendees List.¹³⁷

ENGINEERING EMPLOYERS' WEST OF ENGLAND ASSOCIATION
DEPARTMENT OF WORK STUDY & STAFF TRAINING.

THE DESIGN OF EQUIPMENT FOR HUMAN USE - COURSE NO: 6.

February 27th - March 10th, 1961.

J. ALLEN.	Westinghouse Brake & Signal Co.Ltd., Chippenham.
R.H. ARNOLD.	The Metal Box Co. Ltd., London.
G. CROMPTON.	The Rover Co. Ltd., Solihull.
R.J. DAVIES.	J. S. Fry & Sons Ltd., Bristol.
J. HILTON.	Mather & Platt Ltd., Manchester.
P. McGOUGH.	Coopers Mechanical Joints Ltd., Abergavenny.
R.R. SADLER.	W.S. Atkins & Partners, London.
J. SUMMERS.	Westinghouse Brake & Signal Co. Ltd., Chippenham.

Figure 6-12. Course 6 of Design of Equipment for Human Use, Attendees List.¹³⁸

¹³⁷ BUSCA DM 2648/21. Attendee lists for Courses 5 and 6.

¹³⁸ Ibid.

Coker (BISRA) and Gray (AEI) both came from institutions with an existing ergonomics capability, but were not ergonomists.¹³⁹ Their attendance may have been part of a strategic plan by both organisations to grow an organic capability at a time when ergonomists were in short supply. The attendance of employees from W. S. Atkins and Aldermaston may indicate an early interest being taken by the nuclear industry in ergonomics. W. S. Atkins had been founded in 1938 as a company specialising in civil and structural engineering design.¹⁴⁰ From the mid-1950s onwards they had been involved in the emerging nuclear power industry in the UK, working on Berkeley power station.¹⁴¹ At this stage Atkins did not employ ergonomists, and so they could have been using the course to give their employees an understanding of the science which could then be used in subsequent tasks. Graham Thompson from Austin Motors was in the first cohort of students enrolled on the ergonomics course at Loughborough.

The courses continued until about 1972, when Wade retired, but it is not certain that his retirement triggered the cessation.¹⁴² The paucity of industrial archives has meant that assessing the impact of the courses on industrial practices is problematic. It is noteworthy that the courses continued for fourteen years, which is indicative of their popularity, relevance, scientific standing and perceived value for money by industry.

6.5: Conclusions.

Formal education is key in discipline formation. It provides codification of knowledge, establishment of values and identities and provides a cadre of trained and qualified students who are suitably skilled to enter employment. A considerable body of literature has reviewed the establishment of academic courses and their contribution to the shaping of science and institutionalisation. The interactions between formal and non-credit-bearing courses in discipline formation and growth has not received such detailed analysis. The case studies considered here have charted the formation and growth of formal ergonomic courses in the post-war years, and shown

¹³⁹ AEI had established an ergonomics unit under John Chris Jones in 1960.

¹⁴⁰ Unattributed, About the Group (updated August 2017), <http://www.atkinsglobal.com/en-GB/about-the-group/our-history>. Accessed 31 December 2014.

¹⁴¹ Unattributed, Celebrating Seventy Five Years, Our Founder, Sir William Atkins. <http://www.atkinsglobal.com/en-GB/media-centre/features/our-founder-sir-william-atkins>. Accessed 31 December 2014.

¹⁴² Murrell, (1980).

how non-credit bearing courses helped shape the formal degree level courses and aid the institutionalisation of ergonomics. I have also presented evidence which suggests that the nature of ergonomics was shaped by the academic direction of the host university, giving the science a strong and distinctive localisation factor.

At both Loughborough and Birmingham, the initial impetus for the courses came from the engineering community of Haselgrave and France and Matthew and Dudley respectively. At both institutions, the overarching goal was to gain a competitive edge over rival establishments by developing an ergonomics capability. Haselgrave wanted to ensure that Loughborough was prepared to accept university status by establishing an independent and unique department in a scarce science with Floyd as a respected leader. This would ensure that Loughborough would be well placed to compete for both students and extramural funding. Although located within the Engineering Department, Loughborough ergonomics was more expansive, as shown by its links to architectural departments at other institutions.

Matthew's vision at Birmingham was that engineering production would be a discipline intimately supported by other inter-related sciences. These would be taught and researched by professionals from those disciplines, who would also be members of the department. At Birmingham ergonomics was embedded in the Engineering Production Department, which resulted in it having a distinctive and different shape from that developed at Loughborough. A list of the postgraduate course reports from Loughborough published in 1970, shows that over a six-year period studies were carried out in anthropometry, information processing, equipment design and effects of the physical environment.¹⁴³ In contrast, at Birmingham over a similar period of time, nearly all projects addressed ergonomics in an engineering production context: selection tests for industrial operators and operator performance in conveyor work systems being two examples.¹⁴⁴ I have also shown how both Floyd and Matthew enthusiastically set about establishing networks which cemented the departments into the fabric of local academic and industrial institutions. This provided opportunities to exchange knowledge, place students and identify new research topics and funding providers, so further shaping ergonomics to meet local needs. Moreover, both

¹⁴³ Unauthored. Ergonomics in action-3 The Department of Ergonomics and Cybernetics, Loughborough University of Technology. *Applied Ergonomics*. (1971), 2, 44 - 55.

¹⁴⁴

institutions used non-degree-awarding courses to further build and shape their own distinctive brand.

This chapter has highlighted the distinctive shaping of ergonomics at Loughborough and Birmingham to meet local needs. Attention has already been drawn in Chapter 4 to how ergonomics research was practised at multiple academic institutions, some of which did not possess an ergonomics capability. The IEC and HSC, gave some broad direction regarding the sort of research required, but the ways and means of knowledge generation was set by local imperatives and interests. In this chapter it has been shown that at both Loughborough and Birmingham ergonomics was taught to engineers, architects and designers to enhance and enrich degree awarding and non-credit bearing courses. The science was, therefore, being distributed within the framework of the teaching of another discipline. This distribution provided a competitive edge over other academic institutions, as conceived at Loughborough, or to was used to enhance the employment chances of graduates, as at Birmingham. So, ergonomics was both a geographically and educationally distributed science. Further, teaching ergonomics as part of, for example, an engineering course would be a major contributory factor to the shaping of the science.

Offering non-credit-bearing courses in ergonomics to industry would help generate an income stream. They would also demonstrate to those companies who supported the courses the individual university's research capability and, potentially, their credibility to undertake paid research. Further, courses were residential, which provided an opportunity for social intercourse between staff and students. In such a forum, the industrial attendees would provide information to the universities of the knowledge and skills which companies considered important. This allowed universities to shape their academic course, and non-degree course content and research to address these requirements. A further consideration, certainly for Loughborough, is that students for the non-degree awarding courses came from widely geographically dispersed locations, including Sweden. This would open new markets for research, and provide a broader picture of the requirements for ergonomics research.

There has been no analysis of ergonomics educational courses delivered by non-academic institutions. In the case study reported here, the ergonomics courses were

certainly popular, as evidenced by the longevity of the courses. The contribution that these courses might have made to shaping ergonomics is difficult to assess, although Murrell has claimed that he used these courses to define the ergonomics course he was to offer at UWIST in the late 1960s.¹⁴⁵ A small volume of teaching material from these non-academic providers has survived; there is, however, a rich vein of educational material from other sources which gives a vivid impression of how ergonomics was presented to industry, academia and the general public and this has been reviewed under the work of DSIR.

¹⁴⁵ BUSCA DM 2648/20 Draft script of Undergraduate Training in Occupational Psychology. Presented at the First Annual Conference of the Occupational Psychology Section of the British Psychological Society. January 1968.

Chapter 7: Conclusions.

7.1: Overview.

In this thesis, I have sought to add to our understanding of the management of human science at the operational level in the mid-twentieth century. This has been developed through the lens of the ergonomics element of the government funded industrial human science research programme, which ran from 1947 to 1965. I have shown how the programme was managed and exploited, and how the research programme facilitated the emergence and shaping of ergonomics, both in terms of the nature of the science and its institutionalisation. I have also shown how the DSIR, TUC, the MRC and academia and key actors sought to use ergonomics to meet their own institutional goals. I have, finally, demonstrated how the institutionalisation of ergonomics was achieved with only a marginal input from its professional society. Such an observation has not been previously reported in other discipline studies.

Most studies of post-war UK scientific research have considered the strategic management of high-value, prestigious technology programmes. Such studies include the decision making processes by individual, high ranking civil servants supporting the UK space launcher programme,¹ the garnering of political and financial support for the construction of the Jodrell Bank telescope,² and the post-war development of computers in the UK.³ To this we may add Whitfield's analysis of the roles of Metrovick and government laboratories in the development of gas turbine engines,⁴ and Mort's study of the Trident programme.⁵ Collectively, these examples provide a picture of the strategic management of 'Big Science' research and development in the UK in the mid- to late-twentieth century.

This study differs from these examples in that the human science research programme was extremely low value, maximum funding being £50,000 to £60,000 per annum to cover both ergonomics and human relations research.⁶ In comparison, the Blue Streak

¹ Butler, (2016).

² Agar, (1998)

³ J. Agar, *The Government Machine. A Revolutionary History of the Computer*. Cambridge, Massachusetts, MIT Press, 2003.

⁴ J. Whitfield, *Metropolitan Vickers, the Gas Turbine, and the State: A Socio- Technical History, 1935-1960*, PhD Thesis. University of Manchester, (2012).

⁵ Mort, (2001).

⁶ Primary source information does not differentiate between funding for ergonomics and human relations research.

project had cost £60 million by 1960. This included research, development and management costs,⁷ but it is still orders of magnitude larger than sums afforded to human sciences. Further, the examples quoted above produced physical entities which represented industrial or national prestige. The human science programme, however, was aimed at supporting a political construct – productivity – and, in doing so, drew on physiology, psychology and anatomy to produce a non-physical entity – knowledge. This raises the question, how was this reflected in the management of the research programme and the institutionalisation of ergonomics?

7.2: The Government Funded Industrial Human Sciences Programme – Management and Scientific Content.

The examples of UK science and technology programmes cited above had ministerial backing and were managed by empowered executive committees comprising eminent and well-connected civil servants and scientists. As an example, the Advisory Committee on High Speed Calculating Machines was established by the ACSP and DSIR in 1949 to review the progress in design, construction and use of such devices.⁸ The committee was chaired by David Brunt, the Royal Society Secretary and vice President. Membership included Maurice Wilkes, Director of the University of Cambridge Mathematical Laboratory and Douglas Hartree, the Plummer Professor of Mathematical Physics at Cambridge: both were Fellows of the Royal Society. Another member was Lord Halsbury, the Director of the National Research Development Corporation.⁹ In addition, they were supported by a corps of scientific expert advisers drawn from academia or industry. The post-war expansion in the numbers of government based scientific advisers was fuelled almost exclusively from the physical sciences: outside the military ministries there were no senior human science advisers.¹⁰ Thus, high-value, prestige programmes were managed and guided by powerful policy makers with ministerial access.

As shown in Chapter 2, up to 1949, the human science research programme was afforded strategic support by the Lord President's Office. The presence of the Lord President's Private Secretary, Nicholson, on the management committees gave a

⁷ Butler, (2016), p.62.

⁸ J Agar, The Provision of Digital Computers to British Universities up to the Flowers Report (1966), *The Computer Journal*, (1996), 39, 630 – 642.

⁹ Agar, (2003), p.505. Halsbury was also to become chair of the ORS in 1960.

¹⁰ Vig, (1968).

direct, strategic link to central government, and a legitimacy to the programme. Ministerial support was severed when Tizard proposed that, on the closure of CIP, the human science programme should be jointly managed by the MRC and DSIR. DSIR had no direct cabinet representation and, thereafter, only DSIR civil servants sat on the management committees, providing secretarial support. Effectively, the human science research programme was being directed and managed by academics, industrialists and TUC representatives. Further, the absence of an experienced human science adviser in DSIR from 1960 onwards further strengthened the position of those managing and directing the programme.

Stansfield was recruited by DSIR in 1950 to provide human science advice, and Chapters 2 to 4 describe the work he performed to construct and support both the human science research programme and ergonomics. His resignation in 1960 removed the sole DSIR employee who understood the totality of the ergonomics and human relations research programmes. His departure also meant that expert knowledge of the human science programme now resided with actors such as Drever and Fletcher, who were not employed by DSIR. Now managerial control and corporate knowledge of the human science programme was, effectively, outside government. There were reporting chains back to the DSIR Research Council. Available evidence suggests that the RC was more concerned with strategic issues, such as the formation of a human science research association, rather than the health of the research programme. Such a case where the management of a semi-official government research programme had 'drifted' into the hands of empowered non-government employees has not previously been identified.

A further observation is the positive effect of the absence of government interference on the human science research programme. Bureaucratic histories of large-scale technology programmes have shown how delays may occur through political manoeuvring resulting from economic, home or foreign policy imperatives.¹¹

Because the human science programme was operating without government oversight such extrinsic factors had minimal effect. Further, its low value meant that, except for the issue of the failed bid to the Treasury (Section 3.3), it did not attract attention during savings rounds. The programme progressed unaffected by external pressures.

¹¹ Butler, (2016).

How was this level of autonomy reflected in the ergonomics content of the research programme?

Chapters 2 to 4 have shown how the overarching research requirement for each committee changed over time. The output of the CIP (HF) human engineering programme was aimed at promoting productivity. The IEC programme was constructed against a requirement, probably developed by the MRC, for research which had a “bearing on the technical efficiency of the individual.”¹² The HSC’s requirement, however, which was probably developed by Stansfield, was more clearly defined. This called for research in certain areas, “especially the human aspects of equipment design and at problems of training.”¹³ So, as programme management passed into the hands of scientists the research requirement gained a degree of broad-based definition. Training was specified, but research proposals could address individual, team or group training, or the tools and techniques to deliver training. The requirement was directing researchers to consider top level areas in ergonomics which the HSC believed deserved research. In short, the meaning and scope of ergonomics remained undefined and open to different imaginings.

This clearer definition in requirement specification resulted in the broad, but targeted, research programme that is shown in Table 4-4. This clarity of requirement may have also have encouraged universities, such as Keele, which had not previously applied to either CIP (HF) or the IEC, to submit research proposals. This downward delegation and clarity in research requirements which provided the environment for shaping the content of the science of ergonomics. If this shaped the science content, how was ergonomics institutionalised?

7.3: How was Ergonomics Institutionalised?

Comparable studies of scientific disciplines have pointed to the active role played by learned societies, such as the Biochemical Society and the OR Society, in the institutionalisation and professionalisation of their respective sciences.¹⁴ Such studies show how politically powerful members of these societies used their influence to either gain financial backing for the science, or to raise the profile and awareness of

¹² STAN B100 MRC.53/345 IE.Ag.1 22May 1953

¹³ TNA DSIR 17/728. Report of the Research Council for the Year 1956 – 57.

¹⁴ See Kohler, (1992) and Kirby, (2003) respectively.

the potential benefits of the science within government and industrial circles. At the same time practitioners sought to shape the science to meet the expectations of future stakeholders.¹⁵ It is also clear that such societies possessed a unity of purpose and clear, shared goals. Such attributes were not prominent in the ERS, and may explain why it played such a marginal role in the institutionalisation of the science.

In this thesis I have identified the absence of politically powerful members of the ERS, such as Fletcher for Biochemistry or Goodeve and Wansborough-Jones for OR, who could promote ergonomics within government or industry. It has also been shown that during the early years of its existence, the ERS was riven with internecine rivalries and possessed unclear, or muddled aims and ideals, and tended to introspection. There were, for example, long-running disputes between those who viewed ergonomics as an inter-disciplinary research activity, with those who saw it as an enabling technology.¹⁶ These conflicting views resulted in the ERS being unable to provide a meaningful definition for ergonomics. This, in turn, resulted in poor, and at times conflicting, communications with actors and institutions within government, industry and the TUC. Given such observations it may have been expected that the society, and the science, would have faded into obscurity, much as happened to cybernetics in the 1950s and 1960s.¹⁷ Indeed, this fate was hinted at by Rodger in his review of the 1959 ERS conference.¹⁸ There were two important factors which prevented the fate predicted by Rodger, and they help explain how the science was institutionalised without the deep involvement of the ERS.

Firstly, there was a politically important, long running, securely funded research programme which was producing exploitable ergonomic knowledge, and helping fund the development of ergonomics departments in academia. The programme was also helping to develop the careers of future ergonomics practitioners. Secondly, there were individuals, both ergonomists and non-ergonomists, and other institutions who perceived a requirement for ergonomics to either underpin their own enterprises, or help meet institutional objectives. In the absence of a clear definition for ergonomics, academics and others could envisage a personal purpose for the science and mould it

¹⁵ Kohler, (1992).

¹⁶ Murrell, (1967).

¹⁷ Pickering (2011).

¹⁸ Rodger, (1959).

into their enterprises. Thus, the existence of a politically important, securely funded research programme and a malleable concept for ergonomics were key to institutionalisation. In the rest of this section I will draw together the evidence to show how institutionalisation occurred.

The stimulus for the institutionalisation of ergonomics was the establishment of the government funded human science research programme, and Bartlett's attempts to use the programme to establish his vision of industrial psychology. Tizard's proposal that the MRC and DSIR should jointly manage a future human factors research programme was based on the premise that each would provide technical oversight and a route of research exploitation, respectively. The reality was that the MRC, through Bartlett, took the opportunity to split human engineering from the human relations research and take a primary role in defining and managing that element of the human science programme. Although Bartlett was highly critical of both human relations research and Stansfield,¹⁹ this did not lead to tensions between the MRC and DSIR during the joint management of the research programme. By effectively placing an air gap between the two programmes, Bartlett had ensured that there was no cross-fertilisation between them, but no points of friction.

Splitting human engineering, as defined by Schuster, from human relations research placed the MRC, and Bartlett, in control of both civilian and military human factors research, this latter being through the service specific personnel research committees. This also afforded Bartlett an opportunity to establish industrial psychology as a discipline. Bartlett imagined industrial psychology as a discipline where the dual outputs of field and laboratory based psychology research could be used to increase the efficiency of the worker, especially in working environments where machine control predominated. Bartlett attempted to reach this goal by using both the CIP (HF) and IEC research programmes to develop his concept through preferential distribution of funding. As Sections 2.6 and 2.8 demonstrate, Bartlett failed in this attempt. What he did achieve was to map out the niche that ergonomics could occupy by advancing the notion of the centrality of the human in the human-machine system, and the need to design systems that enhanced or sustained human performance.

¹⁹ TNA FD 1/303. Letter Bartlett to Himsworth 13th October 1950.

In Chapters 2 and 3 I drew attention to the support given by DSIR to the early ERS conferences, and to Stansfield's work within the EPA to bring ergonomics to international prominence. DSIR's imaging of ergonomics was as an enabling science which could support and enhance the outputs of the RAs. This view underpinned the establishment of the ergonomics capability at WSL, a capability that was expected to provide a service, or work in concert with, the RAs. This view of ergonomics as an enabler was taken further by BISRA. As discussed in Section 2.8 Goodeve, the director of BISRA, was persuaded by his information officer, Slade (a member of the ERS) to establish a human factors capability in the RA's operational research division. Here ergonomics was viewed as an enabler for OR, pointing further to the ubiquity of the science. The success of the crane cab study resulted in the establishment of a human factors advisory service within BISRA which would provide advice across the steel industry,²⁰ further institutionalising the science. It should also be noted that the Motor Industry and Machine Tool RAs employed ergonomists, although it is unclear what work they undertook. DSIR both institutionally, and through the actions of individuals played a key role in the institutionalisation of ergonomics. This is a key observation is that these individuals, specifically Stansfield and Slade, and organisations, such as BISRA and DSIR were imagining the science as an enterprise which can inform and support their business processes. The other institutions which used ergonomics as an enabler were the universities of Loughborough and Birmingham.

At Loughborough, the principal, Haselgrave, viewed ergonomics as a science which could support and complement engineering research and other disciplines. Further, because Loughborough had attained CAT status he also saw offering academic courses in ergonomics as a way of gaining a competitive edge over other universities and colleges. At Birmingham, Matthew, the head of the Engineering Production Department, as early as 1950, saw ergonomics as part of a suite of sciences, which included OR, that supported his vision of engineering production. These different views resulted in the development of distinctive academic courses and research agendas. At Loughborough ergonomics was taught as a broad based science with an expansive research portfolio which encompassed anthropometry and biomechanics. At Birmingham teaching and research was tightly aligned to supporting engineering

²⁰ Sell, (1971).

production, which was the driver for institutionalisation. Both universities, however, employed ergonomics practitioners to establish the capability. Although both Floyd and Corlett were senior members of the ERS, there is little evidence to suggest that they consulted with the society in the design of the courses. Course design was predicated on local imperatives, resulting in both universities developing their own 'local' form of ergonomics and using funds from the human science research programme to develop distinctive research programmes.

The other institution which shaped ergonomics was the TUC, where the key actors were Fletcher and Murrell. Senior TUC members had sat on all the human science research management committees but do not appear to have actively sought to shape the direction of the research. They did facilitate the availability of shop floor workers to act as experimental subjects for both Singleton and Murrell, which helped grow the science. The role of Fletcher in promoting ergonomics within the TUC, and in influencing DSIR's management of the human science research programme has been discussed in Chapter 5. Murrell's role is, perhaps, more significant. I have already drawn attention to the absence of a politically powerful leader within the ERS. His appointment to the TUCSAC placed him in such a position within that organisation. He advised on ergonomics, arranged the early symposia and produced strategy papers. These papers helped inform Woodcock, the General Secretary of the TUC, when lobbying the government to increase the content of ergonomics lectures in courses. Murrell worked with minimal support from the ERS. It was not until the formation of the revised ERS Industrial Section in 1965 that there was direct contact with the TUC.

The symposia held through the 1960s helped expose union officials to the potential of ergonomics, but possibly the more important activity was the positive lobbying of government by the TUC on ergonomics. In the absence of efforts from the ERS to engage with government departments, and with DSIR's human science advisor gone, it fell to the TUC to remind government departments of the utility of ergonomics through lobbying. The TUC had, of course, its own agenda. Reminding the Ministry of Transport of the importance of ergonomics in lorry cab safety was a way of ensuring that the safety of their members was paramount. The TUC may, therefore, be viewed as an institution which sought to exploit an understanding of the role of ergonomics into their membership, government departments and industry for the benefit of the worker

What this thesis has also shown is the existence of a network of actors and institutions willing to promote and institutionalise ergonomics to meet local needs, and that they were acting outside the ERS in undertaking these actions. We have seen the actions of Murrell, Floyd and Stansfield in promoting ergonomics on a national and international stage, and of Slade influencing BISRA to establish a human factors unit in the OR department which would eventually flourish to become an industry wide service. Two key points emerge from this analysis. Firstly, each actor or institution in the network had their own agenda for promoting ergonomics, and yet, aside from the internecine clashes within the ERS, there were no points of friction. This suggests that agendas were not mutually exclusive and that because of its openness, and capability to accommodate individual goals. Secondly, institutions such as the TUC, saw no requirement to engage with the ERS, particularly as they were receiving advice from Murrell. The individuals identified within this thesis were viewed as understanding the business imperatives of these institutions and being capable of moulding ergonomics to meet those goals. It was in this way that the science of ergonomics was institutionalised by actors, and institutions outside the ERS. There is a further point. Ergonomics developed to meet individual institutional needs and so develop a number of distinctive identities. This leads to the notion that ergonomics could be viewed as a ‘distributed science.’

Government funded ergonomics research was undertaken at multiple academic institutions (see Table 4-4), and, in the absence of overall co-ordination across these sites, was shaped by local, rather than national factors. It has also been shown that ergonomics was imagined as both an enabling and ubiquitous science. Haselgrave, at Loughborough, and Matthew, at Birmingham, both viewed it as a science which could enable, support and enhance engineering disciplines. At both institutions it was included in degree awarding and non-credit bearing courses for engineers and other disciplines. What has also emerged from this thesis is that the science of ergonomics diversified over time. Starting with studies into the human machine interface in the 1940s, by the end of the 1960s the science was deployed in the derivation of architectural standards, systems engineering, cognitive computer interface design and disabled ergonomics. This geographical dispersion of the centres practicing ergonomics, its role as an enabling science and the mushrooming portfolio of research areas indicate that it was a “distributed science.”

There is a further consideration which underlines that ergonomics was a “distributed science.” As pointed out in Section 2-2, after the war the individual armed forces retained some of their human science establishments, and even opened new centres. These establishments provided employment opportunities for civilian scientists and permitted the growth of military ergonomics which could address problems emerging from the military “working world.”²¹ Although not addressed in this thesis, this allowed the growth of a form of ergonomics which was peculiar to the military environment.

Ergonomics is not the only ubiquitous science, Agar has proposed that statistics could be viewed as a ubiquitous science, coining the terms “meta-discipline” and “science of science” to denote its ubiquity across “working worlds.”²² His example is the fusion of statistics with human science, and botany which developed the science of biometrics.²³ Throughout this thesis I have evoked Agar’s notion of “working worlds” to explore the growth of ergonomics and its inter-relationships with other institutions. This has helped highlight the path of development of ergonomics from the 1940s to the end of the 1960s. The human sciences which were ‘civilianised’ at the end of the Second World War and contributed to the development of ergonomics came from the military “working world,” where they had been used to sustain or enhance human military performance. In the immediate post-war these ‘civilianised’ sciences contributed to the solution of problems arising from the government “working worlds” which represented both reconstruction and the need to solve, or at least ameliorate the balance of payments crisis. Finally, we see ergonomics being combined with design and engineering to address problems arising from the industry “working world.” This provides a much clearer picture of the ubiquity of ergonomics and So, the “working world” which posed the problems for ergonomics to solve was government based. What happened was that the output of problems of the government “working world” were used by the industrial “working world”, neatly demonstrating the ubiquity of ergonomics. It also further highlights that ergonomics was a “distributed science” as it was being deployed to solve problems from multiple

²¹ Gibson and Harrison, (1984).

²² Agar, (2012), p.4

²³ Ibid, p. 48 and p.52.

“working worlds” within industry and the military. More importantly, these problems were being addressed concurrently by different groups of researchers.

Throughout this thesis I have highlighted opportunities which the ERS spurned or ignored to play a role in the institutionalisation of ergonomics. In Section 2.8 I described how they effectively rejected the IEC’s offer to fund an ergonomics journal. In Section 3.5 I described how they declined to become involved in the formation of the International Ergonomics Association, and I have also drawn attention to their reluctance to interact with other learned bodies. Their reluctance to engage with industrial managers and the employers’ associations is equally baffling given their stated aim to engage and work with industry. Yet despite these behaviours the science and the society flourished.

Ergonomics emerged as a science which aimed to provide a multi-disciplinary approach to reducing the stress and strains on the worker. The passivity and insularity within the ERS meant that a clear definition for the science was not promulgated. Consequently, those actors and institutions which perceived a need and purpose for ergonomics, moulded it to their own requirements, which gave the science a far wider range of applications and uses than had been imagined by the founders of the ERS (Figure 1-1, page 20). Indeed, much of the institutionalisation of the science was done without the involvement of the ERS. The form and institutionalisation of ergonomics was further shaped by the nature of the management of the human science research programme. In addition to shaping the science content of ergonomics, it also provided employment opportunities for research workers. What was different here was the management of an official government research programme was in the hands of non-government employees. In conclusion, the emergence and institutionalisation of ergonomics was truly unconventional.

7.4: Future Work.

This thesis has addressed the emergence and shaping of industrial ergonomics during the mid-twentieth century. Natural limitations and new discoveries made during the course of this study indicate areas where further major work could be undertaken.

The human science research programme comprised two elements, ergonomics and human relations studies. Aside from Ussishkin’s analysis of the human relations

studies of CIP (HF),²⁴ there has been no in-depth analysis of the totality of the human relations element of the industrial human science programme. Such an analysis would complement the findings in this thesis and provide a richer picture of the extent, role and management of industrial human sciences research in the mid-twentieth century.

Throughout this thesis I have referred to military ergonomics and to establishments, such as the RAFIAM, where the science was practised. Aside from Gibson and Harrison's book²⁵ there have been no detailed studies of the development and growth of military human science or ergonomics in the post-war years. Bud and Gummert's *Cold War Hot Science*²⁶ is the key study of the development of military science in the post-war years, but apart from Ernsting's practitioner chapter²⁷ the rest of the volume concentrates, for perfectly good reasons, on the development of military technology. There are, however, more cogent reasons why a study of military human science is of importance.

The development of a fighting capability in the UK armed forces is underpinned by technology and complementary human science research programmes, the latter encompassing equipment design, training and personnel issues. These technology and human science programmes are designed to produce research information which contractors can use to develop a military capability against specifications, which include the requirements of the human user. What sets military research programmes apart from their civilian counterparts is that the department setting the research requirements also issues contracts for the capability. DSIR specified research, but not the equipment requirement.

In developing military equipment, contractors may be forced into making trade-offs between performance and human requirements, which is where Singleton's work on ergonomics in systems engineering becomes important. A study of military human sciences would, therefore, provide a comparator to understand how other government departments managed human sciences, particularly where it is more tightly linked to technology procurement programmes. It would also provide an insight into how the

²⁴ Ussishkin, (2013).

²⁵ Gibson and Harrison, (1972)

²⁶ R.Bud and P. Gummert, (eds.), *Cold War, Hot Science. Applied Research in Britain's Defence Laboratories, 1945 - 1990*. Amsterdam, Harwood Academic Publishers, 1999.

²⁷ Ernsting, (1999).

procurement community used human science research and performed trade-off studies between human requirements and technology. This would provide a new perspective on the relationship between research and procurement, and provide a detailed comparator for the civilian study in this thesis. Key areas for investigation would be the different funding mechanisms, how ergonomics became institutionalised, whether it was viewed as an enabler, and what imaginings of ergonomics existed within the military enterprise.

The final limitation of my study is that I only consider the development of ergonomics and the ERS up to 1970. Diminishing government funding for ergonomics did not inhibit the growth of the science. ERS membership continued to climb, reflecting the increasing number of universities, such as UCL, Surrey and Napier, offering degree level courses,²⁸ and the growing stature of the science. Waterson and Sell portray the 1970s and 1980s as a period when ergonomics took a greater role in national policies, such as making substantial contributions in the derivation of UK health and safety standards, through closer co-operation with the BSI and HSE.²⁹

One of the highest-profile activities during this period was the involvement of the ERS in the public inquiry and subsequent build of the Sizewell 'B' Pressurised Water Reactor. Whitfield provides a high-level discussion of this involvement which included provision of evidence to the Board of Inquiry. This contended that the Central Electricity Generating Board had failed to demonstrate that they fully understood the human safety and ergonomic implications of the design.³⁰ The result of the ERS's intervention was to open the fields of nuclear safety management and risk management to ergonomics. A study of these interactions with the BSI, HSE and the nuclear power industry would provide a useful extension to this thesis, and give a new perspective to the study of the history of health and safety and the nuclear power industry in the UK.

This thesis has also revealed the depth and extent of TUC interest in the human sciences. During my research it became clear that the TUC had a deep interest in all aspects of science and technology and how they might impinge on union matters.

²⁸ Ibid. p760.

²⁹ Waterson and Sell, (2006).

³⁰ D.J.S Whitfield, (1995).

Except for Danziger's study of the National Union of Agricultural Workers and the use of pesticides,³¹ TUC histories have not addressed the roles and relationships of the institution and its scientific bodies, the TUCSAC and TUCPD, in science and technology policy. This is further underlined by the TUC founding the Centenary Institute of Occupational Health at the London School of Hygiene and Tropical Medicine, and the establishment of Clegg's Industrial Relations Research Unit at the University of Warwick. A study of the TUC's attitude to science and technology and its relationships with the SSRC,³² would address what may be a major gap in our knowledge of how a significant British institution viewed and interacted with science and technology in the mid-twentieth century. This would also address the larger point that the history of organised labour has not been afforded prominence in histories of science and technology.

7.5 Epilogue.

I have argued that in the mid-twentieth century, ergonomics was an enabling science which supported both engineering and OR. I have also gestured towards ergonomics being an enabler for design, particularly through the provision of human data to British Standards. Despite ergonomics having a predominantly enabling role in the mid-twentieth century, ergonomists maintained a level of independence and identity, as evidenced by the growth in the number of degree-awarding courses in ergonomics.

In 2016 Loughborough University announced that the last intake for the BSc course in ergonomics would be in September 2016.³³ From 2017, a course in User Centred Design would be offered, which would synthesise ergonomics and industrial design to "meet the needs, desires and aspirations of all users."³⁴ The university made this decision after failing to attract sufficient numbers of high quality direct applicants to ergonomics. Loughborough was the sole institution offering an undergraduate course in pure ergonomics, others such as Nottingham only offer masters courses in Applied Ergonomics and Human Factors. It may be questioned if those taking the User

³¹ R. Danziger. *Political Powerless. Agricultural Workers in post-war England*. Manchester, Manchester University Press, 1988, pp. 198 – 242.

³² It will be recalled that Len Murray was a council member of the SSRC.

³³ S. Barraclough. User-centred design comes into its own. *The Ergonomist*, (2017), 557, 12-13.

³⁴ *Ibid*, p12.

Centred Design course would see themselves as ergonomists or designers. Could this be the demise of ergonomics? I think not.

Ergonomists have shown an affinity toward industrial design since the early 1960s, with two significant books on ergonomic design being issued during this period. Michael Farr's *Design Management* described how ergonomics and ergonomists should be included in all design work.³⁵ John Chris Jones's *Design Methods*³⁶ provided explicit guidance to designers on the implementation of ergonomics principles. Both made the case for ergonomics being an enabler for design. The course at Loughborough merely extends this notion. I do not believe this signals the demise of the science, it is another evolution in this distributed science and will offer new opportunities. Perhaps, though, as Joe Weiner said at the 1960 Ergonomics in Industry Conference, "ergonomics may be regarded as an attitude of the mind".³⁷

³⁵ M. Farr, *Design Management*. London, Hodder and Stoughton, 1966. Farr was a member of the ERS and regularly lectured on the ergonomics of clothing design.

³⁶ J.C. Jones. *Design Methods*. New York and Chichester, John Wiley and Sons, 1970.

³⁷ Conference on Ergonomics in Industry, 1960, p.149.

Bibliography.

Acts Of Parliament.

Factory Act, London, HMSO, 1937.

Housing Act, London, HMSO, 1937.

Education Act, London, HMSO, 1944. www.legislation.gov.uk/ukpga/Geo6/7-8/31/contents/enacted

Offices, Shops and Railways Act, HMSO, London, 1963.

Command Papers

Training for the Building Industry. Cmnd 6428, HMSO, 1943.

Higher Technological Education. Report of a Special Committee. London: HMSO. 1945.

Scientific Manpower: Report of a committee appointed by the Lord President of the Council. Cmnd. 6842. London: HMSO, 1946.

Report of the Committee for the Provision of Social and Economic Research. Cmnd. 6868, London, HMSO, 1946.

Economic Survey for 1947. Cmnd 7046, London, HMSO, 1947.

Advisory Council on Scientific Policy, First Report, Cmnd. 7465, London, HMSO, 1948.

Technical Education, Cmnd 9703, London, HMSO, 1956.

Scientific and Industrial Research Act, 1956, Cmnd 9734, London, HMSO.

Ministry of Labour, *Services for the Disabled: An Account of the Services Provided for the Disabled by Government Departments, Local Authorities and Voluntary organisations in the United Kingdom. Standing Committee on the Rehabilitation and Resettlement of Disabled Persons*. 2nd Edition, London, HMSO 1961.

Engineering design: report of a committee appointed by the Council for Scientific and Industrial Research to consider the present standing of mechanical engineering design, London, HMSO, 1963.

Higher education: report of the Committee appointed by the Prime Minister under the Chairmanship of Lord Robbins 1961-63, Cmnd. 2154, London, HMSO, 1963.

Report of the Committee of Enquiry into the Organisation of Civil Science, Cmnd 2171, 1963-1964.

Report of the Committee on Social Studies, Cmnd 2066, London, HMSO, 1965.

Royal Commission on Trade Unions and Employers' Associations. Cmnd 3623, London, HMSO, 1968.

In Place of Strife: A Policy for Industrial Relations. Cmnd.3888, London, HMSO, 1969.

Report of the committee of inquiry on industrial democracy. Cmnd 6706, London, HMSO, 1977.

Unpublished Primary Sources.

TNA - The National Archives, Kew Gardens, London, TW9 4DU.

1. Ministry of Technology (AY).

- | | |
|--------|---|
| 24/30 | Ministry of Technology: Warren Spring Laboratory – It's Origins, Terms of Reference, Achievements and Current Research Programme. |
| 28/6 | Human Sciences Research Sub-Committee: Constitution. |
| 28/7 | Human Sciences Sub-committee: Minutes of Meetings. 1959 – 1962. |
| 28/8 | Human Sciences Sub-committee: Reports. |
| 28/191 | Inter-departmental Committee on Human and Social Problems of Technological Change. |
| 40/6 | Warren Spring Steering Committee: papers for 8 th Meeting 18 July 1962. |
| 40/9 | Warren Spring Steering Committee: papers for 11 th Meeting 6 December 1963. |

2. Board of Trade (BT).

- 194/16 Midlands Advisory Council on Productivity: Employer, TU and Government Organisation.
- 195/6 Committee on Industrial Productivity: Conference on Production Engineering and Formation of the Midland Advisory Council on Industrial Productivity.
- 258/96. European Productivity Agency (EPA): UK participation in EPA activities.

3. Cabinet Office (CAB).

- 124/694 Discussion on Schemes as incentives to production.
- 124/1045 Balance of Payments Crisis.
- 132/32 Committee on Industrial Productivity. Panel on Human Factors – Minutes and Papers.
- 132/84 Committee on Research and Productivity – Minutes and Papers.

4. Department of Science and Industrial Research (DSIR).

- 17/426 Research into the “human factor” in industry.
- 17/681 Department of Scientific and Industrial Research: Human Sciences Committee: Minutes of Meetings.
- 17/683. Department of Scientific and Industrial Research: Human Sciences Committee: Minutes of Meetings.
- 17/684 Department of Scientific and Industrial Research: Human Sciences Committee: Minutes of Meetings.
- 17/689 Department of Scientific and Industrial Research: Human Sciences Committee: Minutes of Meetings 1959.
- 17/690 Department of Scientific and Industrial Research: Human Sciences Committee: Minutes of Meetings.

- 17/691 Department of Scientific and Industrial Research: Human Sciences Committee: Minutes of Meetings 1960.
- 17/728 Committee on Human Relations and Individual Efficiency in Industry: Policy.
- 45/8 Committee of Enquiry into the Organisation of DSIR (Jephcott Committee).
- 46/ 6 Department for Scientific and Industrial Research: Council for Scientific and Industrial Research: Minutes and Papers.
- 46/25 Department for Scientific and Industrial Research: Council for Scientific and Industrial Research: Minutes and Papers.
- 46/39. Department for Scientific and Industrial Research: Council for Scientific and Industrial Research: Minutes and Papers.
- 46/40 Department for Scientific and Industrial Research: Council for Scientific and Industrial Research: Minutes and Papers.

5. Records of the Social Science Research Council and the Economic and Social Research Council (EY).

- 1/1 Social Science Research Council: Minutes and Papers. Meetings 1st.

6. Medical Research Council (FD).

- 13/83 Council Agenda, Minutes and Circulated Papers.
- 1/301 Committee on Industrial Productivity: Research Advisory Group of the Human Factors Panel, Reports and Correspondence.
- 1/303 Committee on Industrial Productivity: Minutes of Panel on Human Factors.
- 1/306 Discussion with the Department of Scientific and Industrial Research (DSIR): future research on human factors in industry.
- 1/361. Clinical Unit for Research in Infectious Diseases.

- 1/7580 Correspondence arising from the Conference on Individual Efficiency.
- 1/7544 Joint Committee with Department of Scientific and Industrial Research (DSIR) on individual efficiency in industry. Constitution.

7. Ministry of Labour (LB).

- 10/2222 National Joint Advisory Council: discussion of Ergonomics in Industry following TUC request for increased attention to be given to this subject.

8. Ministry of Transport (MT).

- 98/697 Vehicle Design: the ergonomics of drivers' cabs in commercial vehicles: correspondence with trades unions and motor manufacturers.
- 102/361 Working Group on Ergonomic Study into Drivers' Cab Design: technical papers and minutes of meetings.

9. Treasury (T).

- 320/568 Contracts: use of government purchasing power to improve standards, efficiency and productivity in industry.

LUA - Loughborough University Archives, Epinal Way, Loughborough, LE11 3TU.

LCT/G/P3 Extended Agenda Governors Meeting. Post graduate Work In Ergonomics and Cybernetics, Agenda Item 7. 2 Feb 1960.

AAD - Victoria and Albert Museum, Archive of Art and Design, Blythe House, Blythe Road, London W14 0QX.

AAD 7/94 – 1989. MF(DI) News August 1965.

MRC - Modern Records Centre, University of Warwick, Kirby Corner Road, Coventry, CV4 7AL.

TUC Archives. (MSS).

MSS.292/552.4/2a	British Productivity Council 1952 – 1956.
MSS. 292/571.7/1	Committee on Industrial Productivity 1947 – 1948.
MSS.292/571.89/1a	Ergonomics 1957 – 1960.
MSS.292B/571.87.4	Ergonomics, 1960 – 1966.
MSS.292B/571.87/5	Ergonomics, 1967 – 1970.
MSS.292B/571.89/3	TUC / Ergonomics Research Society (ERS) Conference 1969 – 1970.
MSS.292B/571.89/4	Ergonomics: One Day Conferences 1962 – 1963.
MSS.292B/571.89/5	Ergonomics: Course at Cranfield, 1964 – 1965.
MSS.292B/571.89/6	Design of Vehicle Cabs Meeting, 1966 – 1967.
MSS.292B/571.89/8	Ergonomics Research Society (ERS) Conference, 1967- 1968.
MSS. 292B/572.1/4	Scientific Advisory Committee, 1969 – 1970.
MSS.292D/571.89/1	Ergonomics, 1974 – 1985.

**BUSCA - Bristol University Special Collections Archive, Tyndall Avenue,
Bristol, BS8 1TH.**

The Murrell Archive

DM, all files are un-indexed.

**STAN - The Stansfield Archive, University of Manchester, Oxford Road,
Manchester, M13 9PL.**

B20 Anthropology Seminars at UCL 1972.

B24 Ergonomics.

- B27 WSL Admin Papers 1959.
- B28 Own Reports DSIR Part II 1956 – 1957.
- B.30 Own Reports DSIR to End 1955 Part I.
- B.100 Human Efficiency Committee from 1953.
- B 150 MoW Human Efficiency Panel Part 1 1945 to 1947.
- U6 Personal Letters MAP and MoW.

SZ - The Zuckermann Archive, University of East Anglia, Norwich Research Park, Norwich, Norfolk, NR4 7TJ.

- CIP/1 Committee of Industrial Productivity. Agenda and Minutes, 1948 – 1950.
- CIP/3 Human Factors Panel, 1948.

Published Secondary Sources.

Agar, J. The Provision of Digital Computers to British Universities up to the Flowers Report (1966), *The Computer Journal*, (1996), 39, 630 – 642.

Agar, J. *Science and Spectacle. The Work of Jodrell Bank In Post - War English Culture*. Amsterdam, Harwood, 1998.

Agar, J. *The Government Machine. A Revolutionary History of the Computer*. Cambridge, Massachusetts, MIT Press, 2003.

Agar, J. *Science in the Twentieth Century and Beyond*, Cambridge, Polity Press, 2012.

Agar, J. and B. Balmer, British Scientists and The Cold War: The Defence Research Policy Committee And Information Networks, 1947-1963. *Historical Studies in the Physical and Biological Sciences*, (1998), 28, 209-252.

Annett, J. Hierarchical Task Analysis, in D. Diaper and N. A. Stanton (eds), *Handbook of Task Analysis in Human - Computer Interaction*. Mahwah NJ, Lawrence Erlbaum, 2003 pp 67 - 82.

Annett, J. Reflections on Task Analysis; Psychological Sciences; and Clinical Psychology, (2014), <http://hciresearchforall.net/>

- Association of Canadian Ergonomists, National Ergonomics Societies, https://www.ace-ergocanada.ca/national_ergonomics_societies.html. Baber, C. Distributed Cognition at The Crime Scene, *AI and Society*, (2010), 25, 423 - 432.
- Badash, L. The Suicidal Success of Radiochemistry, *British Journal for the History of Science* (1979), 12, 245 - 253.
- Bainbridge, L. Ironies of Automation, *Automatica*, (1983), 19, 775 – 779.
- Baldamus, W. *Efficiency and Effort: An Analysis of Industrial Administration*, London, Tavistock, (1961), 45 - 46.
- Barkan, D.K.A. “A Usable Past: Creating Disciplinary Space for Physical Chemistry” in M.J. Nye, J.L. Richards & R.H. Stuewer (eds.), *The Invention of Physical Science*, Dordrecht, Kluwer 1992, 175 - 202.
- Barnes, D. and E. Reid, *Governments and Trade Unions. The British Experience, 1964 - 79*. Heinemann, London, 1980. Chapter 7. A Deep and Fundamental Split, pp 106 - 128.
- Barnett, C. *The Lost Victory: British Dreams, British Realities, 1945-50*. Basingstoke, Macmillan, 1996.
- Barracough, S. User-centred Design Comes Into Its Own. *The Ergonomist*, (2017), 557, 12-13.
- Bartlett, F.C. Fatigue Following Highly Skilled Work, *Proceedings of the Royal Society B*, (1943), 131, 247 - 257.
- Bartlett, F.C. Psychological Problems in the Design of Equipment and Methods of Display, and in the Training of Specialised Skills, *Memorandum presented to the Royal Naval Personnel Research Committee*, 3 April 1943.
- Bartlett, F.C. Obituary Notice. Kenneth J W Craik, 1914 – 1945, *British Psychological Journal*, (1946), 36, 10 - 17.
- Bartlett, F.C. Psychological Research in Industry, *Journal of the Textile Industry*. (1949), 40, 419 - 425.

- Bedford, T. *The Warmth Factor in Comfort at Work: a Physiological Study of Heating and Ventilation*. Industrial Health Research Board No 76, 1936, London, HMSO.
- Birren, J.E How Do I Think I Got Here, LLI review. University of Southern Maine, Fall 2006, pp. 90 - 97.
- Boel, B. The European Productivity Agency and Transatlantic Relations 1953 – 1961 in M. Rudiger and M. Pelt (eds.), *Studies in 20th and 21st Century European History. Vol 4*. Copenhagen, Museum Tusulanum Press, 2003.
- Bonjer, F.H. The EPA and Contacts with Ergonomics, in I Kuorinka (ed.), *The History of the International Ergonomics Association: The First Quarter Century*, Santa Monica CA, IEA Press, 2000.
- Boocock, J. and K. Taylor, The Labour Party and Higher Education, 1945–51, *Higher Education Quarterly*, (2003), 57, 249 - 265.
- Booth, A. and J. Melling, Workplace Cultures and Business Performance: British Labour Relations and Industrial Output in Comparative Perspective. In J. Melling and A. Booth (eds.), *Managing the Modern Workplace. Productivity, Politics and Workplace Culture in Post-war Britain*. Aldershot, Ashgate, 2008, Chapter 1, Workplace Cultures and Business Performance: British Labour Relations and Industrial Output in Comparative Perspective, pp 1 - 26.
- Boud, D. and J. Garrick, *Understanding Learning at Work*, London, Routledge, 1999.
- Boudia, S. The Curie Laboratory, Radioactivity and Metrology, *History and Technology*, (1997), 13, 249 - 265.
- Branowski, B., L. Pacholski, M. Rychlik, M. Zablocki and P. Pohl, Studies on a New Concept of 3D Data Integration about Reaches and Forces of a Disabled Person on a Wheelchair (CAD Methods in Car and Market Ergonomics), *Human Factors and Ergonomics in Manufacturing and Service Industries*, (2013), 23, 255 - 266.
- British Pathe, RAF Institute of Aviation Medicine, (1960),
<https://www.youtube.com/watch?v=6PwmZfyPypk>.

British Pathe, RAF Institute of Aviation Medicine (1964),

<https://www.youtube.com/watch?v=J7LoTtnTbvK>

Broadbent, D. Frederic Charles Bartlett, 1886 – 1969, *Biographical Memoirs of Fellows of the Royal Society*, (1970), 16, 1 - 13.

Brown, W. Obituary: Professor Hugh Clegg, (1995),

<http://www.independent.co.uk/news/people/obituary-professor-hugh-clegg-1525800.html>

Bryant, C. *Stafford Cripps First Modern Chancellor*, London, Sydney and Auckland, Hodder & Stoughton, 1997.

Bud, R. and P. Gummett, (eds.), *Cold War, Hot Science. Applied Research in Britain's Defence Laboratories, 1945 - 1990*. Amsterdam, Harwood Academic Publishers, 1999.

Buften, M.W. *Britain's Productivity Problem, 1948 - 1990*. Basingstoke, Palgrave Macmillan, 2004.

Bunn, G.C. Charlie and the Chocolate Factory, *The Psychologist*, (2001), 14, 576 - 579.

Butler, S. *National Prestige and In(ter)dependence: British Space Research Policy 1960-73*, Doctor of Philosophy Thesis, University of Manchester, 2016.

Cahan, D. *An Institute for an Empire: The Physikalisch-Technische Reichsanstalt, 1871–1918*. Cambridge and New York, Cambridge University Press, 1989.

Callon, M. and B. Latour, Unscrewing the Big Leviathan: How Actors Macro-Structure Reality and How Sociologists Help Them to Do So, in K. D. Knorr-Cetina and A. V. Cicourel (eds.), *Advances in Social Theory and Methodology: Toward an Integration of Micro-and Macro-Sociologies*, Boston, Routledge and Kegan Paul, 1981.

Cantor, L. *Loughborough University of Technology: Past and Present*.

Loughborough, Loughborough University of Technology, 1990.

Capshew, J.H. and K.A. Rader, Big Science: Price to the Present, *Osiris*, (1992), 7, 2 - 25.

Carew, A. *Labour Under The Marshall Plan. The Politics Of Productivity And The Marketing Of Management Science*, Manchester: Manchester University Press, 1987.

Carew, A. The Anglo-American Council on Productivity: The Ideological Roots of the Post-War Debate on Productivity in Britain, *Journal of Contemporary History*, (1991), 26, 49 - 71.

Cassingham, R. The Dvorak Keyboard – A Primer, (2014), <http://www.dvorak-keyboard.com/>

Chartered Institute of Ergonomics and Human Factors, Paul Branton Award, (2017), <http://www.ergonomics.org.uk/awards/paul-branton-award/>

[Chartered Institute of Ergonomics and Human Factors, What is Ergonomics?](http://www.ergonomics.org.uk/what-is-ergonomics/)
[www.ergonomics.org.uk/what-is-ergonomics?](http://www.ergonomics.org.uk/what-is-ergonomics/)

Cherns, A. The Social Setting Of Ergonomic Problems, *Ergonomics*, (1962), 5, 275 - 278.

Chick, M. *Industrial Policy in Great Britain, 1945 – 1951*, Cambridge UK, Cambridge University Press, 1998.

Clark, D.J. *Enclosing the Field: from Mechanisation of Thought Processes to Autonomics*, Doctor of Philosophy Thesis, University of Warwick, 2002.

Clarke, S. A Technocratic Imperial State? The Colonial Office and Scientific Research, 1940–1960. *Twentieth Century British History*, (2007), 18, 453–480.

Clarke, S. Pure Science with a Practical Aim: The Meanings of Fundamental Research in Britain, circa 1916 - 1950. *Isis*, (2010), 101, 285 - 311.

Clarke, S.H. A Contribution. *Proceedings of the Conference on Ergonomics in Industry 27- 29 September 1960*. London, HMSO, 1961, 173 - 176.

Collcutt, R.H. *The First Twenty Five Years of Operational Research, BISRA*, Old Woking, Gresham Press 1965.

Collins, A. The Psychology of Memory, in G. C. Bunn, A. D. Lovie and G. D. Richards (eds.), *Psychology in Britain. Historical Essays and Personal Reflections*, Leicester, BPS Press, 2001, 150 - 168.

- Collins, A. The Reputation of Kenneth James William Craik, *History of Psychology*, (2013), 16, 93 - 111.
- Collins, K. Obituary Otto Gustav Edholm, *Annals of Human Biology*, (1985), 12 383 - 384.
- Conrad, R. Performance of Telephone Operators Relative To Traffic Levels, *Nature*, (1956), 178, 1480 - 1481.
- Cook, P.H. *The Productivity Team Technique*, London, Tavistock Institute of Human Relations, 1951.
- Coopey, R. Industrial Policy In The White Heat Of The Scientific Revolution in R. Coopey, S. Fielding and N. Tiratsoo (eds), *The Wilson Governments, 1964- 1970*. London and New York, Pinter, 1995, 102 - 122.
- Corlett, E.N. The Accuracy of Setting of Machine Tools by Means of Handwheels and Dials. *Ergonomics*, (1961), 4, 53 - 62.
- Corlett, E.N. The Production Engineer and Education. *Production Engineer*, (1962), 41, 358 - 361.
- Corlett, E.N., Human Factors in Machine Control. *Ergonomics*, (1962), 5, 217 - 227.
- Corlett, E.N. and J.W. Goodhand, A Preliminary Investigation of Human Factors Problems In Semi-Automatic Arc Welding. 1. The Effect of Limiting The Field Of Vision On Tracking Performance With Various Shaped Tracks, *International Journal of Production Research*, (1965), 4, 115 - 189.
- Corlett, E.N. The Factory and Its People, *Production Engineer*, (1974), 53, 377 - 382.
- Corlett, E.N. and C. Stapleton, The Ergonomics Society: 50 Years of Growth, *Ergonomics* (2001), 44, 1265 - 1277.
- Costall, A. Why British Psychology Is Not Social: Frederic Bartlett's Promotion of the New Academic Discipline. *Canadian psychology – psychologie canadienne*, (1992), 33, 633 - 639.

Crossman, E.R.F.W., J. E. Cooke and R. J. Beishon, Visual Attention and The Sampling of Displayed Information In Process Control, in E. Edwards and F.P. Lees (eds.), *Human Operator in Process Control*, London, Taylor & Francis, 1974.

The Cybernetics Society, About Cybernetics, (2002), <http://www.cybsoc.org/about-cyb.htm>

Danziger, R. *Political Powerless. Agricultural Workers in Post-War England*. Manchester, Manchester University Press, 1988.

Davey, J.B. Looking After the Lorry Driver. *Design*, April, 1965.

Davis, M. Technical Education 1944 – 1956. In P. Summerfield and E.J. Evans, (eds.), *Technical Education and the State since 1850*. 1990, Manchester, Manchester University Press.

De Long, J.B. and B. Eishengreen, The Marshall Plan, History's Most Successful Adjustment Program. Working Paper, 91 - 184 (1991). Department of Economics, University of Berkeley and California.

Djelic, M-L. *Exporting the American Model. The Post-War Transformation of European Business*, Oxford, Oxford University Press, 1998.

Drew, G.C., W.P. Colquhoun and H. A. Long, Effect of Small Doses of Alcohol on a Skill Resembling Driving, *Medical Research Council Memorandum, No. 38*. London, HMSO, 1959.

Dreyfuss, H. *The Measure of Man: Human Factors in Design*. New York, Whitney Library of Design, 1960.

Dudley, N. Engineering Production Research, *The Production Engineer*. (1960), 39, 195 - 209.

Dudley, N. Obituary Dr T. U. Matthew, *Nature*, (1962), 195, 4837, 121.

Dudley, N. Introduction of a B.Sc. Honours Course in Engineering Production in the University of Birmingham, *Production Engineer*, (1962), 41, 424 - 425.

Dudley, N. Engineering Production in Theory and Practice, *Production Engineer*, (1964), 43, 84 - 87.

Eddison, R.T. Operational Research Course at Birmingham University, *Operational Research Society*, (1953), 4, 77 - 80.

Edgerton, D. *Warfare State: Britain, 1920-1970*, Cambridge, Cambridge University Press, 2006.

Edgerton, D. *England and the Aeroplane. Militarism, Modernity and Machines*. London, Penguin Books, 2013,

Edholm, O.G. and K. F. H. Murrell, *The Ergonomic Research Society, A History*. London, Taylor and Francis, (1973).

Edwards, M. W. T. Singleton, Emeritus Professor, Aston University. Short Biographical Note and Introduction to the Festschrift, *Ergonomics*, (1995), 38, 431 - 436.

The Engineering Employers' Federation, <http://www.eef.org.uk/>

Erlingsson, S.J. The Plymouth Laboratory and the Institutionalization of Experimental Zoology in Britain in the 1920s, *Journal of the History of Biology*, (2009), 42, 151-183.

Erlingsson, S.J. Institutions and Innovation: Experimental zoology and the Creation of the British Journal of Experimental Biology and the Society for Experimental Biology, *British Journal of the History of Science*, (2013), 46, 73 - 95.

Ernsting, J. Defence Physiology, in R. Bud and P. Gummert, (eds.). *Cold War Hot Science*, London. Harwood Academic, 1999, 339 - 369.

Eraut, M. Non-formal Learning and Tacit Knowledge in Professional Work. *British Journal of Educational Psychology*, (2000), 70, 113 - 136.

Farr, M. *Design Management*. London, Hodder and Stoughton, 1966.

Fitts, P.M. *Psychological Research on Equipment Design*. US Army Air Forces Aviation Psychology Programme Report No.19, 1947

Fletcher, E. Industrial Relations and the Production Engineer, *The Institution of Production Engineers Journal*. (1959), 38, 475 - 479.

Floyd, W.F., L. Guttman, C. Wycliffe Noble, K. R. Parkes and J. Ward, A Study of the Space Requirements of Wheelchair Users, *Paraplegia*, (1966), 4, 24 – 37.

Floyd, W.F. and J. Ward, Anthropometric and Physiological Considerations in Schools, Office and Factory, *Ergonomics*, (1969), 12, 132 - 139.

Floyd, W.F. and A. T. Welford, *Symposium on Human Factors in Equipment Design*, London, H.K. Lewis, 1954.

Fox, J.G. Ergonomics and Information Systems, *Aslib Proceedings*, (1972), 24, 178-186.

Fox, R.H. Thermal Comfort in Industry, *Ergonomics in Industry No.8*, DSIR, HMSO, 1965.

Gadsby, G.N, The Army Operational Research Establishment, *Operational Research*, (1965), 18, 5- 18.

Gagne, R.H. (ed.), *Psychological Principles in Systems Development*. New York, Holt, Rinehart and Winston, 1962.

Gieryn, T.F. “Boundaries of Science” in S. Jasonoff, G.E. Markle, J.C. Peterson & T. Pinch (eds.), *Handbook of Science and Technology Studies*. Thousand Oaks, Sage Publications, 1995, 393 - 443.

Gibson, T.M. and M. H. Harrison, *Into Thin Air. A History of Aviation Medicine in the RAF*. London, Robert Hale, 1984.

Gouyon, J-B. Making Science at Home: Visual Displays of Space Science and Nuclear Physics at the Science Museum and on Television in Post-War Britain. *History and Technology*, (2014), 30, 1 – 24.

Grace’s Guide to British Industrial History, James Archdale and Co.

http://www.gracesguide.co.uk/James_Archdale_and_Co.

Grace’s Guide to British Industrial History, Who’s Who in the Motor Industry,

http://www.gracesguide.co.uk/1953_Who's_Who_in_the_Motor_Industry:_Companies_C

Graham, A Contribution in *Proceedings of the Conference on Ergonomics in Industry 27 - 29 September 1960. London, HMSO, 1961*, pp. 168 - 172.

Griew, S. Design of Work for the Disabled, *Ergonomics in Industry, No.3*, London, HMSO, 1963.

Gummett, P.J. *Scientists in Whitehall*. Manchester, Manchester University Press, 1980

Gummett, P.J. and G. L. Price, An Approach to the Central Planning of British Science: The Formation of the Advisory Council on Scientific Policy, *Minerva*, (1997), 15, 119 - 143.

Haley, K.B. War and Peace: The First 25 Years of OR in Great Britain, *Operational Research*, (2002), 50, 82 – 88.

Hall, A. War of Words: The Public Science and The British Scientific Community and The Origins of the Department of Scientific and Industrial Research, *British Journal of the History of Science*, (1999), 32, 461 - 481.

Hall, D. *Working Lives*. London, Transworld, 2014.

Harwood, J. *The Interface: IBM and the Transformation of Corporate Design, 1945-1976*. Minneapolis, University of Minnesota Press, 2011.

Hayward, R. Our Friends Electric; Mechanical Models of Mind In Post-War Britain, in G. C. Bunn, A.D. Lovie and G. D. Richards (eds.), *Psychology in Britain. Historical Essays and Personal Reflections*, Leicester, BPS Press, 2001, 295 - 299.

Hermann, A., J.Krige, U. Mersits and D.Pestre, *History of CERN, 2 Volumes*. Amsterdam and Oxford, North Holland Physics Publishing. 1987.

Horner, D. The Road to Scarborough: Wilson, Labour and the Scientific Revolution in R. Coopey, S. Fielding and N. Tiratsoo (eds.) *The Wilson Governments, 1964 - 1970*. London and New York, Pinter 1993, 48 - 71.

Hugh-Jones, P. The Effect of Limb Position in Seated Subjects on Their Ability to Utilise the Maximum Contractile Force of the Limb Muscles. *Journal of Physiology*, (1947), 105, 332 - 344.

Hughes, J. "Modernists with a Vengeance"; Changing Cultures of Theory In Nuclear Science, 1920 - 1930, *Studies in the History and Philosophy of Modern Physics*, (1998), 29, 339 - 367.

Hughes, J. Doing Diaries: David Martin, The Royal Society and Scientific London, *Notes and Records of the Royal Society of London*, (2012), 66, 273 - 294.

Human Factors Engineering Bibliographic Series Volume 2, 1960 – 1964 Literature. *Human Factors Engineering Information Analysis Centre*. Tufts University, October 1966.

Iles, G. and K. Craik, *Pilot Error: Some Laboratory Experiments*, London, HMSO, 1948.

The Institution of Engineering Technology, The IET Story,
<http://www.theiet.org/about/video.cfm>

International Ergonomics Association, Definition and Domains of Ergonomics, (2017),
<http://www.iea.cc/whats/index.html>.

Jones, D. Obituary Donald Eric Broadbent. *International Journal of Psychology*, (1993), 28, 746 - 748.

Jones, G. The Mushroom Shaped Cloud: British Scientists Opposition to Nuclear Policy, 1945 -57, *Annals of Science*, (1986), 43, 1 - 26.

Jones, J.C. *Design Methods*. New York and Chichester, John Wiley and Sons, 1970.

Jones, R.V. and W.S. Farren, Henry Thomas Tizard, 1885 - 1959, *Biographical Memoirs of Fellows of the Royal Society*, (1961), 7, 313 - 348.

Jordan, G. Sub-Governments, Policy Communities, and Networks: Refilling the Old Boots, *Journal of Theoretical Politics*, (1990), 2, 319 - 338.

King, A. *Let the Cat Turn Round. One Man's Traverse of the Twentieth Century*, London, CPTM, 2006.

King, D. Creating a Funding Regime for Social Research in Britain: The Heyworth Committee on Social Studies and the Founding of the Social Science Research Council, *Minerva*, (1997), 35, 1 - 26.

Kirby, M. Blackett in the 'White Heat' of the Scientific Revolution: Industrial Modernisation Under the Labour governments, 1964 - 1970, *Journal of the Operational Research Society*, (1999), 50, 985 - 993.

Kirby, M. *Operational Research in War and Peace*, London, Imperial College Press, 2003.

Kohler, R.E. *From Medical Chemistry to Biochemistry*, Cambridge, Cambridge University Press, 1982.

Kraut H., and H. Bramsel, Der Calorienbedarf der Berufe ermittelt aus den Erhebungen von Wirtschaftsrechnungen im Deutschen Reich vom Jahre 1927/28, *Arbeitsphysiologie*, (1942), 12, 197 - 221.

Kuchinke, K.P. Education for Work: A Review Essay of Historical, Cross-Cultural and Disciplinary Perspectives on Vocational Training. *Educational Theory*, (2013), 63, 203 - 219.

Latour, B. *Science in Action: How to Follow Scientists And Engineers Through Society*. Cambridge Massachusetts, Harvard University Press, 1987.

Latour, B. *Reassembling the Social: An Introduction to Actor-Network Theory*, Oxford, Oxford University Press 2005.

Lenior, T. "The Discipline of Nature and Nature of Disciplines" in E.Messer-Davidow, D.R. Shumway, D.R. and D.J. Sylvan, (eds.), *Knowledges: Historical and Critical Studies in Disciplinarity*, Charlottesville and London, University of Virginia, 1993, 70 - 102.

Lenior, T. *Instituting Science. The Cultural Production of Scientific Disciplines*. Stanford, Stanford University Press, 1997. Chapter 3. The Discipline of Nature and the Nature of Disciplines.

Longmore, J. Lighting of Workplaces, *Ergonomics for Industry No 9*. DSIR.

Lundgren, F. The Politics of participation: Francis Galton's Anthropometric Laboratory and the making of civic selves. *British Journal of the History of Science*, (2013), 46, 445 - 466.

- McAllister, J.W. Competition Among Scientific Disciplines in Cold Nuclear Fusion Research, *Science in Context*, (1992), 5, 17 - 49.
- McGucken, W. The Central Organisation of Scientific and Technical Advice in the United Kingdom During the Second World War. *Minerva*, (1979), 17, 33 - 69.
- McIvor, A. J. Manual Work, Technology and Industrial Health, *Medical History*, (1987), 31, 160 - 189.
- McIvor, A. J. *A History of Work in Britain, 1880 - 1950*, Basingstoke and New York, Palgrave, 2001.
- McIvor, A. J. *Working Lives. Work in Britain since 1945*, Basingstoke: Palgrave MacMillan, 2013.
- Malpass, P. Wartime Planning for Post-War Housing in Britain: the Whitehall Debate, 1941–5, *Planning Perspectives*, (2003), 18, 177 - 196.
- Mann, A.J. A Contribution in *Proceedings of the Conference on Ergonomics in Industry 27 – 29 September 1960. London, HMSO, 1961*, pp. 42 - 46
- Marsh D. and R.A.W Rhodes, *Policy Networks in British Government*. Oxford, Clarendon Press, 1992.
- Masson, A. E., S. Hignett and D. E. Gyi, Anthropometric Study to Understand Body Size and Shape for Plus Size People at Work, *Procedia Manufacturing*, (2015), 3, 5647 - 5654.
- Matthew, T.U. The Engineer and the Automatic Factory – A Challenge to the University, *Journal of the Institution of Production Engineers*, (1955), 34, 582 - 588.
- Melford, D., P. Duncumb, M. Stowell and B. Graham, Tube Investments Group Research Laboratory, Hinxton Hall (1954 -88). *Notes and Records of the Royal Society*. <http://rsnr.royalsocietypublishing.org/content/64/3/287.article-info>
- Melville, H. *The Department of Scientific and Industrial Research. The New Whitehall Series, No.9*. London, George Allen & Unwin Ltd. 1962.

Morrell, J. B. "Professionalisation", in R. C. Olby, G. N. Cantor, J. R. R. Christie and M. J. S. Hodge (eds.), *Companion to the History of Modern Science*, London, Routledge, 1990, 980 - 989.

Morris-Reich, A. Anthropology, Standardization and Measurement: Rudolf Martin and Anthropometric Photography, *British Journal of the History of Science*, (2013), 46, 487 - 516.

Mort, M. *Building the Trident Network: A Study of the Enrolment of People, Knowledge and Machines*, Cambridge Massachusetts, Harvard University Press 2002.

Murrell, H. Why Ergonomics? *Occupational Psychology*, (1967), 41, 17 - 24.

Murrell, H. Occupational Psychology Through Autobiography: Hywel Murrell, *Journal of Occupational Psychology*, (1980), 53, 281 - 290.

Noyes, J. Over a Century of Psychology at Bristol. A Short History of the Department of Experimental Psychology, University of Bristol, (2008),

<http://www.bristol.ac.uk/expsych/media/experimental-psychology-history.pdf>

Öchsner, A. *Introduction to Scientific Publishing*, Heidelberg, New York, Dordrecht and London, Springer, 2013. Abstract and Index Databases (Web of Knowledge, Scopus, Google Scholar), pp. 31 - 46.

Olesko, K. M. Science Pedagogy as a Category of Historical Analysis: Past, Present, and Future, *Science & Education*, (2006), 15, 863 - 880.

Organisation for European Co-operation. *Acts of Organisation, Volume 12*.

Ortolano, G. *The Two Cultures Controversy: Science, Literature and Cultural Politics in Postwar Britain*, Cambridge, Cambridge University Press, 2009.

Pheasant S. and C. Haselgrave, *Bodyspace: Anthropometry, Ergonomics and the Design of Work*. Basingstoke, Taylor and Francis, 2005.

The Physiological Society, History of the Physiological Society and its Journals: Information Sheets, <http://www.physoc.org/history-physiological-society-and-its-journals-information-sheets>.

- Pickering, A. *The Cybernetic Brain*, Chicago and London, Chicago University Press, 2011.
- Pimlott, B. The Myth of Consensus, in L. M. Smith (ed.), *The Making of Britain: Volume 5: Echoes of Greatness*, London, Macmillan, 1988.
- Pimlott, B. *Harold Wilson*. Glasgow, Harper Collins, 1992.
- Preedy V. R (ed.), *Handbook of Anthropometry*. New York, Springer 2012.
- Price, C.A., H-S Lee and K.Malatesta, Stereoscopy in Static Scientific Imagery in an Informal Education Setting: Does it Matter? *Journal of Science Education and Technology*, (2014), 23, 721 - 734.
- Rasmussen, N. *Picture Control: the Electron Microscope and the Transformation of Biology in America 1940 – 1960*, Stanford California, Stanford University Press, 1997.
- Renbourn, E.T, and Stockbridge, H.C.W, War Office Clothing And Equipment Physiological Research Establishment, *Ergonomics*, (1961), 4, 73-79.
- Rentetzi, M. Designing (for) a New Scientific Discipline: the Location and Architecture of the Institut für Radiumforschung in Early Twentieth-Century Vienna, *British Journal for the History of Science* (2005), 38, 275 p 306.
- Ridler, J. *State Scientist: Omond McKillop Solandt and Government Science in War and Hostile Peace*, Doctor of Philosophy Thesis, Kingston, Royal Military College of Canada, 2008.
- Robinson, S. *Between the Devil and the Deep Blue Sea: Ocean Science and the British Cold War State*, Doctor of Philosophy Thesis, University of Manchester, 2015.
- Robinson, S. A. A Contribution, in *Proceedings of the Conference on Ergonomics in Industry 27 – 29 September 1960*. London, HMSO, 1961, pp. 46 - 49.
- Rodger, A. Ten Years of Ergonomics, *Nature*, (1959), 184, 4688, 20 - 22.
- Rosenberg, C. E. Towards an Ecology of Knowledge: On Discipline, Context and History, in A. Oleson and J. Voss (eds.), *The Organisation of Knowledge in Modern*

America, 1860 – 1920, Baltimore, Johns Hopkins University Press, 1979, pp. 440 - 455.

Rubenstein, W.D. *Capitalism, Culture, and Decline in Britain, 1750-1990*, London, Routledge, 2015.

Russell, A. L. “Industrial Legislature”: Consensus Standardisation in the Second and Third Industrial Revolutions, *Enterprise and Society*, (2009), 10, 661 - 674.

Russell P. and J. P. Taylor, Sponsorship in *Shadows of Progress. Documentary Film in Post – war Britain*. Basingstoke, Palgrave MacMillan, 2010.

Salvendy, G. *Handbook of Human Factors and Ergonomics*. Hoboken, Wiley, 2012.

Schilling, R. S. F. Industrial Health Research: The Industrial Health Research Board, 1918 – 44, *British Journal of Industrial Medicine*, (1944), 1, 145 - 152.

Schlager, K. J. Systems Engineering – Key to Modern Development. IRE Transactions on Engineering Management, (1956), 3, 64 - 66.

Schmidt, J. In Memorandum of Albert Bernard Cherns - (1921 - 1987), *Isa bulletin*, Spring (1987), 31.

Schuster, G. Some Conclusions from the Projects Sponsored by the Schuster Panel on the Human Factors in Industry in *Human Relations in Industry: Report of a Conference Arranged by the Ministry of Labour and National Service*. London, HMSO, 1952.

Schuster, G. *Private Work and Public Causes. A Personal record 1881 – 1978 By Sir George Schuster*, Cowbridge, D Brown and Sons, 1979.

Secord, A. Science in the Pub: Artisan Botany in Early Nineteenth Century Lancashire. *History of Science*, (1994), 32, 269 – 315.

Sell, R. G. Ergonomic Aspects of the Design of Cranes, *Journal of the Iron and Steel Institute*, (1958), 190, 171 - 177.

Sell, R.G. Ergonomics in Action - 4. The Human Factors Section of Bisra, 1950-1964. (The Corporate Laboratories, British Steel Corporation), *Applied Ergonomics*, (1971), 2, 226-229.

Servos, J. W. *Physical Chemistry from Ostwald to Pauling. The Making of a Science in America*. Princeton, Princeton University Press, 1990.

Servos, J. W. Research Schools and Their Histories, *Osiris*, (1993), 8, 2 - 15.

Seymour, W. D. Occupational Psychology Through Autobiography. *Journal of Occupational Psychology*, 1979, 52, 241 - 253.

Shackel B.. *Applied Ergonomics*. Guildford, International Publishing Company, 1974.

Shanks, M. *The Stagnant Society: A Warning*, Baltimore, Penguin, 1961.

Shattock M. and R. Berdahl, The British University Grants Committee 1919-83: Changing Relationships with Government and the Universities, *Higher Education*, (1984), 13, 471 - 499.

Sims, R. E., R. Marshall, S. J. Summerskill, D. E. Gyi and K. Case, Supporting Older and Disabled People's Needs in Product, Environment and Service Design, *International Journal of Business, Humanities and Technology*, (2012), 2, 212 - 220.

Simpson, G.C. An Appreciation. *Ergonomics*, (1984), 27, 239 - 241.

Singleton, W.T. The Industrial Use of Ergonomics, *Ergonomics for Industry No: 1*. DSIR, HMSO, 1962.

Singleton, W.T. A Review of "Psychological Principles of Systems Development". *Ergonomics*, (1964), 7, 345 - 350.

Singleton, W.T. Current Trends Towards Systems Design, *Ergonomics for Industry: No. 12*, DSIR, HMSO, 1966.

Singleton, W.T. Preface, in W.T. Singleton, R. S. Easterby and D. C. Whitfield (eds). *Proceedings of the Conference on The Human Operator in Complex Systems*, 1967. London, Taylor and Francis, 1967.

Smith M. and M. Leiper, *Sickness, Absence and Labour Wastage*, Industrial Health Research Board No 75, HMSO, London 1936.

Social Engineering, eds, A. Podgórcercki, and R. Shields. Ottawa, Carleton Press, 1996.

Stammers, R. What did You do in the War Hywel? *Some Foundations of Ergonomics. Contemporary Ergonomics*, London, Taylor and Francis, 2006, 132 - 136.

Stansfield, R. G. The Origins of the International Ergonomics Association. Paper Presented at the 7th Congress of the International Ergonomics Association. 27th August 1979.

Star S. L., and J. R. Griesemer, Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science*, (1989), 19, 387 - 420.

Stewart, T. Ergonomic User Interface Standards: Are They More Trouble Than They Are Worth? *Ergonomics*, (2000), 43, 1030 - 1044.

Stichweh, R. The Sociology of Scientific Disciplines: On the Genesis and Stability of Disciplinary Structure of Modern Science, *Science in Context* (1992), 5, 3 - 15.

Stone, P. Personal Recollections on the Genesis of an Educational Experiment. Unpublished.

Stone P. and S. Kirk, Obituaries: Professor William Frederic Floyd. *News@lboro*. 2005, p 11.

Stone, R. J. The (Human) Science of Medical Virtual Learning Environments. *Philosophical Transactions of the Royal Society B*. (2011), 366, 276 - 285.

Sumner J. and G. Gooday, Introduction: Does Standardisation Make Things Standard? *History of Technology*, (2008), 28, 1 - 13.

Taylor, A. Conservatives and Trade Unions Since 1945, *Contemporary Record*, (1990), 4, 15 - 18.

Taylor, K. F. Obituary Professor Alec Rodger, 1907 - 1981, *Australian Psychologist*, (1982), 17, 117 - 118.

Taylor, R. *From the General Strike to New Unionism*. Basingstoke, Palgrave, 2000, pp. 41 - 44.

Thomas, W. *Rational Action. The Sciences of Policy in Britain and America, 1940 – 1960*. Cambridge Massachusetts, MIT Press, 2015.

Thompson, N. The Fabian political economy of Harold Wilson in P. Dorey (ed). *The Labour Government 1964 – 1970*. Hoboken: Taylor and Francis, 2004, 53 - 72.

Tiratsoo N. and J. Tomlinson, *The Conservatives and Industrial Efficiency 1951 - 1964. Thirteen Wasted Years?* London, Routledge, 1998.

Tomlinson, J. The Failure of the Anglo-American Council on Productivity, *Business History*, (1991), 33, 82 - 92.

Tomlinson, J. Mr Attlee's Supply –Side Socialism, *Economic History Review*, (1993), XLVI, 1 - 22.

Tomlinson, J. *Government and the Enterprise Since 1900. The Changing Problem of Efficiency*. Oxford: Clarendon Press, 1994.

Tomlinson, J. *Democratic Socialism and Economic Policy. The Attlee Years, 1945 - 1951*. Cambridge: Cambridge University Press. 1997.

Tomlinson, J. “Reconstructing Britain - Labour in Power, 1945 - 1951”, in N. Tiratsoo (ed), *From Blitz to Blair. A New History of Britain Since 1939*. London, Pheonix, 1998, 77 - 101.

Tomlinson, J. *The Politics of Decline: Understanding Post-war Britain*, Harlow, Pearson Educational, 2000.

Trist E. and H. Murray, *The Social Engagement of Social Science, A Tavistock Anthology*.

<http://www.moderntimesworkplace.com/archives/ericssess/tavis1/tavis1.html>

TUC Annual Report, 1939, pp. 259 - 260.

<http://www.unionhistory.info/britainatwork/emuweb/objects/nofdigi/tuc/imagedisplay.php?irn=6009478&reftable=ecatalogue&refirn=6009363>.

TUC Annual Report, 1941, pp.182 - 183.

<http://www.unionhistory.info/britainatwork/emuweb/objects/nofdigi/tuc/imagedisplay.php?irn=6009843&reftable=ecatalogue&refirn=6009942>

TUC Annual Report, 1950, p.216.

<http://www.unionhistory.info/britainatwork/emuweb/objects/nofdigi/tuc/imagedisplay.php?irn=6012381&reftable=ecatalogue&refirn=6012267>.

TUC Annual Report, 1951, pp.262 - 263.

<http://www.unionhistory.info/britainatwork/emuweb/objects/nofdigi/tuc/imagedisplay.php?irn=6012698&reftable=ecatalogue&refirn=6012583>.

TUC, Ergonomics, <https://www.tuc.org.uk/workplace-issues/health-and-safety/ergonomics>.

Tuchman, A. M. Institutes and Disciplines: Recent Work in the History of German Science. *J Modern Hist*, (1997), 69, 298 - 319.

Unattributed, The Psychological Laboratory, University of Cambridge Unit in Applied Psychology Annual Report 1946.

Unattributed, The Institution of Production Engineering: a Brief History, *Production Engineer*, (1947), 26, 145 - 147.

Unattributed, ERS Membership list 1951/52.

Unattributed, Applied Psychology Unit Annual Report 1950 - 1954. <http://www.mrc-cbu.cam.ac.uk/>

Unattributed, MRC Progress Report 1954 – 1960.

Unattributed, The Psychological Research Laboratory 1954 to 1965. Now named EMI Ergonomics Laboratory. EMI Electronics CP.5518.

Unattributed, List of Members and Their Appointments. *Ergonomics*, (1957) 1, 94 - 100.

Unattributed, Scientific, Technological and Technical Manpower, *Nature*, (1957), 179, 1957, 1 - 3.

Unattributed, Abstracting Service, *Ergonomics*, (1965), 8, 111 - 132.

Unattributed, *Human Engineering Bibliographic Series, Volume 2. 1960 - 1964.* (1966).

Unattributed, Ergonomics in Action—3. The Department of Ergonomics and Cybernetics, Loughborough University of Technology 1971. *Applied Ergonomics*, (1971), 2, 44 - 55.

Unattributed, Colin G. Drury, (2005), <http://www.eng.buffalo.edu/~drury>.

[Unattributed, Synopsis Gavriel Salvendy \(2008\),](#)

<https://engineering.purdue.edu/~salvendy>.

[Unattributed, Ken Garland, \(2014\),](#) <http://www.kengarland.co.uk>.

Unattributed, Herbert Haselgrave, (2014),

<http://www.lboro.ac.uk/anniversary/pages/history-vicechancellors.html>.

Unattributed. About the Group, (2017). <http://www.atkinsglobal.com/en-GB/about-the-group/our-history>

Unattributed, Human Sciences 1960 – 1981 Twenty One Years. Loughborough University.

Unattributed, Celebrating 75 Years: Our Founder, Sir William Atkins,

<http://www.atkinsglobal.com/en-GB/media-centre/features/our-founder-sir-william-atkins>.

Unattributed, Defining and Measuring Productivity,

<https://www.oecd.org/std/productivity-stats/40526851.pdf>.

University of Cambridge, MRC Cognition and Brain Sciences Unit, <http://www.mrc-cbu.cam.ac.uk/>

Ussishkin, D. Morale and the Post War Politics of Consensus, *Journal of British Studies*, (2013), 52, 722 - 743.

Varcoe, I. *Organising for Science in Britain. A Case Study*. Oxford, Oxford University Press, 1974.

Varcoe, I. Co-operative Research Associations in British Industry, 1918 – 34. *Minerva*, (1981), 19, 433 - 463.

Vig, N. *Science and Technology in British Politics*. Oxford, Pergamon Press, 1968.

Wade, G. P. A Contribution in *Proceedings of the Conference on Ergonomics in Industry 27- 29 September 1960*. London, HMSO, 1961, pp. 152 - 156.

Ward J. and N. Kirk, Anthropometry of elderly women, *Ergonomics*, 1967, 10, 17 - 24.

Ward J. and B. Beadling, Technical study, Circulation 4. Optimum Dimensions for Domestic Stairways, *The Architects Journal*, (1970), 25th Feb.

Ward, S. V. Gordon Stephenson and the ‘Galaxy of Talent’: Planning for Post-War Reconstruction in Britain 1942–1947, *The Town Planning Review*. (2012), 83, 279 - 296.

Waterson, P World War II and Other Historical Influences on the Formation of the Ergonomics Research Society. *Ergonomics*, (2011), 54, 1111 - 1129.

Waterson P. and K. Eason, “1966 and All That”: Trends and Developments in UK Ergonomics During the 1960s, *Ergonomics*, (2009), 52, 1323 - 1341.

Waterson P and R Sell, Recurrent Themes and Developments in the History of the Ergonomics Society, *Ergonomics*, (2006), 49, 743 - 799.

Weinburg, A. M. Impact of Large Scale Science on the United States, *Science*, (1961), 134, 161 - 164.

Weiner J. and K. Provins, Medical Research Council Climate and Working Efficiency Unit, *Ergonomics*, (1958), 1, 277 - 284.

Welford, A.T. *Aging and Human Skill*. Oxford, Oxford University Press, 1958.

The Wellcome Trust, *The MRC Applied Psychology Unit. The transcript of a Witness Seminar held at the Wellcome Trust Centre for the History of Medicine at UCL, London on 12 June 2001*. L. A. Reynolds and E. M. Tansley (eds.).

White, A. V. *Selling Social Science Solutions. Making the Case for the Human Relations Method of Management in Post-War Britain*. Master of Arts Thesis, University of Kent, 2012.

White, A.V. *From Science of Selection to Psychologising Civvy Street. The Tavistock Group, 1939 – 1948*, Doctor of Philosophy Thesis, University of Kent, 2015.

Whitfield, D. Human Skill as a Determinate of Allocation of Function in W. T. Singleton, R. S. Easterby and D. Whitfield (eds.), *The Human Operator in Complex Systems*. London, Taylor and Francis, 1967, pp 54 - 60.

Whitfield, D.J.C. Ergonomics in the Design and Operation of Sizewell ‘B’ Nuclear Power Station, *Ergonomics*, (1995), 38, 455 - 461.

Whitfield, J. *Metropolitan Vickers, the Gas Turbine, and the State: A Socio-Technical History, 1935-1960* Doctor of Philosophy Thesis. University of Manchester, (2012).

Williamson, A. The Bullock Report on Industrial Democracy and the Post-War Consensus. *Contemporary British History*, 2016, 30, 119 – 149.

Wilson, H. Labours Plan for Science, (1964), nottspolitics.org/wp-content/uploads/2013/06/Labours-Plan-for-science.pdf

Wise, M. J. David Victor Glass 2 January 1912 - 23 September 1978, *Biographical Memoirs of Fellows of the Royal Society*, 1983, 29, 201 - 225.

Wren, D, and Greenwood, R, *Management innovators: The people and ideas that have shaped modern business*. New York: Oxford University Press, 1998.

Wyatt S. and J. Langdon, *Fatigue and Boredom in Repetitive Work*, Industrial Health Research Board No 77, London, 1937.

Yates, D. M. *Turing’s Legacy: A History of Computing at the National Physical Laboratory, 1945 – 1995*. London, Science Museum, 1997.

Zuckerman, S. Wilfrid Le Gros Clark, 1975 – 1971, *Biographical Memoirs of Fellows of the Royal Society*, 1973, 19, 216 - 233.

House Journal Obituaries.

R G Stansfield. Clare Association Annual Report, 1993 – 94 p 71