**PROCEEDINGS OF THE
TWENTY-SIXTH INTERNATIONAL
MACHINE TOOL DESIGN AND RESEARCH
CONFERENCE**

UMIST

The University of Manchester Institute of Science and Technology

PO Box 88, Manchester M60 1QD, United Kingdom

Telephone 061-236 3311

Telex 666094

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INTERNATIONAL MACHINE TOOL DESIGN and RESEARCH CONFERENCE

CHANGE OF TITLE

For some time now the conference organisers have felt that the broad subject interests of the conferences were not being fully served by the title 'Machine Tool Design and Research'.

It has been decided, therefore, to modify the title whilst at the same time retaining the continuity of a Conference that has always enjoyed the respect of Engineers worldwide. We therefore propose for the 27th Conference onwards to use the name 'MATADOR' by which the conference has always been known and to follow this with a second title which may change from time to time according to the dominating theme or themes of the conference.

A handwritten signature in black ink, appearing to read 'B J Davies'.

B J DAVIES
Head of Manufacturing and
Machine Tools Division
Department of Mechanical Engineering

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TWENTY-SIXTH INTERNATIONAL
MACHINE TOOL DESIGN AND RESEARCH
CONFERENCE**

*held in Manchester
17th-18th September 1986*

Edited by

B. J. DAVIES

*Professor of Manufacturing Technology
Division of Manufacturing and Machine Tools
Department of Mechanical Engineering
UMIST*

**DEPARTMENT OF MECHANICAL ENGINEERING
UNIVERSITY OF MANCHESTER INSTITUTE OF SCIENCE AND TECHNOLOGY**

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Foreword

It is with great regret that I have to record the death of Professor S A Tobias, who died suddenly at his home on 24th April 1986 after a short illness. He and the late Professor F Koenigsberger started these MTDR Conferences over 25 years ago on the style of the Aachen Colloquium. During the quarter of a century that this conference has run, he has brought together and stimulated a great number of workers throughout the world in Machine Tool Design and Research, and more recently with a particular emphasis on Manufacturing Systems.

This Conference stands as a tribute to a great engineer who, with Professor Koenigsberger, made research in Machine Tool Technology first respectable and then the key to the greatly improved manufacturing performance achieved over the last quarter of a century.

B. J. Davies.

Professor S. A. TOBIAS 1920-1986

Professor Stephen Tobias, Co-founder of the annual International Machine Tool Design and Research Conferences, and Head of the Department of Mechanical Engineering, University of Birmingham, died suddenly at home on 24th April, after a short illness. He was born in Vienna in 1920, and received his primary and secondary education in both Austria and Hungary. He attended the Technological University of Budapest where he graduated in Mechanical engineering in 1943. Between 1943 and 1947 he worked in industry in Hungary as a machine tool designer. In 1947 he came to this country with a British Council Scholarship and after working for a short time at the Production Engineering Research Association (PERA), he joined the Department of Engineering at the University of Edinburgh. There he worked on basic vibration theory and was awarded the degree of PhD in 1950. He was ICI Research Fellow at Edinburgh from 1951-55 and was awarded the degree of DSc in 1955 for work on linear and non-linear vibrations of rotating discs. He was then appointed Assistant Director of Research, Engineering Laboratory, Cambridge University in 1955, and went to Birmingham in 1959 as Head of the Department of Mechanical Engineering at the early age of 39.

Professor Tobias soon made his mark at Birmingham and together with the late Professor Koenigsberger of UMIST, established Machine Tools as an acceptable field of academic study in the UK. In 1961 the first International Machine Tool Design and Research Conference was held at Birmingham University, which marked a new awareness of the complementary roles, of academia and industry in this field of engineering.

He and his co-workers produced a comprehensive body of knowledge on all aspects of machine tool dynamics which rapidly established Birmingham as a national and international centre in this field. Well over 100 papers were published and his book on Machine Tool Vibration has become the recognised standard text throughout the world and has been translated into five languages.

From the mid-1960's Professor Tobias's main research interest was the development of the Petro-Forge forming system, an innovative, bold and exciting concept which maintained a very large team working under his general direction. This work also inspired other associated interests in which he became very involved, such as noise generation and suppression, computer control and inspection as well as robotics. The list of references to papers relating to Petro-Forge and associated areas contains over 150 publications and over 30 PhD theses.

Although Petro-Forge has not been accepted widely in industry, spin offs from the research work probably had a greater influence on the drop forging industry than from any other single source.

The range of activities and honours associated with Professor Tobias are many. His membership of Government and Research Council Advisory Committees has numbered six, and he has had visiting professorships and taken part in official missions to developing countries on eight occasions; particular links having been established in the USA and China. He was Editor-in-Chief of the International Journal of Machine Tool Design and Research since 1959. He was a co-recipient of the T. Bernard Hall Prize, 1957 awarded by the Institution of Mechanical Engineers, and the sole recipient of Blackwell Machine Tool Prize 1958, awarded by the American Society of Mechanical Engineers, the Joseph Whitworth Prize 1960, from the Institution of Mechanical Engineers and the Frederick W. Taylor Research Medal, 1984 from the American Society of Manufacturing Engineers. The final accolade came in 1985 when he was elected to the Fellowship of Engineering.

Professor Tobias's academic and industrial achievements can only be described as truly outstanding. He was a leader who readily inspired others, and who devoted all his energies towards the development of Mechanical Engineering in Birmingham. He was a dedicated person, often controversial, always constructive — a true academic entrepreneur. This Conference, together with those past and yet to come, stand as a testimony to his energy and dedication to the furtherance of Machine Tool Technology.

OPENING ADDRESS

by PROFESSOR A. W. J. CHISHOLM
(Research Professor in Engineering, University of Salford)

Professor Davies, distinguished guests,
colleagues, ladies and gentlemen:

Many important and distinguished people have given the Opening Address at MDR Conferences since their inception some 25 years ago. My presence here, on the other hand, is a symbol of the close working relationship between UMIST and Salford University in the manufacturing engineering field. This has existed since the early 1960s but is now being developed further through the agency of AMTeC, the Advanced Manufacturing Technology Centre. This Centre aims to bring together, under one umbrella organization, the manufacturing engineering research capabilities of UMIST, Salford University and the former Machine Tool Industry Research Association. But I am also conscious of my responsibility, as the opening speaker, to help this year's Conference get off to a good start by offering a few pertinent remarks.

We have just heard a memorial address for Professor Stephen Tobias which has touched briefly on some aspects of his brilliant career. One of these was of course to launch, in collaboration with the late Professor Franz Koenigsberger, the MDR Conferences. For the past 25 years these meetings have brought together engineers and research workers from all over the world, and have made a unique British contribution to international progress in this field.

I knew Stephen Tobias well, and over many years, because the Professor under whom he worked at Edinburgh University and who inspired Stephen's research in machine tool vibrations was also my own teacher and mentor, the late Professor R. N. Arnold. It was from Arnold that I received my own initial research training when I worked as his assistant in an industrial research laboratory here in Manchester, where I helped him with his pioneering and fundamental research on cutting tool vibration, or tool 'chatter'. Subsequently, Arnold returned to university work as a professor, first at Swansea and then at Edinburgh. So, I was a kind of 'academic brother' to Stephen Tobias, both of us having shared the same teacher and mentor. I am also proud to claim that Franz Koenigsberger was an 'academic uncle' to me, because it was he who introduced me into that influential and seminal international association known as CIRP: College, International, Recherche, Production.

Reflecting on these very personal connections, and trying to survey the influence that pioneers like Tobias and Koenigsberger have had on the whole field of manufacturing engineering research and

development have caused me to wonder, more generally, about the interactions between key personalities and institutions, and the ways in which these have influenced the growth, development and orientations in our particular field of research and development. I have even wondered whether a professor's achievements ought to be assessed by the number of professors of the next generation he has 'fathered', just as much as by the number of publications to his name. At my last count, Ronald Arnold brought up seven professors, including Stephen Tobias; almost all of these proved to be influential heads of academic groups in other universities. Many of Franz Koenigsberger's former research students also became professors and heads of academic departments, both in the United Kingdom and overseas.

Franz Koenigsberger received his training from his professor, the famous Georg Schlesinger at what is now called the Technical University of Berlin. Thus the academic genetic strains (or influences) have passed down from Schlesinger through Koenigsberger to many of the professors now working in our field of research. Likewise, Arnold's influence may have passed down through Tobias to one of his former students who has recently been appointed as the first Professor of Production Engineering at the University of Cambridge. Given the importance of Cambridge University across the whole field of science and engineering, this appointment will certainly prove to be of far-reaching importance to manufacturing engineering research in the United Kingdom. I, too, am proud to have played a part, albeit a modest one, in helping to develop the interests in manufacturing of Professor Roger Crossley, now the Director of AMTeC, and of Professor Geoffrey Boothroyd in the United States. I am proud also to acknowledge the influence on my own development of Dr Eugene Merchant, the 'father' of computer integrated manufacturing, who for very many years has been my colleague at the University of Salford in his role as Visiting Professor there.

Tracing these human relationships and their effects on the development of institutions and on their education and research programmes might provide an entertaining topic for academic historical or sociological research. But I have a more serious and immediate purpose. In our field, such complex human interactions with institutions have produced results - technology, skills, capabilities and attitudes - which, in each country, directly affect the ability of industry to rise successfully to the challenge of modern manufacturing and to compete successfully. They

underline again the importance of people, but perhaps also give a clue to why societies and institutions often appear so slow to change and develop.

The MDTR Conferences were started by Professors Tobias and Koenigsberger in the wake of a series of initiatives, starting nearly 40 years ago in 1949, by the British machine tool industry and the United Kingdom government to strengthen that industry's competitiveness. These initiatives were aimed at increasing research and development in machine tools, and at expanding directly related education and training facilities. In considering a number of alternatives, the industry had explored a policy of relying almost wholly on greatly enhanced machine tool research programmes in the universities as one way of meeting its needs. Another alternative considered was to merge its interests in machine tool research with those of the existing Production Engineering Research Association (whose precursor at Loughborough, incidentally, had been headed by the same Georg Schlesinger, Professor Koenigsberger's former professor in Berlin, and also his father-in-law). However, the industry finally decided, with promises of government financial aid, to establish its own research association. This was to use the model for grant-aided co-operative industrial research launched by the British government in 1916, a model which had been originally conceived here in Manchester at the Manchester Literary and Philosophical Society - the society to which Dalton and Joule had presented their great scientific discoveries.

Opposition to this co-operative research model (with its implication of separate, special research institutes) had been vigorous from the start. As early as the First World War, there were those who believed it was the wrong solution; they considered instead that 'one of the most urgent needs was to develop co-operation between firms on the one hand, and Universities and Technical Colleges on the other'. However, this model for promoting co-operative industrial research appeared in the following 40 years to have successfully served many British industries well. The Machine Tool Industry Research Association was established here in Manchester in 1960, under the direction of Mr Albert De Barr, who had been working at the Research Association devoted to the cotton industry. Concurrently and in parallel, government funds were used to stimulate greatly increased research on machine tool subjects in the universities. Under the leadership of Professors Tobias and Koenigsberger, together with that of Professor 'Bill' Johnson, strong schools of machine tool research were established at Birmingham and here in Manchester. The foundations of our manufacturing engineering research at Salford were also laid at this time.

The initial orientation of these research schools was towards machine tools and the production processes which they drive: machining, grinding, forming. Its emphasis on design gave an unusual orientation to the research, because this broke with the more usual 'scientific' tradition of research conducted in British university engineering departments at that time. This emphasis was firmly embedded in the title of this

Conference, '... Design and Research Conference'; its origin is not hard to find. Both Tobias and Koenigsberger received their early engineering education and training in Continental Europe where design has traditionally provided the theme and core of engineering education.

At this point, I should like to spare a few moments on a digression to try to clarify a point of nomenclature about 'scientific research' which I think causes some confusion among the research community, and may even result in the frustration of the objectives of much of the financial support given to research in engineering subjects. Early leaders of production engineering research used the term 'scientific research' to denote research based on unbiased measurement and observation which was to replace practices based on 'empiricism', meaning based on tradition, rule-of-thumb or experience. A very different meaning of 'scientific research' is current in English-speaking countries; this is 'research aimed primarily at increasing the body of knowledge', for example to 'explain' a phenomenon in terms of the physical processes involved. Any useful result from such research is fortuitous and does not figure in the researcher's objectives. To distinguish the aims of 'engineering research' as distinct from this type of scientific research, I have suggested elsewhere that engineering research should be considered as design based, since design starts with the specification of a defined need, usually within the constraints of an anticipated market. Design requirements thus dictate the research programme required. Design-based engineering research can of course be both short-term, aimed at a specific product model, or it can be generic, long-term and even 'fundamental'. It is the aim of the research planner and researcher which is crucial in governing the nature of the research, and its likely useful outcome.

By their pioneering attention to 'design', the founders of this Conference have made a most valuable contribution to the direction of engineering research in this country. Furthermore, most significantly, they anticipated the conclusions of the Feilden Report on Engineering Design which proved to be a milestone in the reorientation of British university work in engineering.

Looking through the 62 papers from all over the world to be presented at this Conference (70 per cent of them are from overseas.), it is clear that the organizers have held true, in spite of current fashionable trends elsewhere, to the original emphasis on machine tools and production processes. These are still at the core of modern manufacturing systems. The organizers have made appropriate adjustments however in response to the need to integrate these core elements into the total computer-integrated manufacturing systems which are now struggling to develop.

I want now to address the remainder of my remarks in this wider context. Unprecedented challenges are now facing manufacturing industry as a result of the rapid progress in advanced manufacturing technology and the trend towards complete computer integration of the manufacturing business. In addition, we have new management styles worldwide with their emphasis on total quality, and on the

participation and commitment of everyone involved in the manufacturing business. Given the increasingly fierce international competitive pressures, a failure by individual companies to respond to these challenges quickly and effectively enough threatens their actual survival. They must learn to make effective, strategic use of these new technologies and management styles in competition with their rivals in order to increase their flexibility and speed of response to the market: to reduce costs, improve quality and to develop new products.

Mr A. K. Gill, current President of Britain's Institution of Production Engineers and Chief Executive of Lucas Industries PLC, has recently described how his own company was turned around by a combination of a reform in the management of the business and by its engineers. He is one of the latest to affirm, in contrast to those who lightly suggest otherwise, that engineers are crucial to success. Like many others, his Company has found that the lack of 'well-trained professional engineers who have a grasp of other management disciplines is currently a constraint on innovation in (both) product technology and in manufacturing'.

Fewer than one in five of the papers being presented at this Conference have authors from industry. Most authors come from institutions of higher education and training, and I suppose therefore that most people here have a strong interest in the education and training of engineers for industry. Some commentators have even claimed that the most important purpose of academic research in engineering is to provide a vehicle for enabling universities to educate and train relevantly educated engineers for industry and practice.

Responding effectively to the education and training needs for this imminent revolution in manufacturing does therefore present us in universities also with a challenge. The 17th CIRP Manufacturing Systems Seminar in Budapest last year was devoted entirely to considering the future education needs for advanced manufacturing. At that Conference, Dr Joe Hatvany claimed that the reason that CIM was only here in potential and requirement, and nowhere in reality

was because of the absence of people of the right calibre and breadth. He called for a rebirth of what he called a 'Renaissance Engineer'. I arrived at a similar conclusion by a different route: the need for a 'total, comprehensive engineer' (or, by implication, for engineers capable of working effectively in multi-disciplinary teams). The existing specialized branches of engineering would, I suggested, have to adjust to the realities of the comprehensive nature of manufacturing engineering in the future. This presents a considerable challenge to academic and training institutions, and CIRP now has a working group to develop an international perspective and to help produce a prescription for the education and training needed to produce the manufacturing engineers of the future.

Many countries are looking for and implementing new ways of responding to the enormous challenges of the new manufacturing: new institutions; new organizations; new structures linking universities, research institutes, consulting organizations and industry; better arrangements for interdisciplinary work; and revised education and training programmes. Novel mechanisms are being explored for generating a more rapid enhancement of those academic activities likely to improve industrial performance. Here at UMIST and at the University of Salford we are working hard on some of these ideas.

The design and implementation of all these changes depend, of course, ultimately on the effectiveness and qualities of individual people, and crucially upon the leaders involved. For this reason I have dwelt earlier in this Address, in an anecdotal way, on the interaction between such people and their institutions, and on the other people they influenced, down through the generations. It is a long-term process.

In planning to produce radical changes, we should take such effects into account and aim to work with the favourable currents that exist. In our endeavours to respond to these new challenges, I suggest that we try to learn from that test bed for experiment which we know as history.

I wish you all an enjoyable and stimulating Conference!