THE UNIVERSITY OF NOTTINGHAM

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LECTURE 18

"THE ORGANISATION OF A COMPUTER SERVICE IN AN AIRCRAFT DESIGN OFFICE"

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FOREWORD

The organisation of the Domestic computer office described here developed gradually as the computer progressively played an increasing part in the work of the aircraft design office. The present form of the organisation has been established for the last two years, previous to this there was a period of about 18 months during which the computer office was gradually building up. The organisation has in effect been 'tailored' to effectively serve the Firm in which it exists and the test of time has shown it to be efficient and to maintain a high level of productivity. In this latter respect much credit is due to the makers of the computer for their good engineering and to the Servicing Engineers, Programmers and Tape Editing Staff of the Computer Office for their enthusiasm and professional competence.

As to the organisation itself, there are other forms which could have been laid down, but at the time of acquiring the computer, there was no precedent to be guided by and in any case the initial utilisation of the computer was insufficient to require the sub-dividing of the computer office into separate functions. There was also the question of programme development, very few programmes existed in the initial stages and therefore, most of the effort was of necessity concentrated on writing programmes and trying them out on the computer. The amount of 'production' i.e. actual computing, was small in comparison to what it is today and the Tape Editing Staff as such did not exist.

Increased delegation of authority was introduced in stages as the variety and volume of work increased until eventually a settled organisation evolved, but it is not pre-supposed that any future domestic computer organisation engaged on similar work would resolve into the same pattern. A lot depends on the computer itself; the very latest computers are more amenable to auto-coding and it is possible that a programming team as such may disappear; Engineers and Physicists concerned with creating the problems may also become responsible for their own programming.

The Purpose of the Computer Office

The Computer Office is functionally required to provide a service to the aircraft design team so that the day to day calculations and mathematical work are taken out of the hands of the Engineers and Physicists who can then spend more time on creative thinking. This service can be quite extensive in scope if the Computer is used as a design tool rather than simply as a high speed desk calculator turning out rapid solutions to set problems. As a design tool, the computer can greatly extend the scope of a technical investigation by repetitive use on a wide variety of data. The design process of an aeroplane is one of successive elimination and compromise to evolve the optimum design to meet specified performance requirements. Design conclusions are reached by assessing the evidence of calculations relating to performance, shape, strength, stiffness, weight and controllability. Calculations may be repeated many times in the light of previous results and therefore, rapid availability and distribution of information throughout the design team is desirable. For example, take the case of a wing stressing programme. The use of the programme need not be confined to a stress analysis of a finalised structure, but may be used to help in the design of the structure by repetitive use on systematic variations of such parameters as: number of spars, the disposition and angle of sweepback of spars, cross-sectional properties of spars and skin thickness. From the evidence of these repeated calculations it is possible to evolve the lightest structure to satisfy the loadings. In addition much useful information on wing deflections and twists emerges as a by-product for use by the aeroelastic section of the design office.

The design team consists of several groups, each specialising in a certain aspect of design, such as aerodynamics, performance predictions, stressing, aeroelasticity, weight estimation, control and stability and pressurisation. None of these groups can exist alone, they are all in varying degrees influenced in their decisions by the dictates of design requirements of the other groups. Problems requiring computation are passed into the Computer Office from all groups, the computed information in typewritten form is distributed not only to the particular group concerned with the problem, but also to other groups whose work is directly influenced by these results. In this respect the Computer Office acts as a 'clearing house' for information and detailed records are kept of all transactions.

Organisation of Computer Office

The diagram (Fig. 1) illustrates the organisation established within the computer office in order to serve and assist the aircraft design office.

The Computer Office comprising Programmers, Tape Editing Staff and Maintenance Engineers is regarded as a function of the Electronics Laboratory and is therefore, presided over by the Head of Electronics. The Chief Programmer controls the Programmers and Tape Editing Staff and is assisted by Section Leaders each specialising in certain aspects of the work.

The Maintenance Engineers are not responsible to the Chief Programmer, but come under the direct control of the Head of Electronics. With this arrangement the Engineers can do their job without being subjected to too much pressure from the Programmers.

The Programming Staff is divided into three sections so that some degree of specialisation can exist. The three sections are identified by the type of problems they each deal with, namely:- Aerodynamics, Stressing and Miscellaneous problems, (which includes Data Processing).

Each section consists of 3 Programmers and is controlled by a Section Leader who is responsible to the Chief Programmer. Programmers may be transferred from one section to another according to work priorities. The Tape Editing Section consists of four Computer Clerks, directly supervised by a Section Leader who is again responsible to the Chief Programmer.

The supervisory duties of the Chief Programmer and the Section Leaders include the following:-

1) Close detailed supervision of programming techniques, coding and tape editing to ensure that computing experience is passed on to newer members of the staff. For instance it is vital that built in programme checks are made as foolproof as possible, any mistakes here, not only result in loss of valuable machine time, but can lead to the issuing of faulty computation.

2) The study of new problems and mathematical analysis suitable for the computer.

3) Allocation of work having regard to problem complexity, programmers' abilities and experience.

4) Dealing with difficulties encountered in programme development on the machine.

5) Training of new staff.

6) Co-operation with Maintenance Engineers in developing programme controlled methods of fault diagnosis.

7) The study of new applications of computing equipment.

Qualifications and duties of Personnel

There are three different classes of work in the Computer Office; Programming, Tape Editing and Computer Maintenance. The qualifications, experience and training of the Personnel involved are now discussed individually:-

Programmers

The Programming Staff consists of a nucleus of Mathematicians who are responsible for designing Programmes for all problems requiring solution by the Computer. The originator of a problem is first required to write a detailed mathematical description of the problem so that the Programmer can get a complete understanding of what the originator is aiming to do. The Programmer then proceeds to reduce the problem into computer steps, organise the performance of the computer according to its facilities and storage, then prepare the coding sheet.

It has been found that Honours Degree Mathematicians are desirable for this work and that they are at their best when recruited straight from University while they are still very familiar with Mathematical tricks. It usually takes a mathematician about four months time to be able to make a reasonable job of programming the computer, although it is possible after only the first four to six weeks to carry on without direct assistance, but with the aid of a Programmer's Handbook. The computer is a very reliable 'checker' and will quickly sort out any mistakes.

The Programmers individually use the computer for checking and developing the programmes which when completed are stored in the Programme Library ready for use when computations are required.

Tape Editing Staff

Girls with G.C.E. standard of education, in Mathematics and English, have been found to be capable of this work, in fact for tape editing alone, they are above the required level. Tape Editing, however, can lead to computer operation after a little experience and G.C.E. standard is desirable for this work. In addition to tape-editing, the girls are responsible for keeping records of all Computer work. The filing system involved in the Tape Editing Room can become quite complex, for instance, any one programme may be used thousands of times, each time with a different number tape. The number tapes must be identified in relation to the state of development of an aeroplane at the time so that future reference can be made in the event of uncertainty. To complicate this, the programme itself may undergo some revision in the light of new theories in the formulation of the problem and it may also be used on different aeroplanes. A weekly statement is issued on work done and needless to say, the Computer itself is employed for this work.

The most important aspect of Computer operation is ensuring that the correct information is fed into the computer. Unfortunately there appears to be an adverse psychological aspect relating to Computer Data; the people concerned with the preparation of data and also the people concerned with tape editing are apt to be less careful than they would have been if they were solving the problem by long-hand methods. Careful control has to be exercised to ensure that checking procedures are adhered to.

Computer Data is received from the Technical Offices i.e. Aerodynamics, Stress etc., in the form of tabulated sheets of numbers relating to physical properties of the aeroplane. The Computer Staff have no means of verifying that these numbers are all correct and a system of checking has been established in each respective Technical Office.

The Tape Editing Staff prepare the tape on Keyboard Perforators from the numbers listed on the tabulated sheets. In general two tapes are prepared by different operators and then compared either automatically or manually to check for punching errors. Alternatively, a reprint can be obtained by feeding the prepared tape into teleprinter equipment, this reprint is then visually compared with the original tabulation.

If these procedures are faithfully adhered to, one can feel confident that no tape editing errors will go undetected.

An overall check can be employed when practicable by 'check summing' in the Computer, this also verifies that the input tape reader on the computer is functioning properly.

Maintenance Engineers.

It has been found desirable to have at least one technician in the maintenance team plus two or three practical engineers with experience equivalent to Radar Mechanics. For a man with no previous experience of digital computers it takes approximately six months to become sufficiently familiar with the machine. Unfortunately, he cannot be learning all the working day because when the computer is in action it is unwise to allow him to interfere with the circuits. It is only when faults appear that he gets any real practice. Of course, much can be learned during the preventative maintenance period each day about the normal process of adjusting wave forms etc., but usually the Programmer's are needing the machine long before the Engineers are prepared to hand it over.

The idea of Preventative Maintenance is to try to anticipate trouble and then to take the necessary safeguarding action, in the broadest sense this involves Marginal Testing and the systematic checking of circuit elements throughout the Computer.

Marginal Tests are carried out by adjusting the conditioning potentials of valve circuits by a small percentage from normal and in this condition, test programmes are fed into the machine and it's performance observed. If any malfunctioning occurs, the cause has to be tracked down and any suspect components replaced. It takes approximately 1 1/2 hours to complete these tests even when everything is satisfactory. Circuit checking is carried out after Marginal Tests are completed, a small section of the computer is dealt with for about 1 hour each day to check if there is any deterioration in components and circuitry. It takes several weeks to completely work round the whole computer.

Three hours per day are set aside for Marginal Tests and Circuit checking. The Engineers commence work 1 hour earlier than the Programmers, therefore, only two hours of the Programmers day is affected. The computer time is divided in the following proportions:-

7.30 a.m.	-	Switch on and allow to warm up.
8.00 a.m. (approx)	-	Begin Preventative Maintenance.
10.30 (or earlier)	-	Computer handed over to Programmers and operated until 9.36 p.m.

Although there may appear to be a disproportionate amount of time allocated to the Engineers, it has been found profitable to adopt this daily maintenance routine. A very high standard of operational reliability has resulted and the consequent reduction in abortive machine time during computations easily off-sets the time spent by the Engineers.

Day to Day Operation

The Chief Programmer prepares a daily time table for the computer based on degree of priority of the different jobs. During the course of the day, there is a continuous flow of work onto the Computer and the Tape Editing Staff are kept busy not only preparing tapes but also operating the teleprinter equipment used in producing typewritten results from computer output tapes.

Machine time is apportioned between Development time and Production time. Development time is the time used by Programmers when trying out their Programmes on the Computer. Production time is the time absorbed when actually doing computing. Production may be carried out by Programmers or by a member of the Tape Editing Staff according to the degree of complexity of the Programme.

The working day for the Programmers and Tape Editing Staff is divided into two shifts:-

1) 8.24 a.m. to 5.00 p.m.

2) 1.15 p.m. to 9.36 p.m.

Most of the staff are on the first shift and a limited number are on second shift, the allocation of time for development and production is to some extent settled by staff availability.

In general 10.30 to 12.30 is used for development because the majority of the staff are there to carry out their own development work. Production is done in the evening (5.0 - 9.36) when only one or two people are on duty. The afternoon is divided into development and production according to the degree of priority on each job.

In practice the Computer timetable is continually adjusted throughout the day for the following reasons:-

a) Each Programmer makes an estimate of time required for each of his jobs (production or development). Estimates of production time can be accurately made on most programmes, but not on those involving iteration, in these cases the job may finish early or late.

b) Assessments of development time allow for a reasonable time spent in testing and searching for programme errors. Very often the programme, or section of programme, is got into working condition before the allocated time is used up and therefore the programmer comes off the computer early.

   Alternatively, it may become obvious that extra time could be well spent in searching for errors and the programmer requests extra time. If the programme is urgent, extra time is granted and in exceptional circumstances, on high priority work, almost unlimited time is allowed.

c) When a production run is finished, the results may indicate the need for further calculations. Normally this is not done immediately and the extra work takes its place in the queue.

If the work has high priority, especially Initial Project work, then extra time is granted.

d) Normally, production time is scheduled so that tapes can be prepared well in advance. For urgent work the tapes are prepared as quickly as possible and when they are completed the timetable is disrupted to allow this work to go on the machine immediately.

e) Sometimes subtle faults occur on the machine which are not detected by the standard test routines. If this occurs during development, then the programme is regarded as being more suspect than the machine and is taken away for inspection. If it occurs during production on a proven programme, then the machine is at fault, and there is no option but to search for the nature of the fault using the programme in which trouble occurs. This requires the closest co-operation between Programmers and Engineers and even then the hold up may be long enough to completely dislocate the timetable. In the event that hold ups have resulted in the accumulation of an intolerable back-log of Computer work, a temporary night-shift is sometimes introduced to restore the situation.

AN APPRAISAL OF COMPUTER WORK AND THE INDIRECT CONSEQUENCES OF ITS APPLICATION

A phrase often used by Computer Salesmen, is that 'the appetite grows with eating'. From my personal experience of computer application, I can readily agree with this reasoning, for although we did anticipate a justifiable volume of work when our computer was installed, it has been most surprising and revealing to discover the extent to which the computer has exercised its influence. As machine consciousness spread throughout the Aircraft Design Office after a few preliminary but powerful demonstrations of its possibilities had been made, many unforeseen applications arose. The variety of problems dealt with by the Computer Office can be appreciated from the list of programmes given in Table I. Several programmes of a confidential nature have been omitted, but even so some 110 programmes are listed. Programmes 1 to 49 are also omitted since they were written

TABLE I (Continued)

No.	PROGRAMME TITLES
100	Integration of Control Surface Derivatives.
101	Multhopp Subsonic Load Grading:-31 x 3 Collocation Points.
102	Rigidity of Sandwich Cores.
103	Calculation of Lift and Moment from CP. Graphs.
104	Anti-Icing Heat Flow.
105	Corrugation Sandwich Data/B.
106	Wind Tunnel Data Corrections/E.
107	Frame Stressing/B.
108	Refuelling System.
109	Open and Closed Loop Frequency Response.
110	Honeycomb Sandwich Data/B.
111	Engine Performance.
112	Flutter Derivatives - Richardson Method.
113	R.A.E. Tunnel Data Reduction.
114	Method of Characteristics for Drag.
115	Etkin-Woodward Wing Loading.
116	Distributed Flange Wing Analysis.
117	Calculation of Pressure Heights.
118	Evaluation of Convolution Integrals.
119	Heat Transfer Coefficients/B.
120	Wind Tunnel Wall Control.
121	Matrix for Wing Pressures.
122	Descent Performance.
123	Calculation of Wing Twist.
124	Solution of Heat Transfer Differential Equations.
125	Response to Atmospheric Turbulence.
126	Wing Stressing by Plate Theory.
127	Expansion of a Determinant as a Polynomial.
128	Design of Engine Intakes.
129	Factored B.M. and Shear Distribution.
130	Single Leg Undercarriage Performance.
131	Cruise Performance.
132	Machine Tool Control.
133	Solution of Heat Transfer Simultaneous Diff. Equations.
134	Engine Inlet Data Reduction.
135	Overall Modes by Branch System.
136	Computer Time Records.
137	Polynomial Quadratic Factors.
138	Supersonic Wing Wave Drag.
139	General Climb and Descent Performance.
140	Whirling Speeds.
141	Take Off Performance.
142	Take Off and Landing Performance.
143	Engine Inlet Data Reduction/B.
144	Two Group Reactor Equations.
145	Large Deflection Analysis of Flat Plates.
146	Weber-Newby Chordwise Loadings/B.

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TABLE I (Continued)

No.	PROGRAMME TITLE
147	Rolling Response with Inertia Coupling.
148	Evaluations of Determinants.
149	Buckling of Parallelogram Plates.
150	Stability under Arbitrary Elevator Motion.
151	Simultaneous Linear Differential Equations.
152	Turbine Disc Stressing.
153	Simultaneous Equations/C.
154	Digital Differential Analyser Simulation.
155	Matrix Inversion Improvement.
156	General Second Order Transfer Function.
157	Thrust Data Reduction.
158	Simultaneous Equations/D.
159	Wave Drag for Optimum Area Distributions.

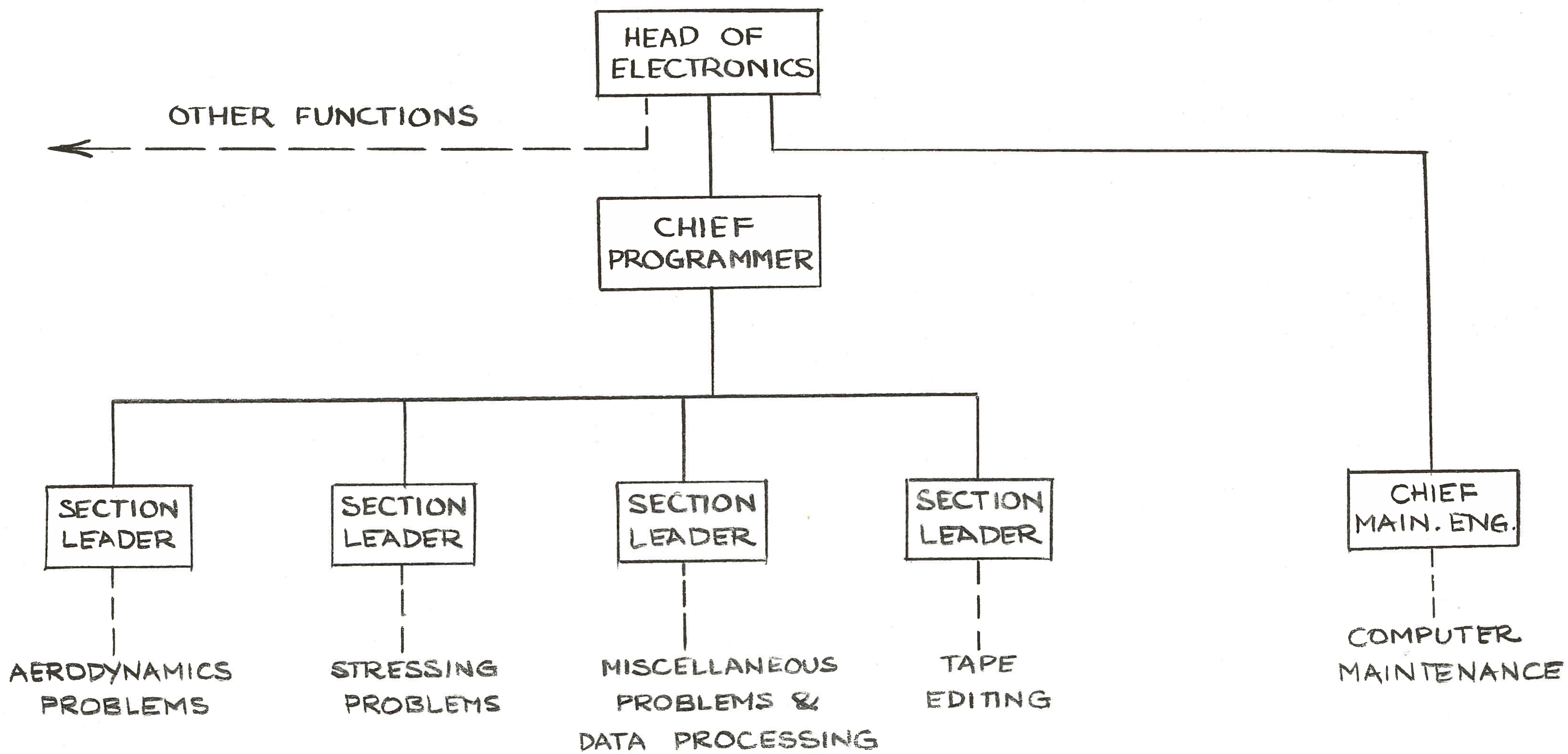
HEAD OF ELECTRONICS
OTHER FUNCTIONS
CHIEF PROGRAMMER
SECTION LEADER
SECTION LEADER
SECTION LEADER
SECTION LEADER
CHIEF MAIN. ENG.
AERODYNAMICS PROBLEMS
STRESSING PROBLEMS
MISCELLANEOUS PROBLEMS & DATA PROCESSING
TAPE EDITING
COMPUTER MAINTENANCE

FIG. 1.