The Experience of Applying a Commercial Computer in a British Organization

By A. J. Platt

This paper, which was read to The British Computer Society in London on 21 October 1960, discusses the experience gained in installing and operating a computer. It deals with the original plans, actual performance and future ideas.

Starting from the original decision of the Board that the possibilities of using computers should be investigated, it deals with the early planning and its implementation, the selection and training of programmers, the first job of production control, the computers used, and their reliability.

It goes on to deal with the way in which new applications are dealt with and higher management are brought into the planning and decision-making procedure.

After considering the likely effect of computer use on future business organization, the paper ends with conclusions drawn from the experience gained.

Introduction

(*a*) *Progress Report*

As I prepared this paper to the title suggested by your meetings committee it forced me not only to look back over a period of four years, but also to peer, however dimly, into the future. It made me realize that I was reporting on progress made on a long-term development plan, as everything we are doing is not an end in itself but a step towards a larger objective, and there ought, therefore, to be added to the title the words "Progress Report."

As always on occasions such as this, I must record the usual proviso that the opinions I express are my own and must not be taken as those of my employers, Pilkington Brothers Ltd.

(*b*) *Looking Back*

This review of the past makes it possible to assess with the benefit of hindsight where mistakes have been made and where correct decisions have been taken. Similarly, one can pick out the important landmarks which may be significant for those starting in this field, and provide a basis of comparison for those who have installed computers. Above all, it brings out quite clearly the time scale involved in any computer application.

Setting the Course

(*a*) *The Survey*

No paper such as this must avoid the issue of whether or not the preliminary decisions as to the type of computer chosen were correct, and so we go back to 9 August 1956 when a Computer Committee consisting of a Director of Pilkington Brothers Ltd., The Group Chief Accountant and myself met for the first time and agreed those functions of the business that should be examined for computer use.

The decision to form this committee was, in my opinion, a correct and essential step if computer techniques are to be fully developed in any organization, as was also its status with director interest.

The fact that I was on this committee, with terms of reference to investigate and report to the Board on the possible uses of a computer in the Pilkington Organization, draws attention to a previous decision that computer investigation is a full-time job. This also seems to me essential.

As I was entirely on my own at this stage of the investigation, I had of necessity to work through our Office Methods Department for general procedures, and through the Chief Accountant for financial matters. This was done by preparing a questionnaire regarding which we received valuable advice from the manufacturers.

Together with the time taken to collect this factual information, which was to form the basis of our investigation, some six months were spent on this survey.

(*b*) *The First Appraisal*

When this information was available, reports were prepared on the three separate spheres where it was considered a computer could be used.

The Sales Procedure
The Materials Procedure
The Wages Procedure

These reports were submitted to nine computer manufacturers and detailed discussion on them then followed. At the same time technical details of the machines available were collected.

Two progress reports were made to the Board during the year 1957 as the detailed investigation continued. Views were beginning to crystallize which led to the decision to examine the sales procedure in detail, with the further realization that only a medium-sized computer would be capable of carrying out the routine.

The committee, at this stage, agreed that in making

any final choice the following points must be taken into consideration:

(i) Ease of maintenance and maintenance staff requirements.
(ii) Technical strength of the computer manufacturer's staff.
(iii) Knowledge of commercial computer techniques and applications.

A technical investigation of the machines available was also carried out by a team consisting of our deputy group chief engineer who was an electrical engineer, an electronics specialist from our research laboratory, and a mathematician who was carrying out an investigation on the use of computers in his own sphere of investigations.

This phase of the investigation also lasted six months and led up to the decision to concentrate on our sales procedure and also, as it seemed certain that a medium-sized computer would be purchased, to select and train specialized computer staff.

(*c*) *The Third Report*

The way in which a computer could be used on our sales procedure was discussed in detail with the manufacturers, and computer procedures were set down and timed.

By the end of 1957 a firm recommendation was made to the Board that we should purchase a medium-sized computer primarily to carry out an integrated system of order and production control, including invoicing and all statistics. The factors governing this choice were reduced to:

(i) Technical—Transistors or valves.
(ii) Output Printing—Electric typewriters or line printers.
(iii) Cost and Saving—A capital figure of £165,000–£175,000 with running costs, including depreciation at £41,000 per annum and gross savings of £40,600 on the main application, with further possible savings.
(iv) Delivery—A machine in production or one being developed.

Although savings were estimated of the order of £40,000 per annum, the takeover was expected to be protracted and could easily extend over three years.

The Board, however, did not agree with the recommendation, as they did not consider that a financial case for the project had been made. One of the factors which was important in their minds was a projected move to new offices. We had ascertained that a gap of six weeks must be assumed while a medium-sized computer is being moved. This, quite clearly, was unacceptable as, if our planning was successful, the whole sales procedure would have been transferred to the computer by the time of this move.

The Board's view was that the arrival of a medium-sized computer should be made to coincide with the building of the new offices, and the matter was referred back for further work.

The time taken was again about six months.

(*d*) *The Final Report*

By now, programmers had been selected, so that a more detailed assessment of the future could be carried out. On 12 June 1958 a fourth report was submitted to the Board. It commented on outside experience, discussed the application of a medium-sized computer to a sales procedure, and explained a demonstration program that had been written.

It reviewed the medium-sized computers which had been considered, and tabled the comparable timings and cost. They were classified as between machines working with magnetic-tape facilities, machines with magnetic-tape facilities under development, and two machines still being developed. It was estimated that a medium-sized computer would involve capital expenditure of £170,000 to £200,000, and that development expenditure (including depreciation) would amount to some £140,000, as it was still assumed that the break-even point would not be reached for three years. Although clerical savings would result and cover the costs, the main justification would be to produce information more quickly or more accurately than at present, and give better control figures. However, to load the medium-sized computer would also entail the centralizing of both materials and wages procedure. Although this could be assumed for the purpose of working out a procedure, such an organization change, in practice, was a major decision.

The case for the small HEC 4 (I.C.T. Type 1201) computer was then considered. This was estimated to cost £42,000 plus development expenditure of £25,000, with the break-even point reached in 1½ years.

The factors now taken into account in making the final decision were the organization problems outside the computer, the technical point as to whether in a period of rapid development one should select an available developed machine or await new and faster machines under development, and the necessity to gain practical experience in computer work.

As it was now considered that no further progress could be made until a computer was on order and definite planning carried out with knowledge of the computer's capability, the final recommendation was to obtain a small computer, continue the investigation into the medium-sized machine with a view to taking the final decision on this after experience had been gained on the small machine, but planning for it to arrive to coincide with the building of our new Head Office.

This report was accepted at a Board Meeting held on 17 June 1958 and our course was set.

Selection and Training of Programmers

I have mentioned that programmers had been selected. This had been agreed in 1957 when it was decided that four programmers should be recruited, and we were faced with the problem of how to select individuals for this new discipline without any previous experience in

the new field. It seemed clear that normal methods of selection by interview alone would not be satisfactory. No interview could possibly assess sufficiently well a person's logical ability, and we decided that selection must be based on tests. The only reliable aptitude tests that we could then find were those provided by one of the manufacturers. The vacancies were advertised internally in the organization and some 50 persons applied. They were reduced to 33 by preliminary interviews. The aptitude tests reduced this field to 18, and further tests reduced it to a short list of 13. Final selection was then made by the computer committee. It was made quite clear that although we were prepared to send them on a training course they would stay on the strength of their departments until they had passed the course satisfactorily. Since that date, we have expanded the department slightly and, in principle, follow the same procedure, but the aptitude tests are now followed by an afternoon, in which I talk for an hour on a very simple computer capable of obeying only seven logical steps. Some examples are then given to be worked out, and the answers are assessed. This usually reduces the field to three or four, from which the trainee programmer is selected by a panel consisting of myself, the head of our Central Works Study Section, and our Staff Personnel Officer.

The original team simply learned their job by experience on the first application, but since then, training has consisted of an introduction to punched-card techniques followed immediately by attendance at a 5-week residential course run by the computer manufacturers.

On the programmer's return, the actual writing and testing of subroutines of a program is carried out, under supervision of one of the now experienced original programmers.

Our experience suggests that it takes about six months to pass the trainee stage and become a junior programmer. From then, development depends on the individual. So far, our methods of selection and training have given us 100% success.

The Pilot Scheme

(*a*) *Selection*

Very often a large undertaking will contain one or more small businesses, and this is so with Pilkingtons. One of our products is a toughened glass high-voltage insulator which many of you will have seen on the power lines across the country.

Pilkingtons manufacture only the glass portion, and all the remaining items of the equipment (both integral fittings, which form part of the insulator, and the non-integral fittings, which connect the insulators, etc.) have to be bought out.

For this particular section of the organization, there is a separate sales office, a separate manufacturing control covering the assembly and despatch operations, and a production control office which decides what is to be made. All wage, salary, costing, accounting and other financial services are centralized. This section of the business employs about 250 wage earners plus a staff of about 48, including works staff. It provided an ideal opportunity to use the computer and it was agreed by the computer committee that this application should be our pilot scheme.

(*b*) *Preparing the Scheme*

The assembly operation is not nearly as complicated as in many engineering factories, yet the more one goes into detail the more practical troubles arise. It is usually the case that your own problems are more difficult than those of the other fellow. During the second half of 1958 there was a whole series of discussions with those responsible for this section of the business, and it took us until 22 December 1958 before a report was prepared and submitted regarding computer use. An integrated computer scheme affects many people and it was necessary to form a committee consisting of Sales, Production, Production Control, Buying and Accounting staff to consider the full implications of what we were trying to do. A whole series of criticisms and comments had to be considered and discussed at meetings during January and early February 1959.

We then retired for a further three months, before producing a final report on 30 April 1959, which was discussed at a meeting on 13 May 1959, when certain further comments were raised. After consideration, we were able to issue amendments on 27 May 1959, and it was on that date that we had a final agreed report.

(*c*) *Description of the New System*

There is no time to give you a description of the old system except to record that planning was on a monthly basis, although a weekly manufacturing schedule had to be prepared.

The basic working paper in the new scheme is a forward load schedule prepared on the computer. This schedule is a complete record of the unassembled order book, projected forward week by week into the future, each week being tested against certain restrainst regarding manufacturing capacity given to us by the Works. If any of these restraints are exceeded, the items in question are so marked. From this document, it can easily be decided into what weeks in the future new orders can be placed when they are received. Similarly, where the manufacturing restraints are exceeded, action can be taken now by those concerned to make the necessary amendment to this schedule which is also the forward production plan. The schedule is produced weekly and gives all concerned an up-to-date record of the future that lies before them.

The next job is to use the computer to break down this forward load into piece-parts required to make those insulators, and the weeks in which these piece-parts are required. We have also to carry out the historical

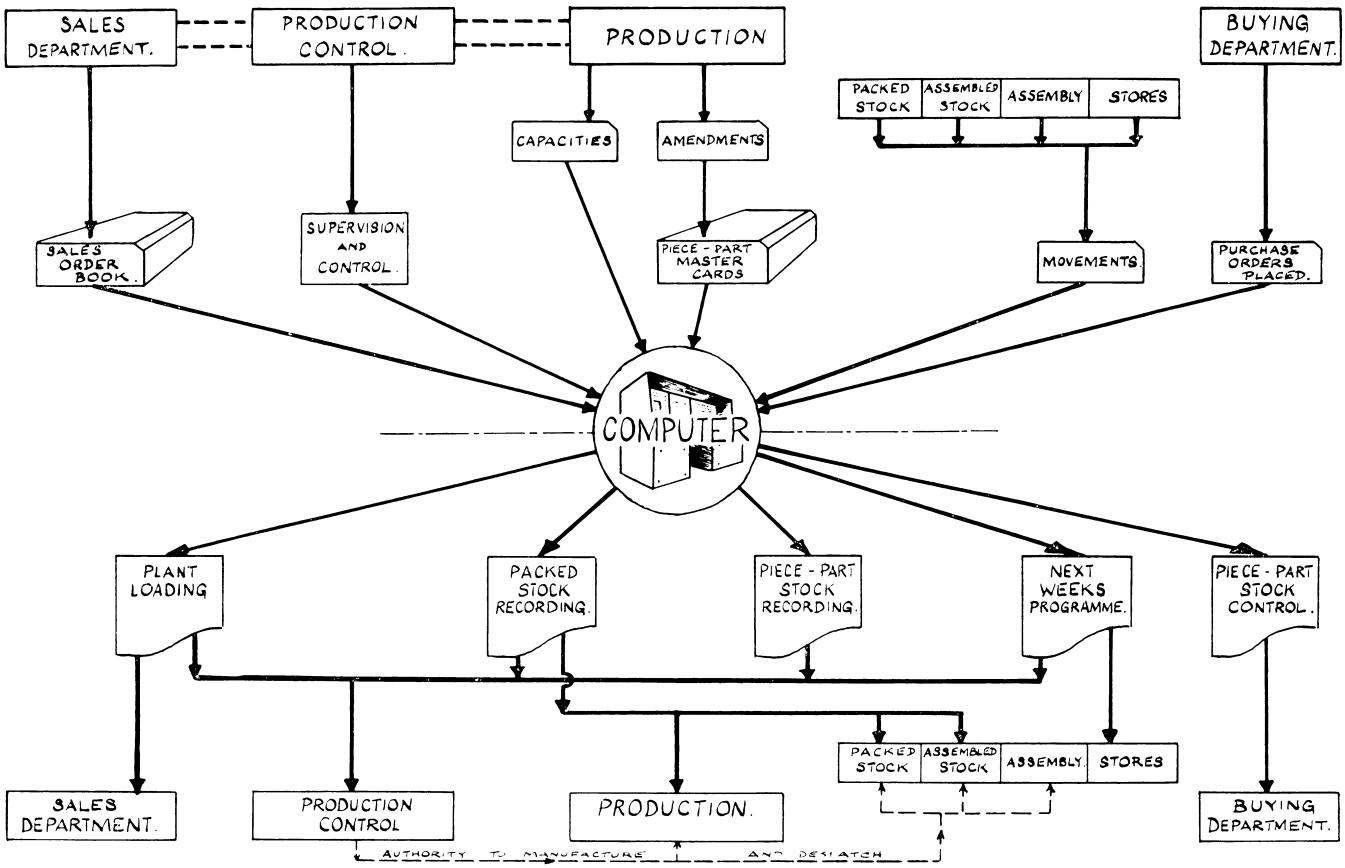

Fig. 1.—Production and stock control program: simplified schematic diagram

recording of stock movements, to which is added a record of all buying orders placed, with due dates.

The statement of requirements is then compared by the computer with the forward plan for piece-part arrivals, which draws attention automatically to quantities required, purchases overdue, deficiencies affecting production, items over-ordered and surplus stocks.

There are other runs which give information to the Works regarding the next week assembly programme with the number of piece-parts required, the glass requirements for forward planning, and a finished stock control account.

A simplified schematic diagram is given in Fig. 1.

(*d*) *Programming*

The necessary programs had to be written, and the whole effort of the programming staff was put on to this work. We did, in fact, take a calculated risk in starting to write programs before the report has been finally completed, but this had to be done in view of the arrival of the machine and the necessity to start debugging the programs. The first parallel operation started in the week ending 4 July 1959, and we made our first planned run during the week ending 25 July 1959.

(*e*) *Lessons Learnt*

Working on this scheme has taught us the following.

(i) That management effort need only be directed to keeping one set of records correct.

(ii) From this basic record, everything else follows logically and automatically, so that all information provided from the one central source is consistent.

(iii) We have been told that two crises have been avoided, one being the shortage of a particularly important constituent of the insulator, and that capital expenditure has been able to be planned well before an increase in the load on part of the factory.

(iv) Control Office can concentrate on real control, being relieved of all tedious calculating work.

(v) It is, unfortunately, not possible to say that a reduction of stocks has been achieved solely by using a computer. There are too many other factors to be considered. One can only say that closer control and better knowledge of the future should enable stocks to be reduced, and then see what happens.

Expressing average month-end stock of integral fittings for the three months ended 30 June 1959 as 100, the averages for the following quarterly periods were:

QUARTER ENDED	MONTH-END STOCK LEVEL
30 September 1959	80
31 December 1959	85
31 March 1960	79
30 June 1960	73

I believe the computer has helped to achieve this reduction.

(vi) Sales promises can be given with the firm expectation that they will be met.

(vii) But above all, computers *work* and can be trusted.

Scientific Applications

When the decision to purchase the computer had been taken, our research staff and our technical development staff were informed that we were prepared to carry out any of the more onerous calculations that they needed, and we have in fact carried out a number of scientific and statistical routines.

A brief description of these has been given elsewhere (Platt 1960). Since then we have written a computer program to support experiments to calculate optical constants using the Kromers–Kronig dispersion relation as follows:

Given n *values of wavelength of light and corresponding measured reflection, compute the negative of the natural logarithm of the square root of the reflectivity and obtain the successive differences which are multiplied by a constant to give a corresponding series of* k *values.*

A symmetrical matrix is formed with the n *values of the independent variable, and each of the columns is multiplied, a line at a time, by the* k *value, the sum of each column giving the number of degrees in an angle.*

From this basic information calculate two further factors, dependent on sine and cosine relationships, on which a simple division and difference of squares routine is carried out, to reach the final required values.

One calculation takes $1\frac{3}{4}$ hours on the computer against an estimated three months by ordinary calculating machines. At the moment we are dealing with 212 values, but we must be able to cope with 400, when the time required will be about 5 hours per calculation.

The Computer

(*a*) *The Type* 1201 *Computer*

At the time when the decision was taken in June 1958, we were promised a second-hand type 1201 computer in November 1958, and a 1202 computer in January 1960. In fact, I.C.T. had to change their minds and we actually received a new 1201 computer which arrived on 13 January 1959. There was a little trouble installing it, as certain intermittent faults were discovered when we started on our acceptance tests, and it was not until 16 March 1959 that we officially accepted it. Before this occurred, we submitted it to one week's hard running on which it reached the figure of 81% useful time as against the 80% required. This machine was operated continually until 9 July 1960, and during that period the maximum down time for any one breakdown was 4 hours 55 minutes.

In order to make way for the 1202 computer which was to replace it, the 1201 had to be moved into an adjoining room. This move occurred on 8 April 1960, and we had about three weeks in which a number of small faults occurred before the machine settled down again, but we have no doubt that this was due to moving the computer and one can only draw the obvious conclusion that it is a bad thing to move a computer.

(*b*) *Changeover*

With the knowledge that a different computer was arriving, it was necessary to consider the re-writing of all the programs. To carry this out by hand would be an onerous task, and having checked with I.C.T., who were not able to provide a conversion program, we had to write such a program ourselves. The 1201 master pack was fed into the machine which broke the instruction into its components of operand, function, next instruction, shift count and location. These were then examined by the computer and converted to their equivalent in the 1202 instruction code, and new 1202 denary cards were punched. There was also printed the 1201 and the 1202 programs side by side, with indicator numbers advising the alterations and special cases requiring attention.

We donated the program to I.C.T. who, we understand, have used it to convert itself into a 1202 program.

(*c*) *The* 1202 *Computer*

The 1202 computer, which had been originally promised for January 1960, arrived on 26 April 1960. It took some time to hand over to us for acceptance testing. On this occasion, as this was a purchased machine, we had decided that it must undergo two weeks' acceptance tests, and these took place from Friday 3 June until Friday 17 June 1960. Overall on this occasion the useful time came out at 90·8% and we had no qualms about signing the acceptance certificate. Since then, the machine has been working satisfactorily, but we have had one or two teething problems. The longest breakdown so far has been for 3 hours 20 minutes. It took 3 hours 5 minutes to trace the fault and 15 minutes to put it right.

(*d*) *Operating Statistics*

One of the factors to be considered when selecting a machine is its likely reliability, together with the time required to maintain it. One cannot be considered

without the other, and figures cannot be compared unless they are prepared on a constant basis.

For our part we take the view that at present the computer should be used for one shift, which corresponds with our normal office hours but including the luncheon break. This gives a normal week of $44\frac{3}{4}$ hours. This total time is then logged to a number of headings, shown in Table 1, which give a detailed breakdown for management control. The headings are easily summarized for comparison, and the operating statistics for the two machines are given in Table 2.

It is too soon to draw any firm conclusion as to the reliability of the 1202 against the 1201 computer on the available statistics. These results compare very favourably with those quoted by Merriman and Mortby (1960), with whose general remarks on the necessity to improve record keeping I would wholeheartedly associate myself. Is not this a matter on which the British Computer Society could make recommendations as to a standard method of keeping a computer log?

Table 1

Computer Operating Log

HEADINGS

WORKING TIME

Good Time

Productive—

01 Planned Runs
02 Special Runs

Program Development—

11 Testing
12 Data Preparation
13 Parallel Operation

21 Demonstrations

31 Training

Total Good Time

Unutilized Time

Lost Time—

41 Operator Errors
42 Program Errors
43 Control Panel Faults
44 Damaged Cards

51 Idle Time

Total Unutilized Time

TOTAL WORKING TIME

DOWN TIME

61 Lost Program Time

71 Investigating Machine Error

Maintenance Unscheduled—

81 Computer
82 Card Feed
83 Printer
84 Card Punch
85 Electro-mechanical

89 Maintenance Scheduled

91 Modifications

TOTAL DOWN TIME

TOTAL TIME AVAILABLE

The Main Application

The original feasibility study proved that the main use of a computer in our organization must be on our sales procedure, from the time an order is received from a customer until such time as the cash is collected in payment for the glass supplied. Whether this will ultimately be a complete computer application, or whether there will be areas of the work carried out by special-purpose machines, I do not know, but certainly it must be considered as a whole.

Before going any further, it is necessary to appreciate that glass manufacture is a mass-production industry, in which large tank furnaces, with a life of up to 5 years, produce quantities of glass working throughout the whole of a 168-hour week.

Theoretically, the most economic way of production would be to cut the glass at the end of the process line and despatch direct or pack into cases according to customer requirements. Some progress has been made towards this theoretically most economic method, but it is also necessary to hold stocks of glass in warehouses and cut to customers' order from these. In any event demand fluctuates and, during times when this is low, it is necessary to build up stocks to a maximum, as any reduction in the rate of production is delayed as long as possible. In principle, it is better to allow stocks to fluctuate rather than production. The closing down of a tank furnace, other than for normal repair, is a major policy decision.

It follows that, so far as is compatible with customers' requirements, an even flow of glass out of the works must be maintained with the minimum acceptable delay between the receipt of an order and its despatch, and there must also be maintained the necessary records to ensure that the foregoing object is achieved.

To do the whole of this throughout the organization would need a medium-sized machine, but an analysis of the problem showed that groups of glasses could be treated separately. It also became clear that if a computer could take over the order book from the time an order was received until the time that order was despatched, we had the raw material available for all future progress. Further, it was possible to commence the takeover with a small machine. In fact, if the alteration of procedures outside the computer is the main difficulty,

Table 2

Operating Statistics

		TYPE 1201 16 MARCH 1959–9 JULY 1960			TYPE 1202 27 JUNE–30 SEPT. 1960		
		HRS.	MINS.	%	HRS.	MINS.	%
WORKING TIME							
Total time in use or available for use		2,673	7	87·1	567	30	83·1
Lost time due to operator and program errors, control panel faults or damaged cards		35	24	1·1	21	45	3·1
	A	2,708	31	88·2	589	15	86·2
DOWN TIME							
Unplanned							
Lost program time		17	30	0·6	6	35	1·0
Investigating machine errors		21	55	0·7	12	10	1·7
Unscheduled maintenance		44	17	1·4	19	35	2·9
	B	83	42	2·7	38	20	5·6
Planned							
Scheduled maintenance		239	25	7·8	49	20	7·2
Modifications		24	25	0·8	6	35	1·0
Moving Computer		16	15	0·5			
		280	5	9·1	55	55	8·2
TOTAL TIME AVAILABLE		3,072	18	100·0	683	30	100·0
Reliability $\left(\frac{A}{A+B}\right)$				97%			94%

then all this reorganization can be carried out before the arrival of a large machine.

The necessary programs have been written and we are in course of taking over the order book for the first glass groups, with the intention of matching it against estimated future production. Immediate objectives are:

(*a*) To provide both sales and works departments with statistics concerning orders received, despatches, and outstanding orders from one source, and thus provide figures which are immediately reconcilable.
(*b*) To provide an analysis of unexecuted orders divided into periods of execution ahead, to assist in planning.
(*c*) To provide works departments with information regarding glass sizes on the orders immediately available.
(*d*) To draw management attention to all failures to reach given criteria.

Other Applications

(*a*) *Wages*

In considering the case for a computer, the Computer Committee placed wages at the bottom of the priority list. This was done on the grounds that present methods were satisfactory and that there would not be any great advantage in using an expensive machine such as the computer for taking over a job which can be carried out equally as well by other means. The staff savings were not expected to be great. However, with the onset of the new National Insurance Act and a decision by the firm to join the Graduated Pension Scheme, it became necessary to consider how this work should be carried out from April 1961. In November 1959 a small committee was set up to consider the implications of contracting in on our wages system.

Methods suggested included use of the computer or an I.C.T. type 555 calculator. In December 1959 I was asked to report on the possibility of using the computer. In a report dated 29 December 1959, although expressing the view that it was preferable to employ our computer on production control applications rather than on wages, I recommended the setting up of a team to carry out a feasibility study. This was completed on 12 May 1960: the net outcome was that while rejecting the use of a computer for all the works, it was agreed that the computer should be used in one of our St. Helens Works, where there are approximately 4,000 employees. A

steering committee was set up to supervise the development of a wages procedure by computer. The committee consisted of the works personnel officer, the works accountant, the head of the wages department, the head of the office methods department, the programmer and myself. We held our first meeting on 9 June 1960 and made the necessary detailed recommendations on 7 September 1960. The scheme is now being programmed and should be working in November 1960. We have then four months to do the takeover.

(*b*) *Expansion of the H.V. Insulators Scheme*

Our High Voltage Insulators scheme is working and has now got control of the physical happenings in the works. The next step is for our accounting departments to reconsider their methods and, if a standard costing system can be devised based on the present computer records, then the basic cost information can be produced at the same time as the production control run. It has been agreed with the Chief Accountant that an accountant will be seconded to us on 1 December to work out the necessary procedure.

Similarly, we can add an invoicing routine to the data already available.

(*c*) *Optical Glass*

We also have at St. Asaph in North Wales an optical glass factory, which, so far as manufacture is concerned, until the glass reaches the examination stage, is almost wholly automatic. But optical glass has to be supplied in a number of different refractive indices. Each type of optical glass may further have to be supplied as optical blanks of different curvatures, thus entailing the holding of a large stock of moulds. To change over manufacture from one refractive index to another takes about twelve hours. Thus loading of the furnace is very critical if one is to minimize cost of production.

We have just been asked to study the production control application at this factory.

Administration

(*a*) *General*

When a computer department is introduced into a large business, its place in the administrative structure will be affected by the already existing organization. Before I was appointed, there was already in being an Office Methods Department reporting, through the head of Central Work Study, to the Director to whom I was made responsible.

As experience had to be gained in our pilot scheme we took the initiative, carrying out first the systems investigation, assisted by Office Methods, before doing the programming and coding, and we were further assisted by I.C.T. on all aspects of the job. This pilot scheme was our first practical training and we all took part one way or another in the planning. When it came to doing the actual coding one of the more senior programmers was appointed to take the co-ordinating role and spread the work among the team.

It was not to be expected that this method would be a precedent for the future, when we must be prepared to take on more than one job at a time.

Discussions with my Director led us to the view that the Computer Department must specialize in computer techniques. It was considered to be wasteful to use trained programmers to carry out the detailed investigation, in the department affected by a proposed application, when we already had trained systems investigators.

Policy is now to send suitable members of the Office Methods Department on computer systems courses, leaving my team to concentrate on advising as to the best use of the computer and finally writing the necessary program.

(*b*) *The Computer Department*

Although we started with all our programmers being considered general-purpose programmers and available to carry out both the investigation and the detailed coding, the time has come when an organizational subdivision has occurred. We have added to our strength two junior programmers, one aged 22 who was transferred from our Wages Department, and a young school leaver, a girl aged 16 who has seven passes at Ordinary level in the G.C.E., including Maths, Physics, and Chemistry. We are encouraging her under our Education Scheme on day release to take G.C.E. Advanced level in Maths and Physics.

We have, therefore, set up a separate coding section who are responsible for the final programming and coding of an agreed new scheme. The trained programmers are responsible for taking on all new applications and working with our Office Methods Department in the preparation of a detailed report on the proposed application. They are, of course, responsible for consulting the leader of the coding and programming team to ensure that any computer runs suggested in their report will be compatible with the capabilities of the machine.

(*c*) *Settling Policy*

We are certainly not alone in finding that the most difficult task in any proposed application is agreeing what the computer should do. Our experience shows that the ratio between time taken in deciding what to do and doing it is as 4:1.

When a new proposal comes along, a Systems Investigator is appointed from our Office Methods Department, and one of my trained programmers is nominated to assist and advise. This little investigating team is supervised by myself and the head of our Office Methods Department who meet regularly to discuss the work being done and decide on any points referred to us.

As a result of this preliminary investigation, it is possible to prepare a report to top management containing proposals for a computer scheme. If this is

accepted, an *ad hoc* committee is set up of all those likely to be affected by the scheme, who have the power to take policy decisions. This I believe most essential. There must be a routine by which decisions can be obtained, quickly and finally.

(*d*) *The Final Report*

Eventually, an agreed report is prepared which starts with a section dealing with the proposed scheme in principle (usually written and certainly edited by myself), together with a second section dealing with the computer operations and proposed forms (written by the programmer responsible and approved by myself).

This report, after being approved by the committee, is handed over for detailed programming and coding. During this period our Office Methods Department prepare their own report on the organizational changes required, outside the computer, to install the now agreed scheme.

(*e*) *A Case Study*

I will illustrate this, with the significant dates in what is the first step in a scheme, which will, I believe, ultimately lead to the takeover of the bulk of the routine clerical work in our sales procedures on a medium-sized computer. After the decision to obtain a Type 1201 computer in June 1958, the whole of our efforts were directed on to our pilot scheme, and it was only in the spring of 1959 that we were able, as it were, to look around once again. The factual information had been collected, so this was reviewed, and we discussed with the department concerned methods of improving our order control procedure, in the light of the availability of a computer.

On 24 June 1959 an outline scheme was submitted to top management and approved. The next five months were spent fitting in the detail. This was done by a series of discussions with middle management.

On 17 November 1959 detailed proposals were made to top management with 11 points of principle affecting present methods on which decisions were required.

On 23 November 1959 at a Flat Glass Management Committee the following decision was taken.

> "The report on the application of the Hollerith Computer to Glassworks Order Control, with special reference to Rolled Glasses, was accepted. It was remitted to the Rolled Plate Liaison Committee to decide upon, and to put into effect, the administrative arrangements necessary to enable the proposals in the Report to be carried out."

On 4 December 1959 the Rolled Glass Liaison Committee took the following decision.

> "The Committee welcomed the proposal and it was agreed that the application should be made initially to wired glasses, from all three works, including wired for polishing. During the installation period decisions will have to be made regularly by both Sales and Works and to cope with this work a Sub-Committee was formed. It will consist of:
>
> Export Sales Manager
> Home Sales Manager
> Main Works Production Manager
> Warehouse Manager
> Subsidiary Works Production Manager
> Main Works Administration Manager
>
> This will meet as required and liaise with Mr. Platt or his representative."

We met regularly to discuss and take the necessary decisions until 2 May 1960 when the final report was approved by the Committee.

On 23 May 1960 it was approved by the Rolled Glass Liaison Committee. The detailed programming and coding, including program testing, had then to be carried out.

On 8 September 1960 a meeting was held to see a demonstration and agree the procedure starting the scheme. On 16 September 1960 the Office Methods Report on the procedure outside the computer was published.

On 20 September 1960 it was discussed and agreed at a meeting of Office Managers and Chief Clerks. On 11 October 1960 takeover started.

Finance

(*a*) *Some Figures*

We must not avoid examining the economics of computer use, so, after one year's operation on our H.V. Insulators applications, the position was reviewed.

The financial effect expressed as a percentage of the cost of using the computer and considering only the recurring cost is as follows:

Cost of using the computer	100%	per year
Deduct: Staff Savings	73%	per year
Apparent increase in costs	27%	per year

But we have obtained more effective control procedures. A valuation of this can only be arbitrary, but one can equate it to the cost of carrying out the work by ordinary clerical methods. This is not a real comparison because the work simply could not have been done in time, unless you could further assume that it is possible to have a large staff on one day of the week only, with no personnel problems.

On this basis the value of better control is put at between	36% and 55% per year

Then there is the saving due to the reduction in stocks. The overall saving can be taken as 91% of the cost of using the computer per year but, as I have already suggested, this cannot be

claimed entirely as due to the computer. Suppose one-fifth is treated as due to the computer then this is worth	18% ..... per year
Giving an arbitrary value of the additional control as between	54% and 73% per year

To this must be added the further actual savings that will be made when accounting and invoicing procedures are taken over at a marginally increased computer cost.

We believe these figures show that the routine is economically sound.

(*b*) *Double-Shift Working*

Basically, we are substituting for the cost of the number of clerks a depreciation charge, so it follows that if depreciation is calculated on a time basis the cost of working double shifts on the computer only increases overall costs by the marginal extra cost of operators, maintenance, etc.

The larger the computer and the higher the fixed element in the cost of operating, the stronger becomes the case for double-shift working. We estimate that on our small machine, costs per hour will be cut by 25 to 30% if two shifts are worked, which will reduce the cost of the above procedure to between 70% and 75% of the present costs.

Thus, when accounting and invoicing have been taken over and double-shift working has started, there will be an actual financial saving on previous methods. The intangible benefits will be pure gain.

(*c*) *Long-Term Benefit*

In introducing a computer, one has to face a period of increased costs

(i) due to the computer being under-employed,
(ii) due to the cost of development of new procedures.

But once the computer is fully used and the new procedures are working, there will be an actual financial saving. When intangibles are taken into account the saving can be substantial. These benefits can only be obtained by long-term planning, but this is nothing new in manufacturing processes where full economies from capital expenditure may only come after a period of years.

Why should not the same philosophy apply to office procedures?

The Future

(*a*) *The Effect of Mass Production*

Glass making is a mass production industry, and I am able to quote to you certain indices which show the effects of major mechanization schemes as compared with earlier methods, which are taken from the manufacture of polished plate glass.

Table 3

Comparison of Melting Processes

(Pot = 1)

	POT PROCESS	RIBBON PROCESS
Square feet per man hour	1	11·9
Square feet per ton of fuel consumed	1	8·3

Table 4

Comparison of Grinding Processes

(Disc = 1)

	DISC	CONTINUOUS	TWIN
Square feet per man hour	1	3·1	24·2
Square feet per unit of electricity	1	3·1	4·5

Table 5

Benefit to the Customer

1913 = 100

YEAR	WAGES	COAL (Pithead Prices)	RAW MATERIAL PRICES	PRICE OF PLATE GLASS (Shop window 10 ft. × 7 ft.)
1913	100	100	100	100
1920	308	341	290	240
1930	214	134	105	145
1938	242	164	104	148
1960	780	772	850	275

Table 3 shows a comparison of the old method of making glass out of a pot with the present method of casting a continuous ribbon of glass.

Next we have to grind the glass so that the two surfaces are parallel. Table 4 gives a comparison of

(i) the old method of disc polishing
with (ii) continuous grinding
and (iii) twin grinding where both surfaces of a continuous ribbon are ground simultaneously.

In Table 5 we may look at the overall effect and compare the movement of prices and wages with the price of plate glass as the finished product.

These figures bring out very forcibly the effect of mechanization, and show that in our case the benefit of the inventions and improvements to our process have been passed on to the customer, and our reward has been the consequent and continual increase in the use of glass. Many of you will know that further improvement has been made by the invention of our new glass called Float Glass. I quote these figures because I believe that with the arrival of the computer similar

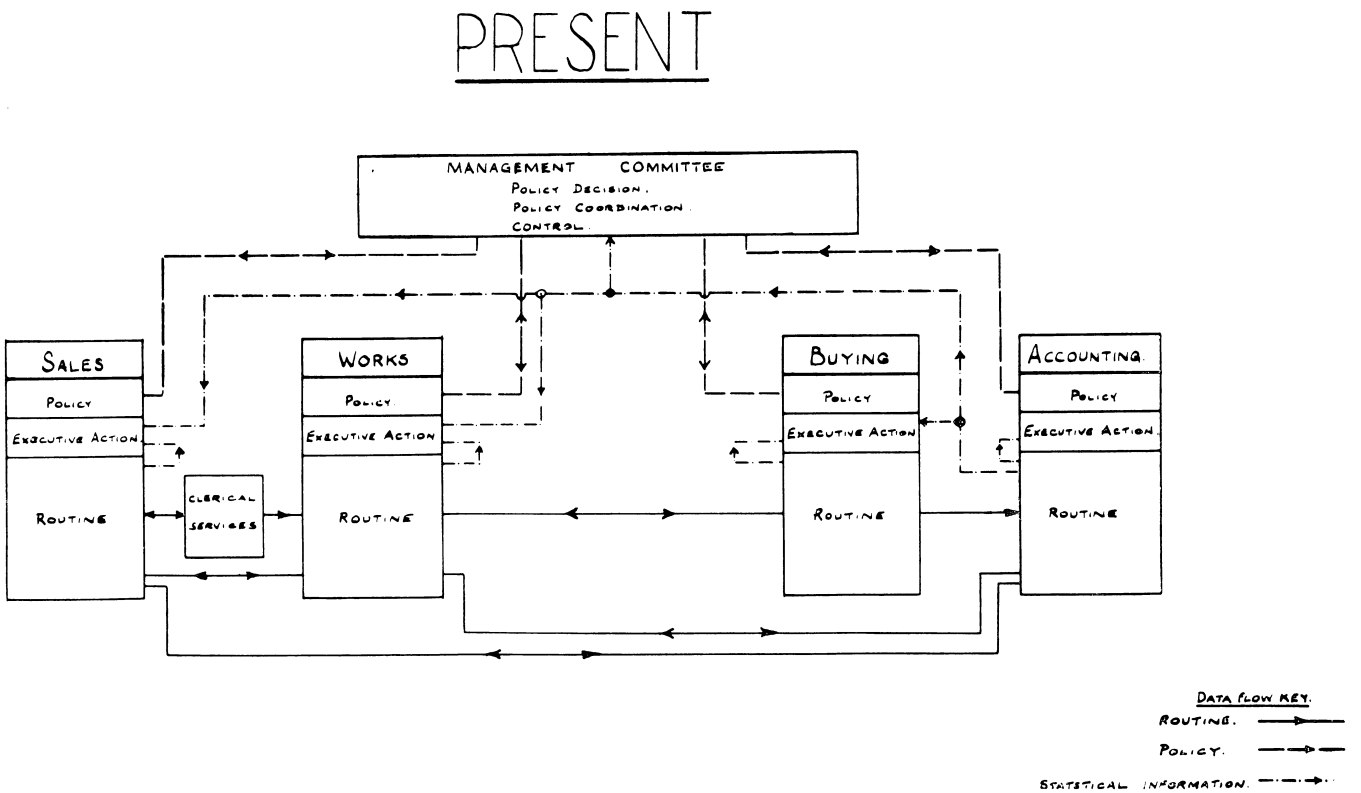

Fig. 2.—Present inter-departmental organization

changes and similar increases in productivity will take place in the offices.

There is another analogy here in the time needed to develop a new process. Many of us become despondent at the length of time required to bring into use a computer and the heavy development costs involved, but one has to take the long view. It took all of seven years to develop our new Float Glass process, from the time of its conception until sales were made, and until then development had cost £4,000,000. I would not for a moment think that we are going to spend the same amount of money in the development of computer procedures, but I think a long-term view has got to be taken, especially should the foregoing order of productivity increases be obtainable in office procedures, which are often in the most elementary form of batch production.

(*b*) *The Large Computer*

At the British Computer Society meeting held in London on 22 September 1960, we were introduced to the latest developments in the computer field, and those of us who are responsible for development of these new procedures have to face once again a multiplicity of choice.

The time has now come when we must draw our conclusions from the work carried out so far and try to assess the effect of mass production techniques on our office procedures during the next ten years. If it is planned to obtain a bigger computer in 1963, it is not going to be working fully, I am sure, until 1965. This means we have to try to envisage the office procedures of 1970, and this leads naturally to some views on the way the computer will fit into a large organization.

(*c*) *The Place of the Computer*

This alone could be the subject of a paper in itself, but tonight I have only time to deal with the broad outline. Most firms are at present organized on the basis that each of the main departments carry out their own routine work, and so there is an immediate problem of reconciling the figures produced by each section. In fact, I would go so far as to say that, in certain cases of dispute between departments, almost as long is spent in deciding which are the figures on which a decision ought to be taken as is spent in taking the decision.

This procedure is illustrated in Fig. 2.

As I see it, the future, aided by a computer, will bring a transfer of the bulk of routine data processing into the computer, which will entail the formation of a general office responsible for supplying reconciled data for action to the various departments of the business, and this is illustrated in Fig. 3. An examination of this diagram

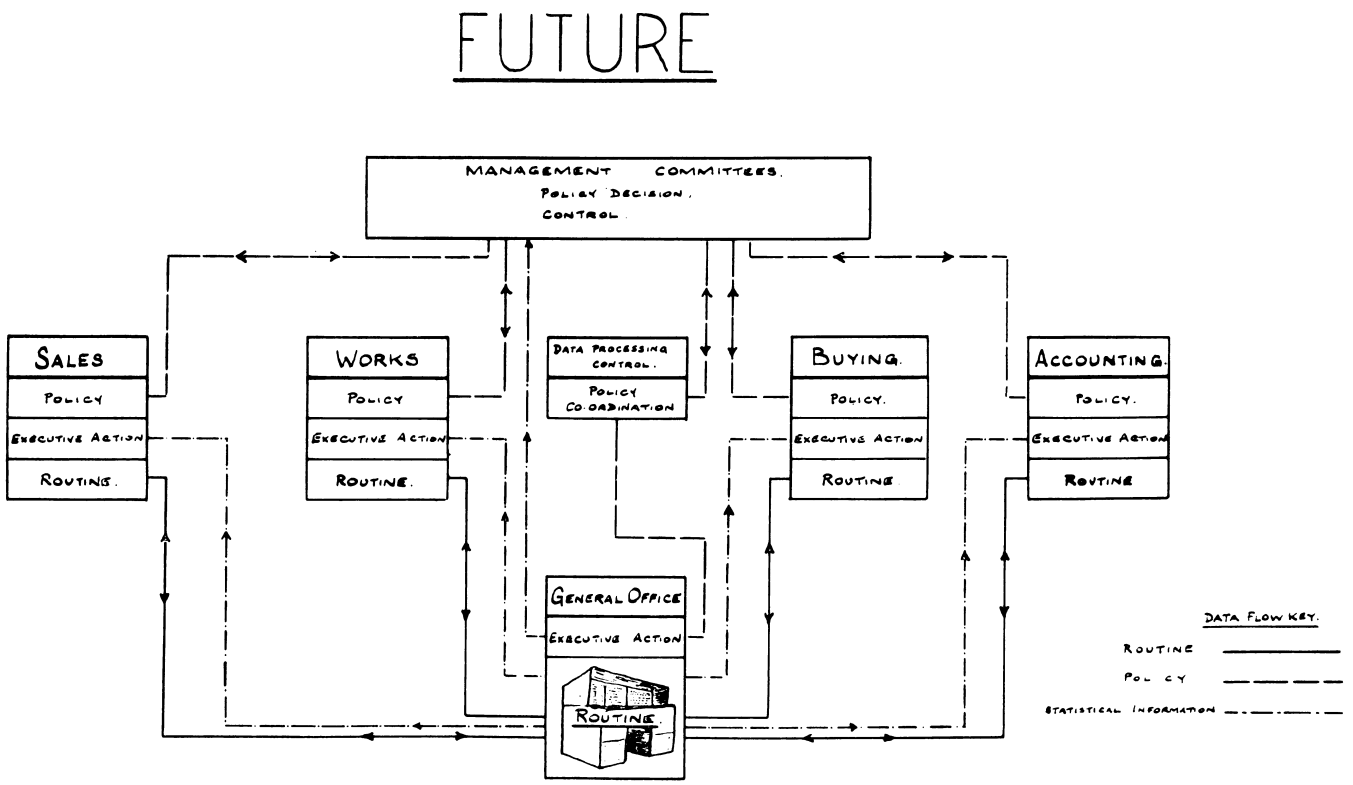

Fig. 3.—Possible future inter-departmental organization

can only make one appreciate that such changes with the transfer of responsibility involved cannot be carried out over night. It is long-term planning in the highest degree, implying organizational and personnel problems of great importance which can only be decided finally at director level.

Therefore, I believe there must be a master plan, however slowly the individual parts of it may be filled in.

Conclusions

For what they are worth, I have drawn certain conclusions. This may be presumptuous of me, but I believe that they must be put down so that they may be discussed and accepted, rejected, or amended.

(*a*) *On Computers*

(i) Computers are not just another step in office mechanization but new *types* of machine, because of their ability to choose between alternative courses on the basis of predetermined criteria.

(ii) Just as developments in computer-controlled machinery will lead to the installation of process lines, which do not need operatives, so similar developments in computers for office use will enable an automatic production line for clerical work to be installed.

(*b*) *On their Use*

(i) The speed of operation enables work, at present considered impossible, to be carried out; e.g. in our case the order book of the company could be held so that the individual sizes of the pieces of glass on order were available. If this information could be used effectively, it could have considerable effect in reducing the warehouse loss, which is a very important factor in the cost of glass as sold.

(ii) The computer enables work at present being carried out in different departments to be integrated, but this raises the problem of reconciling differing departmental requirements.

(iii) More emphasis will need to be placed on the correct preparation of input data. Incorrect data can negate completely the benefits of any computer system.

(iv) It must be admitted that any form of mechanization tends to make an organization less resilient to sudden change. Hence care must be taken in

selecting those sections of the flow of paper for mechanization.

(v) It is probably preferable to use ordinary punched-card equipment, if statistics only are required, or if operations as at present carried out are to be mechanized.

(*c*) *On their Effect*

(i) The primary justification for the use of a computer should be to obtain better management control, but it must be economically sound even if only long term.

(ii) Provided the necessary criteria are set, a computer can calculate the effect of various policy decisions, so that full consideration can be given to their effects before a final choice is made.

(iii) In so far as routine clerical duties are taken over by the computer there will be consequent staff savings.

(iv) The real commercial savings will only occur when more than one procedure is carried out on the same data centrally.

(v) The ultimate success or failure of a computer installation will depend on the ability of management to decide the criteria by which the routine office work should be carried out, together with their willingness to delegate to a machine the responsibility for carrying out such work. Thus the rate of change can only be as fast as management are prepared to make the necessary decisions.

(*d*) *Finally*

In the larger offices, during the next ten years, the computer will revolutionize clerical work, and I have no doubt the tedious mass of routine decision will be made by the computer which, as Dr. Booth has said (Booth 1960), will refer only those choices that fall outside its terms of reference to the office workers of the future.

This will require an entirely new mental outlook, both on the part of management and clerical staff, so education in these new procedures becomes most important.

I have said before on another occasion, but it bears repetition—the computer itself is the least of our troubles. It is we, ourselves and our colleagues, that are the problem.

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