A Small Business Computer at Work

By D. V. Cheesman

An examination of the reasons leading to the installation of a small computer designed primarily for commercial work; a description of the principal features of the machine, and details of jobs on which it has been employed during the first year of operation. The paper concludes with a note on an ingenious simplified programming system, which has been developed to handle statistical work on this machine.

Introduction

The publicity inevitably surrounding the larger computers, whether this is related to their cost, their achievements or their potentialities, has tended to obscure the fact that throughout the United Kingdom, there are numerous small computers performing routine office functions faster and more economically than ever before. These notes are concerned with such a machine, designed and installed for commercial work. In fact, it is also giving a useful service on statistical and mathematical jobs.

The phrases "automatic office" and "complete integration of office procedures" which so fired the imagination in the early nineteen-fifties are encountered less frequently today, but there is still a tendency to view a punched-card-and-computer installation as a failure to "think big." It is hoped that the reasons given for our decision will demonstrate that a genuine attempt was made to compare the claims of the alternative systems for our particular business.

These notes are intended to illustrate ways in which our computer is being used. Inevitably, frequent reference is made to punched cards, in so far as they provide the means of input and output, but it will be appreciated that a considerable volume of other work is undertaken by punched-card methods not involving the computer.

The Company

J. & J. Colman Ltd., have long been established as the manufacturers of a wide range of food products. One of the principal partners in the Reckitt & Colman Group, the Company is largely autonomous and has itself a number of subsidiaries. This article is concerned only with the parent Company at Norwich, where the total payroll including factories, offices and sales force is in the region of 1,600 persons.

History

Colman's have used punched cards for over forty years. Until 1948, they were employed solely in the preparation of Sales Statistics, but from that date, invoicing, sales statistics and allied work were undertaken by a new set of 65-column machines.

This was replaced by the present 80-column Powers-Samas (Interstage) installation, which began operation in October 1959. The modernization programme was completed by the addition of a P.C.C. computer, which was brought into daily use in January 1961.

Whilst we had followed with interest the main trends of computer development in the early nineteen-fifties, it was not until 1956–57 that we began more detailed studies, both of our own work and the machines available. Although the investigations included appreciation courses with two manufacturers of medium-scale computer systems and visits to a number of actual and prospective users of computers, they were undertaken by existing staff, and costs were low.

Two major reports resulted from this work. The first examined all the main areas of clerical work in relation to the introduction or extension of mechanization. The second compared estimated savings to be expected if a medium-scale computer system were introduced, with those anticipated from a punched-card installation including a small computer.

A more detailed report on the latter was called for, and on the basis of this information a contract with Powers-Samas Accounting Machines Ltd. was signed in the autumn of 1958.

Delivery periods were less than one year for the punched-card equipment, and two years for the computer. This was eminently suitable since we had thus almost one year in which to make all the preparations for a change from 65-column to 80-column equipment, and a further twelve months in which to undertake the additional planning and programming required for the computer. A new office building was due for completion in mid-1959; thus there was a unique opportunity to plan layout, furniture, and other equipment in relation to the new machines and systems to be installed.

Reasons for Decision

Although the decision to employ a small computer in conjunction with punched-card machines (rather than a medium-scale computer-system) was made in 1958, it is thought that a number of the reasons for the choice remain valid today for a business of our particular type and size. All major reasons given at the time have been included therefore. It was held that with a medium-scale computer-system:

(*a*) The capital outlay would have been large, and the anticipated return on capital appreciably less than with the alternative scheme;

(*b*) The heavy capital expenditure demanded that a

considerable volume of work should be taken up by the new equipment with the least possible delay;

(*c*) In order to cover in a reasonable period of time, all the systems-investigation and programming required, it would be necessary to recruit, train and pay a sizeable team of people;

(*d*) Programming appeared invariably to take very much longer than estimated;

(*e*) In most cases, a complete change of system was necessary to provide new forms of input;

(*f*) Many of the enthusiastic and well-intentioned claims made by salesmen were based on theory only. This was especially true of plans for highly-integrated systems;

(*g*) Installation-costs were high, air-conditioning being necessary in many cases;

(*h*) Maintenance costs were high, and the allowed maintenance time considerable.

On the other hand, it was thought that the small computer envisaged in the alternative scheme:

(*a*) Had capacities and speeds adequate for normal commercial requirements;

(*b*) Was comparatively easy to program and demanded the recruitment of few, if any, specialist staff;

(*c*) Had been proved in practice; performance reports were encouraging;

(*d*) Was little more difficult to set up and operate than a large tabulator;

(*e*) Would provide useful computer experience (admittedly on a limited scale) on which to base future decisions on mechanization.

It was considered that complete integration of office procedures, or even the full integration of a number of large areas of work was good theory, but impossible to achieve in many commercial undertakings. Granted the "educated managements" which computer manufacturers seek for the most effective use of their machines, national and international events, weather, competitor-action, amalgamations and a dozen other factors can necessitate rapid sectional changes in office procedures. All possibilities cannot be foreseen, and the more complete the integration and complex the programs, the less the flexibility available.

Scope

Investigation had shown that there were sixteen main areas of data processing, and twelve of these were included in a mechanization (or, in some cases, re-mechanization) programme which would cover a period of four years.

Phase I involved the transfer of work already undertaken on 65-column punched-card machines. In practice, this represented major re-planning, since the new equipment enabled many system-improvements and extensions to be effected; in addition, provision was made for the requirements of the computer which was to be installed later.

Phase II covered the preparation for and commissioning of the computer. Here, again, the first step was to secure further improvements and extensions of work already mechanized, but several new jobs were included in our plans.

The computer began daily operation on 2 January, 1961, and took up successively the initial jobs planned for it, the programs having been proved during November and December 1960. During 1961 several minor programs relating to commercial work have been written, and systems-preparation made for mechanizing two further jobs. A considerable variety of mathematical programs has also been run for our Statistical Department, to which further reference is made in the penultimate section of this article.

Punched-card Equipment

The Powers-Samas Company having become part of the I.C.T. Ltd. organization subsequent to the placing of our contract, all our equipment bears the I.C.T. label.

The installation comprises the following principal machines:

3 Tabulators (2 fitted with Summary Card Punches).
2 Sorters.
2 Interpreters.
1 Interpolator.
1 Auto-Verifier.
1 Reproducer.
5 Automatic Key Punches.

All the machines are capable of dealing with normal and interstage punching. The latter facility permits information to be punched into (or sensed from) the areas between the normal punch positions. This enables the capacity of a single card to be doubled (as with our Address cards described later) and information to be sensed from normal positions and punched into interstage, or vice versa. The latter feature is employed extensively in our computer work.

The Tabulators are fitted with a device which permits first the left half of a card to be sensed, followed by the right half. This feature, combined with the "normal and interstage" punching already described, enables four lines of information to be printed from one card if required, as in the case of our Address cards.

The Computer

The P.C.C., designed primarily for commercial work, operates with punched-card input and output only, and is capable of working with normal and/or interstage punching.

A single card-track carries a card successively through two sensing stages. Information picked up at the first and second stages is compared. Any difference causes the card to invert as it leaves the machine and falls into the receiving hopper, and at the same time an error is signalled on the control panel.

The input is thus checked, and it is then dealt with in accordance with the program, the resulting information being punched out into the card. Here, again,

there is a check-sensing and comparison operation, similar to that on input.

All 80 columns of a card are thus presented to the machine at one time, the basic card-cycle being $\frac{1}{2}$ second. Should a program call for a larger "calculation time" than $\frac{1}{2}$ second then the card-cycle is increased to 1 second. This, obviously, is a condition which the programmer seeks to avoid.

The drum used for storage within the computer revolves at 50 r.p.s. and provides the input and output buffer stores, 160 words of main storage (4 tracks each of 40 words) and the means of access to six fast stores.

The P.C.C. is a dual-radix machine, thus a word carries indication of decimal or sterling significance, in addition to provision for positive or negative signature and a parity-check bit. The effective word-length is 16 decimal digits, and a binary-coded decimal system is used on a 1, 2, 4, 8 basis.

To set up the machine for a particular job, it is necessary to insert a set of 11 connection units. These are best described as plastic sheets embodying printed circuits, and pierced with regularly-spaced holes. The required connections are achieved by small cadmium-plated rivets positioned in appropriate holes. Four units control the distribution of information from card-columns to the input store, and from the output store to card-columns. Three small units relate to the significance given to the "over-punch" positions of the cards (alternatively known as the upper-curtate or A, B, C positions). The program is carried on 4 units which together provide 160 program steps. It will be noted that the program is thus external to the machine, in the sense that it occupies no space in the main drum storage, also that any instruction is immediately available.

In practice, a complete set of 11 connection units is not always necessary for a job, since certain units may be common to more than one job, or it may be possible to accommodate two or more programs on one set of units. Division, multiplication and modification of track or location within a track are all in-built subroutines which can be called up by single orders in the main program.

It will be appreciated from the foregoing that the limited storage available within the machine makes it necessary to hold any "backing stores" required in the form of punched cards.

Commercial Applications

Brief descriptions of jobs for which the computer is being used may serve to illustrate the approach required by this type of machine.

Invoicing

The punched cards relating to an invoice are as follows:

1. Address.
2. Reference.
3. Leader.
4. Commodity.
5. Sales Ledger.

No. 1 is punched in normal and interstage positions, and is the means by which addresses are printed on invoices. The card contains no information used by the computer.

No. 2 has interpreted on its face the full address (punched into Card No. 1) together with any standing invoicing instructions. This card is punched in interstage with the following:

Territory Number.
Account Number.
Trade Classification Number.
Terms Classification Number.
Representative's Journey Number.

If the account concerned is regarded as a "Key Account" for Sales Statistics purposes, then this is also indicated in interstage. In certain cases, a brief indication of destination of goods (Store No., Customer's name or town) is similarly recorded.

Nos. 1 and 2 together comprise an Address-set which has been taken from a standing file.

No. 3 contains Representative's Number and Order Number in interstage. These have been recorded by a punch operator.

No. 4 is punched in normal positions with size and description of product-packing together with an identifying code; and in interstage with the basic price and any varying prices which may apply, dependent upon quantity ordered; a price-factor code number; quantity per pack; terms class number; and Trade Discount code number. These cards have been drawn from a file and subsequently punched in interstage with the quantity ordered, and, if other than basic price is involved, the number of the "price step" required. The number of commodity cards per invoice can vary from one to about twenty, but the average is between 6 and 7.

No. 5 is a blank card, designed to take the invoice-total and other Sales Ledger information punched out by the computer.

Prior to the actual invoicing run, constants relating to price factors and discount rates are read into the computer. In the course of a single pass of the invoice cards through the machine, the principal transfers and calculations made are as follows.

C indicates information punched into Commodity cards, and S that punched into Sales Ledger cards.

1. Transfer from Interstage of Reference Cards into Normal of Commodity card:
   Territory No., Account No., Trade Class No., Terms Class No., Journey No., and (where required) Key Account indication. C
2. Transfer from Interstage of Leader Card into Normal of Commodity Card:
   Representative and Order Number. C
3. Check Terms Class Number in Reference Cards with Terms Class Number in Commodity Card.
   Disagreement inverts card and signals error.

4. Select price by applying price step number (if punched), otherwise apply basic price.
5. Select price factor by Price Factor Code Number.
   (Note: Gross Value is obtained by multiplying Price by Quantity of packs. Prices are per dozen. A price-factor is required therefore if a pack contains anything other than 1 dozen.)
6. Select Trade Discount Rate by Trade Discount Code Number. C
7. Calculate Quantity × Price (× Price Factor) = Gross Value. C
8. Calculate Trade Discount and deduct = Net Value. C
9. Calculate Quantity × Statistical Quantity per pack = Statistics Quantity. C
10. Transfer selected price from Interstage to Normal of Commodity Card. C
11. Accumulate Net Values. S
12. Segregate items on which $2\frac{1}{2}\%$ Cash Discount is allowed and calculate discount. S
13. Transfer Territory Number, Account No., and Journey No. (and Destination, if punched) from Interstage of Reference Card to Normal of Sales Ledger card. S
14. Transfer Representative's No., and Order No., from Interstage of Leader Card to Normal of Sales Ledger card. S

It should be mentioned that the Terms Classification provides for certain types of exceptions, which may call for a reversal of the normal tests for particular packings, or additional tests where special types of customer are involved. It will be noted that throughout the job, the P.C.C. is sensing information from interstage positions and punching results into normal positions.

The present volume is about 900 invoices per day on which the computer is engaged for approximately $2\frac{1}{2}$ hours, including time for setting-up, error-correction, etc.

The cards are subsequently tabulated to print out the invoices, and then sorted. Address-sets are returned to their file, Leader cards are scrapped, Commodity cards are filed for later use in providing Sales Statistics, and Sales Ledger cards are filed in an open-item ledger system, having been gang-punched with a date and certain other information.

Compared with the purely punched-card methods which it replaced, the present system has made possible (*a*) a striking reduction in the size of the pre-punched Commodity-card file, (*b*) automatic checks and transfers of information, providing greater accuracy, (*c*) reduction in staff, (*d*) the provision of additional information.

Sales Ledger Discount Elimination

It will have been noted that in the course of the invoicing run, the computer calculates and punches into Sales Ledger cards the amount of cash discount allowable.

At the end of each calendar month, all Sales Ledger cards representing unpaid items are tabulated to provide statements, and on these, the discount figures appear.

Our discount terms permit the deduction of discount up to the 14th of the next month. It is necessary, therefore, as soon as possible after the 14th of each month, to "net" all items no longer within the discount period. This is achieved by passing all unpaid Sales Ledger cards through the computer. The date in each card is compared with a pre-stored date, and a hole is punched in all cards no longer eligible for discount.

When the cards are subsequently tabulated on statement-forms, this hole operates an eliminator which prevents the discount figure appearing.

The computer run occupies about 4 hours.

This simple application provides a good example of time saving by computer since the conventional punched-card methods previously employed involved out-sorting, gang-punching and re-sorting, which occupied at least two days.

Cost Rating

The Company operates a Standard Costing system and at the beginning of each year cost rates are fixed for each product-packing. A cost rate comprises four major components (Works, Administration, Selling and Carriage rates) and a total, for a standard quantity of 100 dozen, 100 lb., etc.

The rates are punched in shillings and decimals into a set of master-cards. At the end of each costing period of four weeks, the master-cards are reproduced into a working-pack. With this are merged Summary cards containing totals of sales for four weeks (in quantity and value) for each selling territory. (These cards are originally created and used in the course of Sales Statistics work.) The combined pack is then passed through the computer which:

1. Accumulates quantity and value from Sales Summary cards for a particular product-packing;
2. Checks that these are followed by the appropriate Cost Rate cards;
3. Divides quantity sold by standard quantity and multiplies by each of the four component rates and the total rate;
4. Checks that the resultant component answers agree with the total answer;
5. Punches out results in £ s. d., product-packing code number, quantity sold, and selling value into interstage positions of the Rate cards.

It will be noted that in this case, all basic information is in normal positions, the results being punched in interstage.

The Rate cards are out-sorted from the pack, and tabulated from interstage to provide a Standard Cost of Sales schedule which shows total cost per product-packing analysed under four headings and set against sales value.

This method is employed not only for sales, but also for issues for sample, replacement and research purposes.

Computer time is about $\frac{3}{4}$ hour.

Sales Statistics

The computer is used for the following jobs in connection with four-weekly Sales Statistics.

(*a*) To convert sales quantities in various denominations, to agreed common units. This is necessary both to meet the requirements of Sales Management and to permit accumulations of quantities where sales of one product are in a number of differing packings.

(*b*) To accumulate quantities and values of sales of each product-packing, and divide one by the other to arrive at an average selling price. This is then compared with agreed maximum/minimum tolerances, and any unacceptable variations signalled.

These two runs together occupy the computer for about 1 hour.

Assets Records Updating

A punched card is created for every additon to the Company's fixed assets—machinery, buildings, vehicles, land, etc. All the relevant information is recorded on the face of the cards, as well as in the form of punched holes. Basic information is reproduced from this card into interstage positions of an Annual card, which thus contains Budget Centre Number, Cost Centre No., Location, Obsolescence Code No., Asset Type No., Machine, Building or Vehicle No., Year of Purchase, Estimated Life, Floor Area, and Cost. The card is filed with Annual cards representing earlier purchases. Sales, and any changes, are advised in order that the necessary adjustments can be made to the file, which is processed annually.

Prior to the computer-run, Replacement Value indices related to years, are stored. The Annual cards are then fed through the machine and the following calculations made.

1. Cost divided by Estimated Life = Annual Depreciation.
2. Accumulated Depreciation brought forward plus Annual Depreciation = Current Accumulated Depreciation.
3. Cost minus Accumulated Depreciation = Written-down value.
4. By reference to year of purchase "look up" Replacement Index and apply to Cost to obtain Current Replacement Value for Insurance purposes.

These are the basic calculations, but in addition, provision is made for the following.

Apportionment of Cost, Floor area, Depreciation, written-down value, and Replacement value, when a machine or building is used for more than one activity, together with checks to ensure that apportionments total 100%.

Special "rounding off" arrangements, since all results are required in £'s only.

Special "final year" arrangements, when the amount to be written-off may be less than the normal annual depreciation.

Special and supplementary depreciation.

Special treatment of particular types of asset, etc. etc.

All results are punched into normal positions. The cards are then sorted and tabulated to provide details and totals of Depreciation, written-down values, and replacement values under various headings of Budget Centre, Asset type, etc. Subsequently, the basic information only is reproduced from the normal positions of these cards into interstage positions in a new pack of Annual cards, which is thus available for the next year's work.

A duplicate of this pack is also created and designated the Budgeting pack. Later in the year it is adjusted in the light of any known or proposed changes, and run through the computer to provide Budgeted Depreciation for next year.

There are thus two computer-runs per year, approximately six months apart, each of which occupies about six hours.

Statistical Department

The Company maintains a Statistical Department, the services of which are available to any section. The Department is therefore engaged in mathematical work connected with a wide variety of operations—from crop yields and factory output to sales forecasts, market-research data, and tasting-panel statistics. The latter are a regular feature, and a computer program to deal with them was brought into operation soon after the delivery of the machine, taking some 45 minutes per week.

However, many of the other jobs are undertaken at widely-spaced intervals, some are once-only, and new requirements frequently arise. To create new sets of connection-units for all these would have been costly and involve considerable delays, and it appeared that some form of generalized mathematical program was required.

The Statistical Department conceived the idea of designing a set of connection units which permitted program instructions punched into cards to be loaded serially into the store. Such a stored program becomes the master-program, and that riveted in the connection units a slave-program. Data cards subsequently fed into the computer are processed in accordance with the stored instructions.

These techniques for performing mathematical work on a machine not primarily designed for this type of job have proved successful, although the detailed planning and development was quite a complex undertaking. By general computer-standards, and by our own commercial-program standards, these methods are very slow (some calculations take twenty or more $\frac{1}{2}$-second cycles per card), but they are still many times

faster than other methods available within the office. The facilities for rapidly writing or changing programs which the system affords have already proved most advantageous.

At the present time, six hours per week are allocated for testing and running mathematical programs, including Linear and Multiple-Linear Regression Analyses, Chi-squared analyses, and Linear Simultaneous Equations. Additional time is provided for urgent jobs when they arise.

Conclusion

The computer has now been in service for eleven months, its present loading being about 60% of capacity in normal working hours. Staff in the Department has been reduced by four during the current year, and worthwhile indirect savings have been made in other departments. The "break-even point" on our investment has almost been reached, and it is anticipated that within a few months real savings will begin to accrue. This position, quite apart from the improvements in efficiency and the additional information we are obtaining, leads us to believe that we made the right computer-decision for our business.

However, much remains to be done. Plans for the next stages of development are in hand, and already, ways of improving existing computer jobs are being devised.

It is intriguing to speculate as to the position six or seven years ahead. One hopes to be able to look back on a steady expansion of the mechanization of our office procedures, and perhaps the changes resulting from the introduction of decimalization of coinage; and to look forward to the next installation of equipment. What form will it take? It may well be that small-scale, but readily-expandable computer systems will be the answer for many medium-sized businesses by the late nineteen-sixties.

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Book Review

Sequential Decoding, by JOHN M. WOZENCRAFT and BARNEY REIFFEN, 1961; 74 pages. (London: *John Wiley and Sons Ltd.*, 30s.)

This book is one of a series of Research Monographs published by M.I.T. The aim of the series is the praiseworthy one of making new results rapidly available to those who are professionally interested in them. It is therefore unfair to judge this book by the criteria one would use to judge a longer and more thoughtful work, for it consists essentially of 70 pages of research notes. The reader should not therefore be deterred by having to work hard to understand it, and should feel stimulated rather than frustrated if questions present themselves to him which the text leaves unanswered.

This is certainly not a book for those who are unfamiliar with coding theory but who wish to learn something of the subject. Such a book probably remains to be written and when it is, this present volume will feature in its list of references.

The authors apply themselves to the decoding problem that arises in the following way. Suppose that when it is required for messages to be transmitted over a noisy channel such as a telephone line, they are encoded in some manner. Thus to the uncoded form of each message are added some carefully chosen redundant digits, these redundancies being such that, if a particular coded message becomes corrupted, it still resembles the original coded message more than any other. The function of the decoder is to detect this resemblance. This clearly could be done, in principle, using a stored-table procedure, where a list of all possible received messages is kept and, against each entry, a note of what actual message was sent. However, such a table would in many cases be impossibly large, so the question arises as to how else a decoder might be constructed.

The authors have realized that the decoding problem is a special case of the general statistical decision problem. The decoder has a large number of hypotheses to choose from about what message was sent, and it also has some received results. Its function is merely to determine the most likely hypothesis consistent with the results. The problem of decoding, then, is the statistical one of determining this hypothesis in an efficient manner. Hence the authors set up a statistical scheme whereby unlikely hypotheses are rejected with a small amount of computation, while the more likely ones are examined in greater detail.

To be explicit, the decoder is arranged to calculate the frequency of corruption by noise, of digits in a message, on the assumption that a particular message was sent. If this frequency is higher than would be expected, this hypothesis is rejected and a new one tried. The frequency of corruption is measured using a variable sample size, short samples being sufficient when the corruption appears to be high, and vice versa. In this way economy of computation is achieved.

This book is almost entirely devoted to an analysis of the performance of such a system when such a strategy is employed. Its achievement is the setting of bounds on the probability of an uncorrected error occurring in the presence of random noise, and of bounds on the average number of computations per digit that the decoder has to make. This latter is of crucial importance, and the valuable result derived is that this number is so low that the scheme is practicable.

This book would be improved in lucidity if some examples were given showing the decoding process in action, and if there were more examples of specific codes. It would then be easier to appreciate what problems arise. As it is, one plunges into a mass of analysis without being quite sure to what end it is being pursued. However, if one is actively engaged in the design of systems of the type suggested, this is a valuable book, because it illustrates some methods of analysis that may be usefully copied, and shows some practicable schemes.

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