

Practical Application of Data Processing in Small and Medium Manufacturing Companies

by H. S. Gellman, R. C. Carroll

*A Paper Prepared for the Conference
"Productivity Through New Technology"*

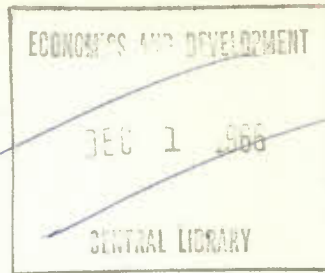
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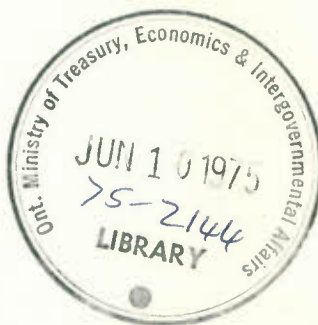


PRACTICAL APPLICATION OF DATA PROCESSING
IN MEDIUM-SIZED AND SMALLER MANUFACTURING COMPANIES

by

H. S. Gellman

R. C. Carroll



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FOREWORD

This paper was prepared by Dr. H. S. Gellman, Vice-President, Research and Analysis, and R. C. Carroll, Chief Analyst, of DCF Systems Limited, Malton, Ontario.

The authors are among a group of specialists commissioned jointly by the Economic Council of Canada and the Ontario Economic Council to undertake special studies and prepare papers, such as this one, for the Conference on Productivity Through New Technology, held at Ryerson Polytechnical Institute, Toronto, May 27 and 28, 1965.

The purpose of the Conference was to inform senior executives of small- and medium-sized businesses about the practical application of the new management, production and handling concepts, techniques and tools available to them, including the use of computers and automatic production equipment. The Conference participants -- approximately 300 businessmen -- were afforded the maximum opportunity of informal discussion with the authors of the papers.

In publishing these Conference papers, the Economic Council of Canada hopes that the material will be useful to others, and perhaps serve as the basis of similar conferences. A list of the studies being published, with a brief description of each, will be found at the end of this document. The views in these papers remain the responsibility of the authors.

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INTRODUCTION

Last year in the United States, the first commercial electronic computer, a UNIVAC I, was retired in good condition and sent to a museum, after working for less than fifteen years. This year, more than 24,000 computers are at work in the United States and more than 650 in Canada. Annual sales of the computer industry in North America alone amounts to several billion dollars.

Clearly, the growth of computer usage is phenomenal and its impact on commerce, industry and government has already been significant and is increasing steadily.

The view of computer manufacturers and their salesmen is that every organization should use a computer to save time and money and to streamline management. If an organization is too small to afford its own computer, they say it should rent time by the minute on a data centre machine.

The view of many managers who have seen others struggle with making computers work is that computers don't necessarily produce benefits - instead they often seem to increase costs and create upheaval in the organization.

This paper presents an unbiased view of computers and other automatic data processing equipment. Our aim is to show the manager of a small or medium-sized manufacturing company what can be done with some of the modern equipment and with some new systematic and mathematical techniques for improving control of operations; and what other companies in Ontario are already doing with automatic data processing equipment.

Our paper includes the results of a questionnaire survey completed by several hundred small and medium-sized companies in Ontario, giving information about their application of data processing and management techniques. We are grateful to all the companies who co-operated with us in the survey.

In preparing for this paper, we conducted interviews with more than a dozen companies in Ontario to obtain authoritative views on actual applications, benefits and problems in data processing. The companies were selected to cover a range of industries and provide examples of small and medium-sized punched card and computer installations. We are particularly grateful to the companies concerned for their ready co-operation and for their permission to quote their experiences.

Readers who are familiar with the principles of automatic data processing equipment may bypass Section A of this paper and go on to Sections B and C, which describe the applications of such equipment.

CONCLUSIONS

The most striking fact to come out of our survey is that a number of companies with fewer than 100 employees have their own automatic data processing installation. Another important fact is that 16% of the companies surveyed make use of punched card or computer data centres.

In looking at the ways in which companies use automatic data processing, we found that sales analysis is the most popular application, followed by general accounting, payroll and inventory control. Less than 20% of the companies with installations are using their equipment for some form of production control or scheduling. We believe that this figure will increase as the benefits become more widely known.

Very few companies are using automatic data processing in forecasting or operations research type applications. It is our belief that there is considerable potential for applications of automatic data processing to these and other areas of management control.

It is evident that managers of all companies, irrespective of size, are becoming more interested in the application of automatic data processing equipment and are investigating its potential in their own circumstances, drawing on the advice and experience of other users, equipment suppliers or systems specialists. It will be shown here that companies which are already using automatic data processing are gaining important advantages in improved efficiency and reduced costs.

A. DESCRIPTION OF AUTOMATIC DATA PROCESSING SYSTEMS

The two main characteristics of Automatic Data Processing (ADP) are:

1. The information to be processed is on machine-readable media, such as punched cards, punched paper tape, magnetic tape, optical or magnetic ink characters;
2. The machine works to prescribed rules that are built into its design or are programmed for a particular application.

In this section we describe the principal features of three types of equipment: punched paper tape, punched card and computers.

Magnetic ink characters have been mainly employed in banking and will not be referred to, but mention should be made of recent developments of special printing which can be read by machines. This opens the way to direct input of printed documents to a data processing system without any conversion operation. This special printing, called optical font, can be used with cash registers, adding machines and other printing devices. In many applications these printed documents are direct substitutes for punched paper tape.

Table 1 shows some typical prices or rental costs for the various types of equipment. These are quoted to show the order of machine cost involved; operating costs for salaries and supplies are usually about the same as the rental costs.

Table 1 - Typical Equipment Costs

The following purchase prices or rental figures are representative of equipment available. This is not intended to be a comprehensive list.

PAPER TAPE EQUIPMENT

<u>Manufacturer</u>	<u>Machine</u>	<u>Remarks</u>	<u>Approximate Price</u>
Friden	Flexowriter	Automatic typing from punched paper tape	\$ 4,800
Friden	Computyper	Automatic printing-computing machine for invoicing, etc.	\$ 15,000
Friden	6010	Desk-sized computer system	\$ 23,500

PUNCHED CARD EQUIPMENT

<u>Manufacturer</u>		<u>Remarks</u>	<u>Approximate Monthly Rental</u>
IBM		Series 50, slow speed installation	\$ 850
IBM or Remington-Rand		Typical standard installation	\$ 1,150 up

AUTOMATIC ACCOUNTING MACHINES

<u>Manufacturer</u>	<u>Model No.</u>	<u>Remarks</u>	<u>Approximate Monthly Rental</u>
Burroughs	E2100	Small accounting systems	\$ 600-1,500
IBM	6400	using magnetic stripe	\$ 600-1,500
NCR	5900	ledger cards	\$ 600-1,500

SMALL AND MEDIUM-SIZED COMPUTERS*

<u>Manufacturer</u>	<u>Model No.</u>	<u>Approximate Monthly Rental</u>
Honeywell	H120	\$ 2,600-3,500
Honeywell	H200	\$ 6,000-9,000
IBM	360/20	\$ 2,200-6,000
IBM	360/30	\$ 5,000-15,000
IBM	1401	\$ 5,500-15,000
UNIVAC	1004	\$ 1,800-2,500

* Cost will depend on the size of memory and the number of input-output units. The figures quoted are given as a guide only.

Punched Paper Tape

For small volumes of data processing or as an input medium to a larger system, paper tape is well worth considering. The tape can be prepared as a by-product of a normal typing or adding operation and the information need not be produced again, since it can be printed automatically from the tape. When fed into an automatic typewriter-calculator or a desk-type computer, for example, the tape can be used in the preparation of invoices, since these machines can perform the necessary calculations. Paper tape can be converted automatically to punched cards or used directly as input to a computer.

Punched Card Equipment

A typical installation will comprise a card punch, card verifier, reproducer, interpreter, sorter, collator, calculating punch and an accounting machine. Figure 1 illustrates the operations.

The card punch is the machine used to transfer information from source documents into punched cards. It is a key-driven operation similar to typing.

The card verifier checks the accuracy of the information that has been punched in the cards.

The reproducer is the machine that punches data from one set of cards into another; information in a master card can be punched automatically into all the cards that follow. When connected by cable to the accounting machine (described below), the reproducer can also punch summary totals, thus reducing the card volume and permitting balances to be carried forward.

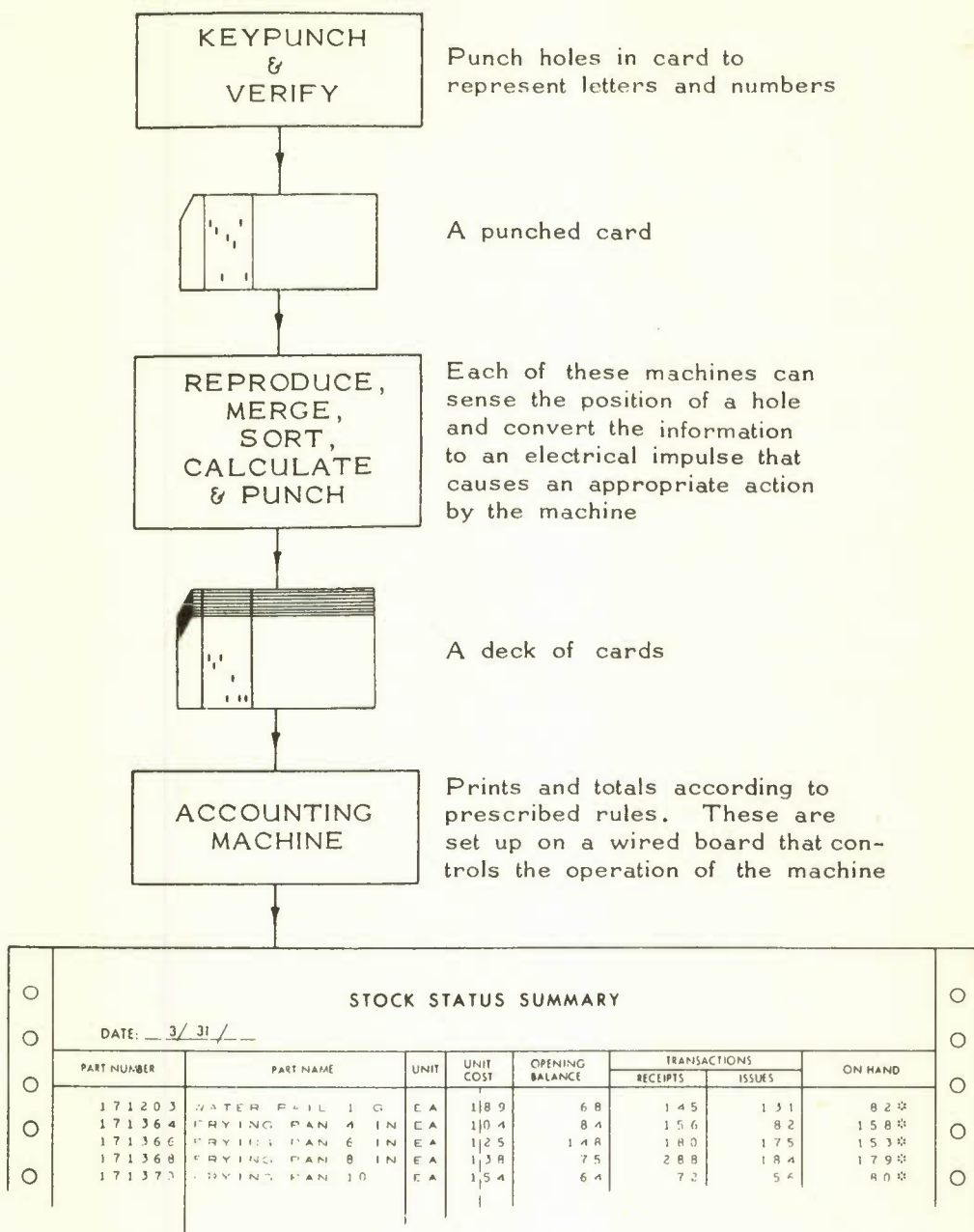


FIGURE 1 ILLUSTRATION OF PUNCHED CARD OPERATIONS

The interpreter automatically translates the punched holes into letters and numbers, printing the characters on the card itself.

The sorter is a machine that sorts and groups cards into alphabetical or numerical sequence according to any classification punched into them. This permits the cards to be used over again to prepare many different reports. In addition the sorter can be used to select particular cards.

The collator is more elaborate than the sorter. It can handle two batches of cards at the same time and can read several columns of several cards simultaneously. Aside from selection operations its major functions are merging and matching the groups of punched cards.

The calculating punch is a calculator that accepts information from punched cards, performs calculations rapidly, and produces the results in the form of punched cards. If the calculations are sufficiently complex, a punched-card computer takes the place of the calculator.

The accounting machine prints alphabetical and numerical data from punched cards and totals data by proper classifications. Cards are fed into the accounting machine to produce the final reports.

The flexibility of a punched card installation derives not only from the versatility of the various machines but also from the unit record principle in which a card contains information relating to only one particular customer, product or sale. A batch of cards can thus be sorted or matched in different ways. Punched cards are particularly suited to

applications where the same information is used a number of times, as in sales analyses. They are also used where the basic information is on master cards and only a minimum of variable information need be punched.

The efficiency of a punched card system is highest when it is processing data in quantity so the work can be planned in batches. It is least suited to the handling of exceptions; these are best dealt with manually.

Electronic Data Processing and Computing Equipment

Computers as business tools are less than fifteen years old, yet there are now 24,000 electronic digital computers installed in North America and 12,000 on order. This is an amazing growth considering the required investment, not just in machines but also in the manpower that builds and operates them. An estimated 650 computers are in use in Canada, with a further 300 on order.

A computer has the following important capabilities:

1. It can handle large volumes of data at high speed.
2. Through the use of its memory and auxiliary storage, it can organize all the information necessary for processing.
3. It can follow long and complicated procedures, selecting between alternative courses of action in dealing with exceptions.
4. It operates with extreme accuracy over millions of operations.

On the other hand, in order to use a computer, the entire

procedure must be carefully thought out and defined. Computers can provide the quickest and most efficient method yet devised for turning out wrong answers.

Disadvantages of computers include:

1. High purchase or rental costs, by comparison with other office equipment.
2. The costs of conversion; every eventuality has to be catered for; subsequent changes in programs may be difficult and costly.
3. Relative inaccessibility of records: most of the information is inside the computer.
4. Changes in organization and responsibilities are necessary: there may be a lowering of morale in company personnel.

All computer systems can be divided into four types of functional units: input, output, storage, and central processing. Figure 2 is a block diagram of a typical computer system.

Input devices read or sense coded data and make the information available to the computer. Data for input are recorded in cards and paper tape as punched holes; on paper documents as special optical font characters or characters printed in magnetic ink; and as magnetized spots on magnetic tape.

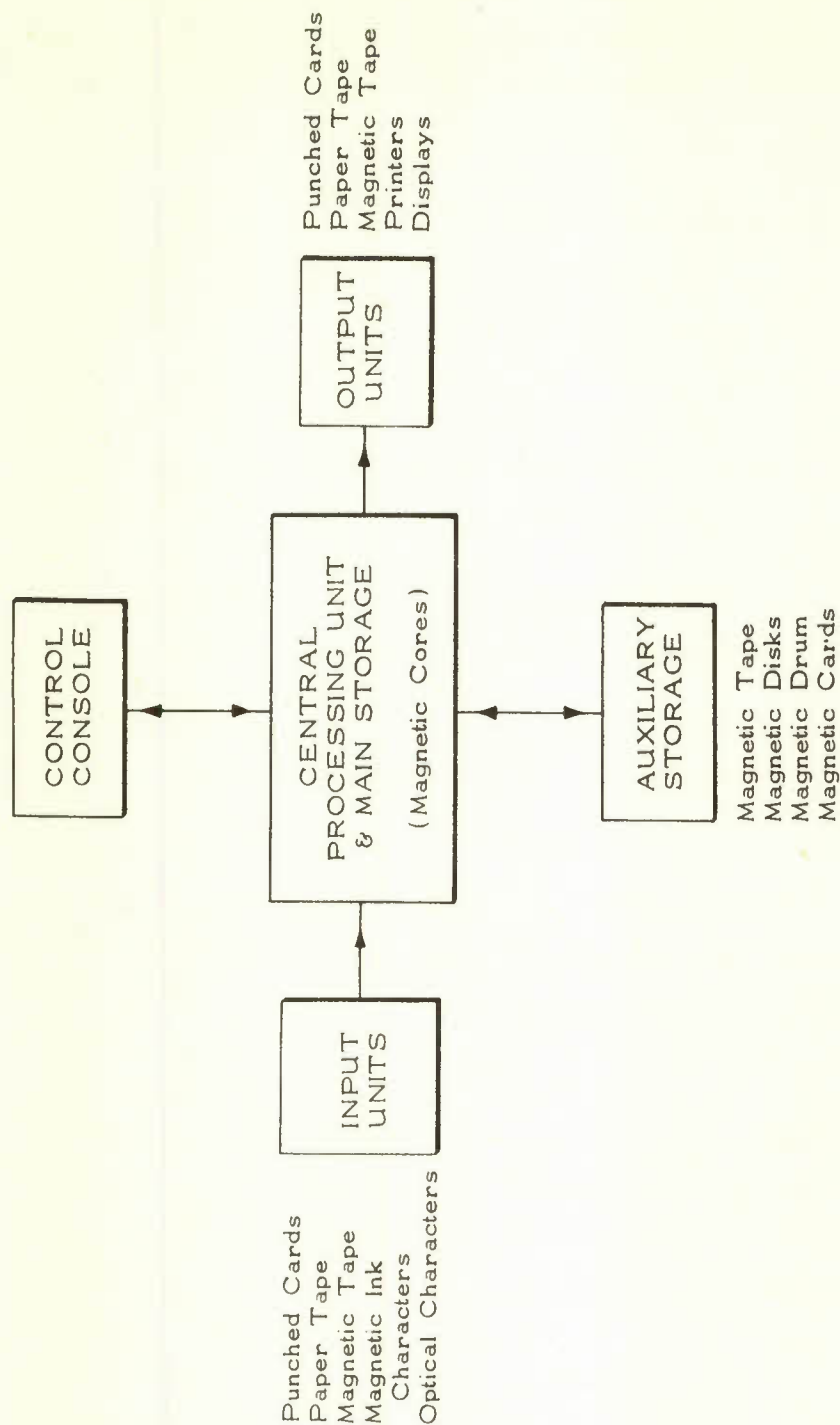


FIGURE 2 BLOCK DIAGRAM OF A TYPICAL COMPUTER

Output devices record or write information from the computer on cards, paper tape or magnetic tape, or as printed information on paper. A varied assortment and quantity of input-output devices can be connected directly to the computer, depending on the requirements.

Storage is somewhat like an electronic filing cabinet, completely indexed and almost instantaneously accessible to the computer. Each location, position, or section of storage is numbered so that the stored data can be readily located by the computer as needed. Information is read into storage by an input unit and is then available for internal processing.

The computer may re-arrange data in storage by sorting or combining different types of information received from a number of input units. The computer may also take the original data, calculate new information, and place the result back in storage.

The size or capacity of storage determines the amount of information that can be held within the system at any one time. In some computers capacity is measured in millions of digits or characters, providing space to retain entire files of information. In other systems, storage is smaller and data are held only while being processed. Consequently, the capacity and design of storage affect the method in which data are handled by the system.

The central processing unit is the controlling centre of the entire data processing system. It can be divided into two parts:

- (1) The arithmetic-logic unit.
- (2) The control section.

The arithmetic-logic unit performs such operations as addition, subtraction, multiplication, division, transferring, comparing and storing. It also has the ability to make simple logical decisions of the 'yes-no' type.

The control section directs and coordinates the entire computer system as a single multipurpose machine. These functions involve controlling the input-output units and the arithmetic-logic operation of the central processing unit, and transferring data to and from storage, within given design limits. This section directs the system according to the procedure originated by its human operators.

Stored programs

Each data processing system is designed to perform only a specific number and type of operations. It is directed to perform each operation by an instruction. The instruction defines a basic operation to be performed and identifies the data, device, or mechanism needed to carry out the operation. The entire series of instructions required to complete a given procedure is known as a program.

Thus, a complex problem must first be reduced to a series of basic machine operations before it can be solved. Each of these operations is coded as an instruction in a form that can be interpreted by the computer and is placed in the main storage unit as a stored program.

One computer can be applied to a great number of different procedures by simply reading the proper program into storage. Any of the standard input devices can be used for this purpose, because instructions can be coded into machine language just as data can.

Data centres

Those companies who do not have their own installations may make use of ADP equipment by hiring time at a data centre. These are usually run by equipment manufacturers and are located in cities or large towns. Their main purpose is to provide training and testing facilities for companies in the area who are awaiting delivery of similar equipment or require backup for an existing installation.

Spare machine capacity at the centres is often available for companies who can make use of standard computer programs or prepare their own. Operating staff is provided and a certain amount of systems help is available, but in most cases the company should have someone on its staff with appropriate training in systems work or should obtain the advice of a specialist.

B. HOW AUTOMATIC DATA PROCESSING CAN BE USED
IN MANUFACTURING COMPANIES

The most familiar applications of data processing are in the office, where routine payroll, accounting and invoicing operations may usually be undertaken more quickly and at less cost than with conventional manual methods and bookkeeping machines. In the plant, there is a growing use of data processing as an aid to production planning, scheduling and inventory control, leading to more efficient use of manpower and capital equipment. The most important applications are the least developed as yet: the areas of management information and control -- increasing the productivity of management.

It is unlikely that any automatic data processing installation will be used in one area of application alone but some companies use their equipment primarily for accounting work, others for sales analysis and yet others for production scheduling and inventory control.

In the early days, it was natural that equipment would be used mainly for accounting work - the installation was usually the responsibility of the Accountant or Comptroller, clerical savings were possible and the conversion was straightforward. Extension into other areas followed, partly to utilize spare capacity and partly because of a growing appreciation by management of the value of timely and accurate control information in other parts of the business. Now we are on the threshold of a major development in the use of data processing as an aid to management control. The benefits from these new applications may far outweigh those from conventional uses.

The first step in examining the feasibility of ADP equipment for a particular company is to establish the cost of the existing data processing

systems. This should then be compared with the approximate costs of suitable equipment, to determine whether a more detailed study is justified. If so, a senior man in the company should be appointed to undertake the study, which will require support and cooperation from all departments. The purpose of this study should be to draw up a detailed specification of the requirements and invite equipment proposals from selected manufacturers. If an order is placed as a result of a careful assessment of the benefits, there is need for an intensive period of further systems study and education of all the people concerned so that a smooth conversion to the new procedures is made.

It is still customary for an installation to be fitted into the organization as part of the accounting function. However, several Ontario companies are aiming at an integrated information and control system, embracing nearly all aspects of their operations, which will be the direct responsibility of a Vice-President. This is a reflection of the growing importance of data processing.

Typical Applications

Table 2 illustrates the suitability of the various types of ADP equipment for ten areas of application. We describe these applications briefly below, and then go into more detail on Inventory Control and Production Scheduling. Examples of actual applications are described in Section C of this paper.

1. Invoicing and Accounts Receivable

In a typical punched card installation, the basic information used in preparing invoices - customer name and address, product description and price - is held on file on pre-punched cards. The appropriate cards are

Table 2 - Suitability of Equipment
for Different Applications

Application	Suitability of Equipment			
	Punched Paper Tape	Automatic Accounting	Punched Card	Computers
Invoicing & Accounts Receivable	Yes	Yes	Yes	Yes
Other Accounting	Yes	Yes	Yes	Yes
Inventory Control	Yes	Yes	Yes	Yes
Scheduling	-	-	Yes	Yes
Sales Analysis	Yes	Yes	Yes	Yes
Forecasting	-	-	Yes	Yes
Requirements Planning	-	-	Yes	Yes
Engineering	-	-	Yes	Yes
Purchasing	Yes	Yes	Yes	Yes
Operations Research	-	-	Yes	Yes
Volumes	Small- Medium	Small- Medium	Medium	Medium- Large

This table is intended as a guide to the application of equipment. Compared with computers, the other equipment is limited in the speed and volume of information which can be processed; and also in the number of calculations which can be done.

selected by hand and the quantities are key-punched from a packing slip or similar document. It is then a straightforward operation for the equipment to perform the necessary calculations and print the invoices.

Similar principles apply to other ADP equipment - that a minimum of information should be entered by hand. The standard information may be on punched paper tape, punched cards, magnetic stripe ledger cards, magnetic tape or disk files.

Usually a by-product of the invoicing application is the preparation of accounts receivable statements. The statement is readily derived from an opening balance and the accumulation of debits and credits.

Black Diamond Cheese Limited in Belleville is a small company with only just over 100 employees, which is successfully using a punched card installation for invoicing and accounts receivable, as well as other applications. The equipment prepares about 30,000 invoices a year. In contrast, Sunshine Uniform Supply Co. Ltd. of Toronto, prints 8,500 invoices a day for its Ontario operations alone and has recently installed a computer.

2. Other Accounting Functions

These are too diverse to list completely. Typical applications are payroll, costing, ledger accounts, profit statements, product costs, accounts payable and budget comparisons. The feasibility of ADP equipment is determined by comparison with the clerical costs of existing systems and by assessment of the value of additional information which can be made available.

Many companies are using their ADP systems in conjunction with standard costing systems and budgetary controls so that management can focus

attention on the exceptions, knowing that the other cost elements are under control. The speed with which reports can be prepared and issued means that action can be taken quickly to correct adverse trends.

3. Inventory Control

This will be described in more detail later. Typical applications are in the control of manufacturing parts for sub-assembly or of finished stocks at distribution points. Data processing equipment is particularly suitable where a multiplicity of stock items or a significant amount of working capital is involved.

Snap-On Tools of Canada Limited is using punched card equipment for control of stocks in several thousand items of hand tools. Canadian Pittsburgh Industries Limited uses a computer data centre for inventory control of 1,000 different paint products in 40 branches. The computer updates the inventory levels and automatically raises an order on the supplying factory for items which need replenishing.

4. Scheduling

A number of small and medium-sized manufacturing companies are using ADP in some aspect of planning and scheduling. In a typical job shop operation with an appreciable number of different products, parts and processes, it is becoming very difficult to exercise adequate control by manual methods alone and to maintain a high standard of customer service.

The use of ADP equipment enables production documents to be prepared automatically. Lists can be made of jobs ahead of each operation, which production planners and foremen can use in determining individual plant schedules. Burndy Canada Ltd. is using this approach in the manufac-

ture of electrical and electronic connectors at its Scarborough plant.

Summaries of the work load in standard hours by work centre and department make it possible to spot overloads in time for suitable arrangements to be made. They also show up under-employed facilities so that stock orders may be raised.

Coulter Manufacturing Company Limited is using a small punched card installation (total costs are less than \$1,500 a month) for manufacturing control of its plants which make 300 different items of automotive hardware. The control ranges from detailed requirements for each component part to departmental machine loadings, costs and set-up times.

5. Sales Analysis

This is a popular application, which often stems from the basic invoicing operation. The virtue of data processing equipment is that once the information has been put in machine-readable form, it can be analyzed in many different ways. The sales data can be broken down by branch, by product, by customer or by some combination of these in weekly, monthly, quarterly or annual reports. The danger is that too many reports may be prepared and the user may be swamped with statistics. This calls for close co-operation between the sales and systems staff in determining the most useful ways to analyze sales. Many companies use the results of regular sales analyses to determine policies for allocating production and sales efforts and for assessing the performance of sales offices.

Mead Johnson of Canada Limited produces a weekly analysis of sales by product for each of the 30 sales regions as well as comprehensive monthly and quarterly reports. The effects of special sales campaigns can be quickly seen.

Canadian Pittsburgh Industries Limited supplements its routine reports with special year-end analyses which are particularly useful. For each branch, customers are ranked in order of sales value and lists are prepared of customers who did not buy at all during the year, showing the value of their previous business. A further analysis by customer classification shows the value and number of accounts separately for new customers, increased business from existing customers, decreased business and lost business.

Further examples could be quoted of companies in various industries performing sales analysis on all types of ADP equipment. Most of the companies quoted in Section C of this paper use their equipment for this purpose.

6. Forecasting

Nearly all companies use some form of forecasting in establishing inventory control, in developing production and sales policies, and in preparing budgets. ADP equipment can be used in these applications in three ways:

- (a) Preparing reports on recent actual results to use as a basis for the forecasts.
- (b) Analysing historical data to test the accuracy of different rules for use in forecasting.
- (c) Performing the calculations on past data using selected rules to produce forecasts.

An example of sales forecasting on a computer is provided by Parke,

Davis and Company Limited which manufactures pharmaceutical products at Brockville and experiences a seasonal demand for much of its output. In estimating sales for a particular month, the computer selects the actual sales for the corresponding month a year earlier plus the sales in the preceding and following months. The average of these values and the corresponding figures for the previous years is calculated, and then the computer applies various factors including an allowance for the trend in sales of the item and the anticipated effect of promotion campaigns. In this way, forecasts are prepared for each of the next ten months and these are particularly useful to production and sales management. They are also used to adjust inventory limits for stocks in the warehouses.

The method used in this example is appropriate with a computer. A new technique, which does not use large volumes of historical data and is therefore more feasible for a punched card installation, is being used successfully by a number of companies. This involves carrying forward from one period to the next only one figure for each item.

The technique is based on the fact that, in many situations, the best estimate of future usage is to take a weighted average of actual usage, applying most weight to the recent figures and proportionately less weight to older data. We need not go into the mathematics, but this boils down to a simple relationship:

(Estimate for next period) =

(Estimate for last period)+(Factor)x(Error of Last Estimate).

The factor is usually chosen between .1 and .3 depending on how sensitive a response to fluctuations is desired.

An example will illustrate the use of the relationship. Suppose our estimate of January sales of an item was 100 units and actual sales were 110. Then our estimate for February, using a factor of .2, would be:

$$\text{February Estimate} = 100 + .2X(110 - 100) = 102 \text{ units}$$

If actual sales for February turned out to be 97 units, then our forecast for March would be:

$$\text{March Estimate} = 102 + .2X(97 - 102) = 101 \text{ units.}$$

In this way, fluctuations are smoothed out and yet the forecasts can follow trends. The technique has been developed in a number of ways and is described in the book by R.G. Brown 'Statistical Forecasting for Inventory Control' published by McGraw-Hill.

Other systematic mathematical techniques can be used effectively with ADP equipment in forecasting from past history. Standard computer programs can be used to analyse seasonal demands and to smooth out cyclical effects in determining long-range growth.

7. Requirements Planning

Where the finished product is manufactured from a number of assemblies, sub-assemblies and parts, breaking down the orders (commonly termed 'explosion') into their components can be a sizeable job. It is an important one, because the lack of a particular part may hold up the entire production program. Parts explosion is readily undertaken on data processing equipment, leading to preparation of bills of materials. Suitable coding of items enables separate listings to be made of requirements for purchased and manufactured parts.

This application is important in a wide range of industries. Robbins and Myers Company of Canada Limited uses a punched card installation to break down the material requirements for its production of electric motors; Koehring-Waterous Limited applies similar principles in the manufacture of heavy machinery.

8. Engineering

Early applications of computers were in scientific areas where lengthy calculations are required. Publicity was rightly given to computers performing in one hour calculations which would take a man several years to complete by hand. Some manufacturing companies have design or engineering calculations which are quite complex. Such companies find it profitable to train an engineer in the use of a relatively simple computer language, such as FORTRAN (Formula Translator) or ALGOL (Algorithmic Language), that enable programs to be written in algebraic terms rather than machine codes.

Tedious calculations can often be done more quickly, accurately, and at less cost on a computer. Robertson-Irwin Limited, of Hamilton, makes use of a computer data centre in design calculations concerned with the deflection and loading characteristics of different metal floor sections. This is typical of the applications which are possible.

9. Purchasing

Companies can use data processing equipment for printing purchase orders and for regular analysis of purchases, comparing, for example, actual and standard prices. If purchase orders are on punched cards or in computer memory, it is a simple matter to provide expediting lists for orders falling due, in conjunction with a system of documentation for receipt of goods and certification of invoices.

10. Operations Research

Operations Research involves the application of a scientific approach to management problems. It has been used mainly in Government, the Armed Services and large companies but there is, in our view, considerable scope for its application in smaller companies. Standard computer programs can be used at data centres for the special techniques that have been developed. Typical of these are:

- (a) Simulation. The operation of an inventory control system, a distribution system, a production system or the company as a whole, can be simulated on a computer. The advantage is that several years' operation can be reproduced in a few minutes, so that various alternative policies can be evaluated quickly.
- (b) Inventory Control. By taking actual usage figures over a period and feeding them to a special computer program, the most economic stock policies can be determined. Operations research techniques can also be applied to the determination of optimum order sizes.
- (c) Linear Programming. This is a mathematical technique which is used in various areas: typical applications include the most economic distribution of goods from plants to warehouses, the optimum loading of products to machines, and determination of the most profitable combination of products or services to sell.

- (d) Other Techniques. These include methods for dealing with problems of Queues of work at a machine, Sequencing and Routing of orders, and replacement of machines.

The essence of Operations Research is not just the application of standard techniques: it is the scientific approach to a management problem, defining the important factors, exploring fresh ways of measuring and relating these, and establishing a workable solution. This approach is accepted as a tool of enlightened management, whether or not the name Operations Research is applied to it. Several companies in Ontario are using their ADP equipment in exploratory work of this nature - studying, for example the location of new warehouses, the effects of different manufacturing methods, the influence of order size on costs, the allocation of sales effort or the increase of plant efficiency. Every manager should from time to time sit back and reflect whether an alternative approach to his problems would pay off; or whether improved control would avoid some problems.

Inventory Control

In this context, inventory control relates to stocks of finished goods in warehouses or at the plant, or stocks of basic raw materials and parts. Control of in-process inventories is more appropriately part of a production scheduling system.

With inventory control, we are concerned with supplying a service - the availability of stock most of the time - at minimum cost. The larger the stock, the less likely we are to run out, but the greater are the interest and storage costs. Management policy establishes a balance between

cost and service to determine rules for controlling the stock items. A simple illustration of the variables involved is shown by the graph of Figure 3.

On the vertical scale is the quantity of stock on hand, and on the horizontal, time measured (say) in weeks. The vertical lines of the graph show increases in stock and the sloping portions represent the gradual issue of stock in small quantities, causing a decline in the quantity available. This continues until the next receipt causes another sudden rise in the stock level. For obvious reasons, this drawing is called a 'saw-tooth graph' and is very useful for analysis of most inventories.

It is apparent that the material is received into stock some time after the order is placed. This interval is the time required to issue the order and manufacture, receive and inspect the material. It is referred to as the 'lead time'.

The quantity of stock on hand when the order is placed is called the 'order point', and is set so that there will be enough stock to last during the procurement lead time for the item, as well as some stock left over. This 'safety stock' is needed because estimates of the usage during the lead time will not be exact and because the lead time itself may be longer than expected. The inventory policy is usually a set of rules laid down by management from experience. A computer enables more accurate methods to be used to determine the expected lead time usage and the safety stock requirements.

The other main item on the inventory graph is the order quantity. This needs to be carefully determined to minimize the average inventory

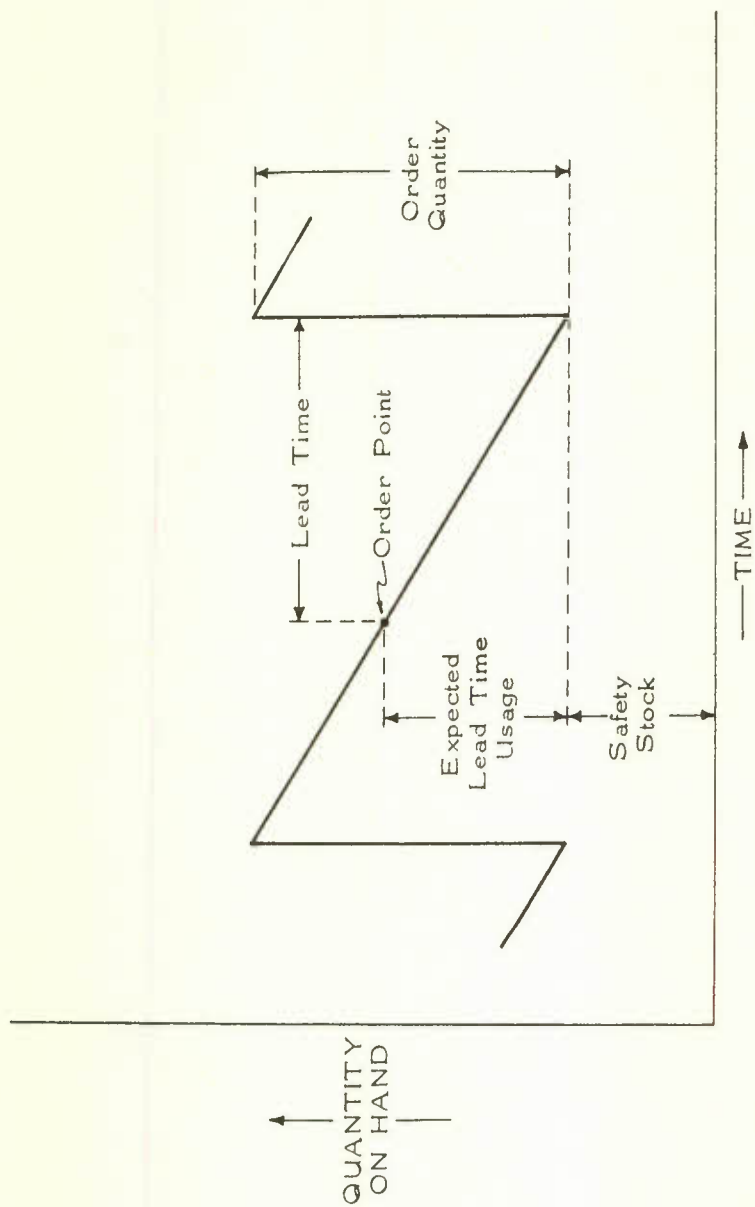


FIGURE 3

IDEAL USAGE PATTERN FOR A SINGLE ITEM OF AN ORDER POINT INVENTORY

investment while obtaining low procurement costs, quantity discounts, and carload shipping economies.

With the minimum-maximum system of inventory control, two numbers are usually shown on the ledger card to define the order policies for an item. The minimum is the point at which a replenishment is ordered and the quantity ordered is the difference between the minimum and maximum. Thus, two numbers define the 'when to order' and 'how much to order' with this system of control.

To describe the application of data processing to inventory control, let us compare a small punched card installation with a computer system.

With the small installation, we would probably start with a deck of cards, each one of which represents a stock item. It contains the item number, quantity on hand and order point. We then have cards for transactions since the inventory was last updated -- receipts, withdrawals and stock adjustments. The equipment sorts the cards and performs the simple additions and subtractions required to produce new balances. An updated deck of cards is punched for use next time and a printed list can show the status of all the items, denoting with an asterisk those items due for replenishment. It is then up to the purchasing or production departments to take action.

On a computer, the stock status might be held in storage. Transactions are entered and the computer updates the stock status in a similar way. However, the true potential of the computer is shown by the other tasks it can readily undertake. For example, it can automatically print out the order for replenishment. At the same time, the inventory can be costed and a report prepared showing the stock value by product group.

Some form of forecasting may be used in determining whether to reorder. This can be a fairly complicated formula based on past usage modified by factors reflecting the trend in demand and other special influences. The computer may itself adjust the order points and calculate the order quantities, using rules determined by management policy. Other by-products may be expediting lists for outstanding orders, receiving documents, variance statements etc.

In practice, an individual system will be somewhere between the two extremes, depending on the economics of the application and the nature of the equipment available. The manufacturing company may not have its own computer but can obtain benefits by using a data centre.

A good inventory system will yield some or all of the following benefits:

- (a) Savings in working capital and better use of storage space.
- (b) Reduced likelihood of wastage from deterioration or obsolescence.
- (c) Better customer service - reduced occurrence of stock-outs and crises.
- (d) Reduced clerical costs.
- (e) Improved management control.

Production Scheduling

We will consider a typical job shop where numerous products, either for stock or against customer orders, are manufactured by taking a set of raw

materials and parts through a sequence of operations. A basic requirement of any form of production scheduling is that the standard method of manufacture and materials requirements be firmly established. This may sound obvious, but many companies transferring production scheduling to data processing equipment have found this to be the most difficult step. On the other hand, it has also been a rewarding step, leading to better control of plant operations.

Production planning can be considered in three phases:

1. Forward planning to compare plant loading and capacity.

If the problems are recognized far enough in advance, it is possible to make arrangements for additional labour or over-time work on overloaded items of plant; or to arrange for stock orders to utilize spare plant capacity.

2. Requirements planning which summarizes the orders in terms of raw materials and parts requirements to ensure that the correct items will be available at the right time.

3. Scheduling of individual work centres, listing the orders in the desired sequence. This is determined by reference to the delivery date and the provision of adequate work loads at each operation.

Proper planning requires that the processing time of the order at each operation is known with reasonable accuracy. If incentive schemes are used, most of the times will be readily available; otherwise the times must be estimated by experienced personnel or deduced from actual times on similar work.

In a typical punched card installation, each finished product is represented by a master deck of cards stating all the parts requirements and listing the operations and times per unit quantity. This deck must be kept up-to-date in line with engineering and design changes. A smaller set of cards is punched with the customer's name and other details, the product number and quantity. Using this information, an order deck can be prepared from the master deck, containing the full details necessary for production of the order.

Processing of the order decks results in preparation of the necessary production documents: bills of materials, route sheets, labour cards, etc. Sorting and summarizing provides material requirements in total for comparison with available stocks. Similarly, forward plant loading figures can be obtained and a print-out shows the jobs ahead of each process. This is not itself a production schedule, as someone has to put the jobs in order of priority.

In contrast, a computer has the facility to sort the work according to programmed rules and to prepare the schedules. The more advanced computer systems are capable of operating in 'real-time'. That is, the computer has the complete status of all orders in memory and receives inputs directly from the plant, recording the processing of an order through each stage. With suitable programming, the computer can re-schedule to take account of a rush order or a sudden cancellation. On request, a list can be printed of orders falling behind the delivery date. With standard costing incorporated, the regular production reports can show variances of cost as well as time.

A remarkable feature is that the computer may answer a progress query while it is in the middle of another routine such as payroll. Such systems are a practical reality now and although we are not suggesting that the average user will have one within a few years, the potential should be appreciated. In practice, as with inventory control, the individual production scheduling system will be somewhere between the extremes.

A good production planning and scheduling system will yield some or all of the following benefits:

- (a) Better utilization of machines and manpower. Capital expenditure for new equipment may be reduced or postponed.
- (b) Reduced working capital. With better control, there is less work lined up in front of each process.
- (c) Shorter lead times. The shorter waiting lines enable the average job to get through the shop quicker; selected rush orders can be accommodated more easily.
- (d) Improved customer service. A greater percentage of orders are manufactured on time; stock replenishment orders arrive on time.
- (e) Improved quality. Use of standard manufacturing practices ensures a more uniform quality of product.
- (f) Reduced costs. There will be fewer set-ups. Lost time and rejections will be reduced.

(g) Better management control. All these benefits contribute to the more efficient operation of the business. Problems are identified in advance and management is better able to concentrate on these and on general policy.

C. HOW AUTOMATIC DATA PROCESSING IS USED
IN MANUFACTURING COMPANIES IN ONTARIO

Questionnaire Survey

In order to obtain up-to-date information on the use of data processing equipment in Ontario, a questionnaire was prepared and sent to about 1,300 companies. These were deliberately chosen to include a high proportion of small and medium-sized companies, as we were particularly interested in the impact of data processing on this group.

Replies were received from 312 companies, ten of which were excluded because of insufficient detail. Table 3 summarizes the replies from the remaining 302, dividing the companies into those using ADP (27.5%) and those not; the table also shows the breakdown of companies by number of employees. Table 4 gives the information in more detail, distinguishing between companies with their own punched card or computer installation and those using data centres. These companies are representative of all types of manufacturing, from cheese to carpets and from small components to heavy machinery.

We are often asked how big a company has to be to justify using ADP equipment. Unfortunately, there is no easy answer to this question: each case has to be treated on its own merits. The noteworthy fact from these survey figures is that there are companies of less than 100 employees who have their own installations. Another important point is that 16% of the companies in the survey make use of punched card or computer data centres. The moral is quite definitely that all companies, irrespective of size, should be acquainted with the application of ADP equipment and investigate its potential in their own circumstances, drawing on the advice and

Table 3 - Summary of Questionnaire Replies

Number of Employees	Number of Companies		Percentage Using ADP
	Using ADP	Total	
1-50	3	26	11.5
51-100	15	114	13.2
101-150	13	57	22.8
151-200	12	35	34.3
201-300	20	40	50.0
301-400	8	14	57.1
Over 400	12	16	75.0
Total	83	302	27.5

Table 4 - ADP Users by Size of Company

Number of Employees	Number of Companies			
	With Own Installation		Using Data Centre	
	Punched Card	Computer	Punched Card	Computer
1-50	1	-	2	1
51-100	6	-	1	12
101-150	4	-	4	6
151-200	9	1	2	-
201-300	13	-	2	8
301-400	4	-	2	2
Over 400	8	2	3	5
Total*	45	3	16	34

*Note that some of the 83 companies using ADP are included in more than one column, if the company has its own installation and also uses a data centre. Data processing by an associate or parent company has been included under data centres in the few cases where this applies.

experience of other users, equipment suppliers or systems specialists. Companies of 100 employees or more should examine whether to have their own equipment and smaller companies should consider the use of a data centre.

Table 5 summarizes the replies on the ways in which companies use ADP. Sales Analysis is the most popular application; nearly 80% of the installations are used for this and it is quoted by 66% of the data centre users. The next most frequent applications are in Accounting, Payroll and Inventory Control.

Less than 20% of the companies with installations are using their equipment for some form of Production Control or Scheduling. We expect an increase in this figure as the benefits become more widely known. Very few companies are using ADP in their forecasting or in operations research type applications. It is our view that there is considerable potential for applications of ADP to these and other areas of management control.

Some additional information from the questionnaire replies is given in two further tables. An analysis of companies using ADP for inventory control (Table 6) suggests that if inventory investment exceeds \$250,000, then ADP may be justified for this application. A similar analysis of number of invoices (Table 7) indicates that ADP might be feasible when a company sends out more than 10,000 invoices a year, though use of ADP in a particular company for invoicing and accounts receivable will depend on the costs and efficiencies of the existing methods.

Specific Examples of ADP in Use

Through the cooperation of the companies concerned, we were able to visit a number of punched card and computer installations in Ontario and

Table 5 - Applications in Survey Companies

	Number of Companies			
	With ADP-48		Using Data Centre - 50	
Applications	No.	%	No.	%
Invoicing & Accounts Receivable	26	54.2	14	28.0
Payroll	23	47.9	7	14.0
Other Accounting Functions	22	45.8	6	12.0
Inventory Control	25	52.1	7	14.0
Production Control	9	18.7	3	6.0
Sales Analysis	38	79.2	33	66.0
Forecasting	4	8.3	5	10.0
Engineering Calculations	1	2.1	3	6.0
Purchasing	3	6.2	4	8.0
Operations Research	2	4.2	1	2.0

Table 6 - Inventory Value: Companies Using
ADP for Inventory Control

Value of Inventory \$ 000	Number of Companies	
	With Own Installation	Using Data Centre
Less than 250	-	1
250 - 500	8	2
500 - 750	4	1
Over 750	13	3
Totals	25	7

Table 7 - Annual Number of Invoices: Companies
Using ADP for Invoicing & Accounts Receivable

Annual Number of Invoices	Number of Companies	
	With Own Installation	Using Data Centre
Less than 5,000	3	3
5,000 - 10,000	3	2
10,000 - 20,000	8	5
20,000 - 30,000	4	1
30,000 - 40,000	4	1
Over 40,000	4	2
Totals	26	14

obtain examples of ADP applications. We are grateful to these companies for allowing us to quote their experience.

A brief description of each company's installation with comments on the main applications or features of interest is given in the following pages. There are examples of production control, sales analysis, inventory control, accounting and payroll applications. Several companies also use their equipment for special studies and experiments to lead them towards a better understanding of the potential applications. The descriptions include useful comments about preparations for conversion of applications to ADP equipment.

In most of the companies interviewed, the data processing installation is part of the Comptroller's Department (or equivalent title). This implies a broadening of the Comptroller's function, as the installation usually serves several Departments and it is generally appreciated that the full cooperation of the staff members is essential for efficient use of ADP, particularly in plant applications. Education is stressed by all the companies; education on the effects of the installation and the need for accurate data, and education on the ways in which it can best be used.

All the companies were asked what benefits they get from their equipment. In some cases, specific savings and advantages were cited; in others, there was a frank admission that costs are probably higher but that this is compensated by the speed with which information is processed and by the added detail available. The companies were unanimous that they could not envisage managing without their installations; each one plans to introduce new applications or new equipment.

Some companies have had less fortunate experience with data processing. Costs have increased and no real benefits have been obtained. Others have fully investigated the use of ADP and decided against it. Such a company, which we have called 'XYZ Ltd.' is described at the end of this section.

The company examples which follow are:

Black Diamond Cheese Limited, Belleville.
Burndy Canada Ltd., Scarborough.
Canadian Cannery Limited, Hamilton.
Canadian Pittsburgh Industries Limited, Toronto.
Coulter Manufacturing Company Limited, Oshawa.
Joy Manufacturing Company (Canada) Limited, Galt.
Koehring-Waterous Limited, Brantford.
Mead Johnson of Canada Limited, Belleville.
Parke, Davis and Company, Limited, Brockville.
Robbins and Myers Co. of Canada Limited, Brantford.
Robertsteel (Canada) Limited, Hamilton.
Robertson-Irwin Limited, Hamilton.
Snap-On Tools of Canada Limited, Toronto.
Sunshine Uniform Supply Co., Ltd., Toronto.

Application of ADP in
BLACK DIAMOND CHEESE LIMITED

Black Diamond Cheese Limited provides an excellent example of a successful punched card installation for a company with only just over 100 employees. About 200 different items are manufactured in the Belleville plant and distributed throughout Canada from eight storage points. There is also an active export business to all parts of the world. A small office staff of a dozen people, including the punched card personnel handles all the accounting, purchasing, invoicing, payroll and secretarial work. The punched card equipment plays an important part in making this possible.

The equipment rental is \$1,300 per month and direct operating salaries are only about \$600 per month. A major task is the preparation of 30,000 invoices per annum. In preparing for this run, a girl selects cards from the master file:

- (a) Customer name and address.
- (b) Shipping instructions.
- (c) Price card (one for each item).

Cards are punched with quantity and bill of lading number and the deck (after checking) is ready for the calculations of invoice and shipping documents. The cards are then used for a number of related tasks:

- (1) Sales analyses.
- (2) Invoice listing.
- (3) Customer statements and accounts receivable.

(4) Retailers' incentive calculations.

(5) Brokers' commission.

An important factor in preparing invoices is to check their accuracy. This used to take 6 man-hours per day but has been cut to 2 by a neat arrangement. In order to update the inventory, a card is required showing product code and quantity sold. Rather than duplicate this from the invoice deck, the information is punched independently, together with customer code, and used to check the invoice cards. This is done on a special 15 - 20 minute run on the collator, which stops if there is an error in punching.

Other functions of the equipment include a returns analysis, issuing of cheques for accounts payable, monthly inventory valuation, raw material and production reports, payroll, standard costing and department efficiencies. In fact, a significant amount of information is being obtained from the equipment and savings in clerical costs alone are at least \$1,000 per month. There is an excellent customer relationship and brokers are pleased with the speed and accuracy of their commission calculations.

When the installation was being planned in 1961, the Secretary-Treasurer was concerned whether suitable personnel could be obtained in the Belleville area, but in practice it proved not too difficult to select and train people for the positions.

With a smooth development program, Black Diamond Cheese has demonstrated that a punched card installation can be a success in a small company.

Application of ADP in

BURNDY CANADA LTD.

This company has about 250 employees in Scarborough, engaged in the manufacture of electrical and electronic connectors and cable supporting systems. The product range of approximately 4,000 stock items extends from those used in power transmission to small connectors for computers. The modern plant of 110,000 square feet includes a foundry, machine shop, plating room, metal fabricating, and assembly areas.

Use of the small data processing unit is slanted toward the plant, the main applications being shop loading and incentive earnings statements. Other operations, which include sales analysis, labour distribution, accounts receivable and cost of sales, will not be described here. The rental of the punched card equipment is \$1,500 and operating salaries are also about \$1,500 per month.

Approximately 70% of orders are for stock and the balance to customer requirements. For each order, punched cards are prepared for every operation (6 per order on average, though there may be as many as 50), from sheets issued by the Engineering Department which show the processing and the standard machine time at each stage. The cards are reproduced so that one set (green) goes into the shop to be used by Production Scheduling personnel, while the master deck (red) remains in the punched card installation. Sorting and printing of the master deck twice weekly produces a 'shop load status' report that shows the jobs ahead of each work centre. This report provides the basis for department schedules. Summaries of the work load in standard hours by work centre and department enable overloads to

spotted in time for suitable arrangements to be made. They also show up under-employed facilities so that stock orders may be raised.

When an operation is completed, the green card is returned to the punched card installation so that the corresponding red card can be sorted from the main deck. A weekly 'unload' report summarizes the production from each work centre.

Machine operators are paid bonuses according to the number of 'premium hours' that is, standard minus elapsed hours. Operators clock on and off each item and punched cards are prepared from the time sheets. A daily run prepares a 'work measurement report' which includes Job Number, Work Centre, Standard, Elapsed and Premium Hours, Efficiency, Date and Clock Number. The operator gets a copy and is thus able to gauge his performance; weekly summaries enable management to assess the productivity of individual departments and work centres. Not all jobs have standard times and a monthly summary showing the incentive coverage by departments enables industrial engineering effort to be allocated where most needed.

Since punched card equipment was first installed about six years ago, Burndy Canada Ltd. has found an increasing requirement for speed in the preparation of information. People now expect, as a matter of course, quick acknowledgement of an order and up-to-date information for production planning. The punched card installation is performing tasks that could not be done by hand in the time available.

Application of ADP in
CANADIAN CANNERS LIMITED

Canadian Canners Limited has an IBM 1401 computer at its headquarters in Hamilton. This company is engaged in processing fruits and vegetables and its 1,200 product lines (i.e. items) are marketed through wholesale outlets and chain stores, principally under the established brand names of Aylmer and Del Monte. The main processing plants are in Ontario and Quebec, but the company also has plants and warehouses in other provinces. Excluding seasonal employment, there are about 1,100 employees in Canada, of whom approximately 80% work in Ontario.

The 1401 computer was installed in May 1962 and is used for invoicing, sales analysis, inventory records, ledger accounting and responsibility reports, product profit and loss analysis etc. A regular physical movement report provides an analysis of the activities and freight costs for the 20 major distribution points (plants and warehouses).

The transition from their punched card installation to the computer was particularly successful. The company emphasizes careful forward planning; as a result, it was able to release its Type 407 accounting machines within three days of computer start-up. Subsequent applications have been implemented after studies indicated benefits.

The cost of the computer has been justified by the routine but important applications listed above. Now, the company is getting into new applications that may well prove of even greater benefit. It has no fixed ideas about these new areas but feels that in cooperation with line management, useful studies can be undertaken on the computer. Current activities

take up about 1-1/2 shifts per day, on average, so there is spare computer time available.

Three examples of programs already developed illustrate the possibilities:

- (a) The tendency of the market to swing from F.O.B. producing plant, where the customer arranges and pays for the movement of his purchases, to delivery at the market site by the producer, has placed new emphasis on the small order problem. A computer analysis has correlated the incidence of small orders with such factors as product item, customer, salesman, and demand point. While the computer cannot directly determine sales policy, it can provide a basis for informed decision by management.
- (b) Experiments in inventory management systems for a major distribution point have been run on the computer using 6 months' actual sales. This permitted the evaluation of the feasibility of such systems.
- (c) With storage and freight costs playing an important role in profitability, a special analysis of movement patterns has been undertaken. This is a computer simulation of the distribution and warehouse system, with appropriate costs and restrictions on storage capacity. With this simulation, it will be possible to evaluate possible decisions aimed at ensuring the most efficient method of storing packs and supplying market points.

The rental cost of the 1401, the two disk drives and all other peripheral equipment is \$7,600 per month; operating salaries are around \$8,000 per month. Canadian Cannery Limited is confident that the economic benefits and timeliness of reports outweigh these costs and that recent special applications and similar developments will provide additional benefits to the company.

Application of ADP in
CANADIAN PITTSBURGH INDUSTRIES LIMITED

The most interesting applications by this company are in Sales Analysis, Accounting and Inventory Control. Canadian Pittsburgh Industries Limited has approximately 2,400 employees and is organized in three divisions - paint, glass and merchandising. The main plants are in Toronto, Montreal, Vancouver and Windsor. There are 40 branch offices serving retailers and customers across Canada.

Invoices are raised in the branches and a copy is sent to the Toronto headquarters, which has a small UNIVAC 120 computer and associated punched card equipment, installed in 1958. Cards are punched from the invoice and, in conjunction with master cards for each customer, serve a number of purposes: accounting, costing, branch inventory and sales analyses. Examples of the sales analyses are:

- (a) For each branch, a monthly report by each of the 45 product groups, showing sales and profit for the month and year to date, with comparisons for the previous year. It also includes the gross profit as a percentage and the month-end inventory level.
- (b) For each salesman, a monthly report giving customer name and classification, number of sales, month of last purchase, sales this year to date and last year in total and a percentage ratio of the two. This report is prepared separately for glass and paint.

- (c) For each branch, a quarterly analysis of sales by customer classification: retailers, dealers, contractors, etc.

This shows the sales this year to date and last year with the percentage contribution by each class to the total.

This is compared with the similar figures for the average of all branches. This report is also prepared separately for glass and paint.

It is easy to see how these reports are useful to division managers, branch managers and salesmen in the field. The information is supplemented at year-end by special analyses for each branch derived from the same source data:

- (1) A ranking of customers in order of sales.
- (2) A list of customers who did not buy at all during the year, and the value of their previous business.
- (3) A breakdown of sales by customer classification, separately for paint and glass. This shows for each group the total number of customers, number of invoices and total sales value together with the averages. This helps to determine where best to expend sales effort.
- (4) A further analysis by customer classification shows the value and number of accounts separately for new customers, increased business from existing customers, decreased business and lost business.

Before the installation was in operation, each of the branches

had to maintain accounting records and journals virtually as if they were separate companies. All the accounting work is now done with the computer; the inputs are sales and cost data already at the computing centre, together with journal entry sheets from the branches. Every month the complete income and balance sheet for each branch is prepared on the computer. There is no general ledger book; the details are held on punched cards.

The operating divisions, factories and general office also send in accounting data each month. This is processed to prepare 22 financial statements, including the Consolidated Income and Balance Sheet for the whole company and each division. These are available within two days of processing. General ledger decks of cards are maintained for each accounting centre and the fairly complicated allocations and summations of cost which go to preparing the financial statements are readily accomplished by the computer.

The inventory control application relates to the individual stock levels of the 1,000 paint products in each of the 40 branches. This work is undertaken twice per month at a computer data centre using punched cards prepared from the branch invoices. These cards carry the branch number, line, colour, size and quantity. The computer updates the inventory levels and automatically raises an order on the factory for items which need replenishing. The method used to determine this is based on a sales forecast which is derived from actual sales for the corresponding periods last year, modified if necessary by the branch office. The computer compares the stock on hand with the forecast sales over the next 14 weeks, which allows for production and delivery time plus a safety margin. If it is

found that the available stock will be used up within that period, a replenishment order is automatically raised.

Each paint factory serves a group of branches. Therefore, an important by-product of the inventory system is a twice-monthly report for each factory showing each product, the total stock position, four weeks' forecast sales, sales this month and year to date. This is a useful aid to scheduling, since priorities are identified by the letters A or B to denote stock shortage now or approaching. Another by-product is that the billing to the branches is all done by the computer.

The costs for data processing, including computer rental, operating costs and data centre charges are about \$12,000 per month.

There have been clerical savings in that field office employees need not be as technical and increased business is being met without staff increase. The inventory system has resulted in improved stock turn and fewer stock-outs. There is much more management information available; the majority of reports produced today did not exist before and existing reports are produced faster. Further, there is advantage in removing problems from the field to one central location.

Application of ADP in
COULTER MANUFACTURING COMPANY LIMITED

This company is using a small punched card installation for payroll, accounts payable, invoicing and manufacturing control. There are about 500 employees in Oshawa and Uxbridge engaged in the manufacture of automotive hardware. The product range comprises 300 different items and the principal processes are die casting, metal stamping, plating and assembly.

Payroll and Personnel Records

In the payroll application, employee earnings are calculated from time and rate cards and allowance is made for tax and other deductions. Payroll cheques are then printed and the installation also prepares control registers for earnings, deductions and cheques as well as accumulating earnings for tax purposes.

Accounts Payable and Expense Analysis

Information from suppliers' invoices is punched into cards, which are sorted and accumulated by supplier at the end of the month to produce accounts payable cheques and a cheque register. By sorting against accounting codes, the same punched cards are used for expense analysis. The cards are then held in the Accounting Department and are available for specific listings for audit or other purposes.

Invoicing and Sales Accounting Controls

Each product is represented by a master punched card which contains all the standard information including unit price and cost. In conjunction with customer cards, invoices are prepared daily from shipping documents. Sales are analysed monthly by customer, class of sale, division

and product. Other regular reports show cost of sales, gross profit and cumulative sales by product or product line.

Manufacturing Control

This is a comprehensive application embracing production forecasting, scheduling, material and machine requirements, and inventory control. The control is in three stages.

Stage 1 involves the translation of forward customer requirements into a detailed listing of assemblies, purchased parts and raw material requirements showing quantity and value; and a list of parts to be manufactured. These gross requirements forecasts enable purchasing and production departments to look ahead and make provisional arrangements. Approximately 500 purchased parts and 500 manufactured parts are involved.

Stage 2 follows the establishment by the Production Planner of a quantity schedule, taking account of customer requirements in relation to existing stocks. This schedule is broken down in a similar way to provide firm purchasing and manufacturing requirements including supporting production orders, bills of material and operating instructions. The departmental machine loadings, costs and set-up times for each product are shown. From the planner's point of view, the important thing is that once the quantity schedule has been established, the punched card installation prepares all the necessary information for the various departments.

Stage 3 monitors the performance by preparing reports of the status of all items, on a daily basis if required. A shipping report for example shows for each product the quantity shipped to date, the quantity required and the shortage, if any. Similar reports show the position on

manufactured parts and assemblies, and for purchased parts and raw materials. By these means, control of all aspects of planning is complete and management is able to assess performance readily and take action to meet difficulties.

A direct result of this system is that inventories of each item are controlled. The information makes it possible to reduce investment and is especially valuable where the finished product may be affected by a model change. Supplementary studies determine economic order quantities for each item to obtain the best balance between order costs and inventory costs.

Installation

All these applications are being accomplished with a minimum of punched card equipment and a staff of one supervisor and one key-punch operator. The equipment used is a key-punch, a reproducer, an interpreter, a sorter and an accounting machine. The main units are IBM Series 50 machines which are identical with standard equipment except that they operate at a slower speed and command a reduced rental. Access is available to a calculator in a neighbouring company, who in turn pays for time on the interpreter.

An important principle which contributes to the efficient operation of the installation is that cards are not verified after punching. Instead, control on totals or visual checking of reports is used. Source departments are responsible for the accuracy of input data and appreciate that the usefulness of the reports they get depends directly on this input.

Rental costs for the equipment are only about \$650 per month and, with operating salaries, the total costs are around \$16,000 per year. The equipment was installed in October 1962 and has enabled an increased volume

of business to be handled without increase in clerical staff. There are many benefits in the better control of manufacturing, inventories and customer service.

Application of ADP in
JOY MANUFACTURING COMPANY (CANADA) LIMITED

This company has had punched card equipment for six or seven years and is currently preparing for a transition to high speed data processing when a small computer is installed later this year. The company manufactures mining, constructional and industrial machinery including rock drills, compressors and air hoists. The headquarters and main plant are in Galt and other divisions are in Winnipeg and Montreal. In total, the company has around 400 employees in Canada.

The punched card installation has a rental of about \$1,950 and operating salaries are about \$1,600 per month. The main applications at present are in accounting and sales statistics for all three divisions; applications envisaged for the computer will extend into nearly every phase of the business. A carefully planned program in three stages will transfer the existing work to the computer and then introduce inventory control, machine loading, job scheduling, personnel records, standard costs, etc. An IBM 1401G computer will be installed in July, to be replaced in about 18 months' time by an IBM 360 Model 20. Inventory control will be a major application: some 25,000 different items are held in stock for assembly into machines or for sale as spares for existing machinery.

Certain features of the plans for the changeover are of general interest:

1. Support - The program has the full support and interest of all levels of management, from the President down.
2. Education - One seminar has already been held to explain the

plans to the staff. Others will be arranged and selected staff will be sent on courses to familiarize them with computer concepts.

3. Input - Systems studies are being undertaken to ensure a smooth flow of accurate and timely information.

4. Output - Each report will be tailored to the responsibilities of the person concerned. With mutual exchange of ideas, it is intended to avoid swamping senior management with voluminous reports; wherever possible they will be factual and concise.

5. Staff - It is not expected that there will be much dislocation of staff. With increasing sales activity, it is expected that affected staff will be reallocated; in fact, people doing rather dull jobs will find their work more interesting.

The savings are expected to stem from the benefits of increased control rather than from staff reduction; it is also expected that the extra machine costs will be more than covered. The important factor will be the management itself. The computer can provide the tools for control and help in making decisions, but the actions must come from management.

Application of ADP in
KOEHRING-WATEROUS LIMITED

This company is located in Brantford and has about 350 employees. It manufactures heavy machinery including excavators, crawler cranes, asphalt and concrete plants for the construction industry and various pulp and paper machines including grinders, chippers and pulp screens. Its facilities comprise a machine shop and plate shop with equipment for the various metal-working operations.

Koehring-Waterous provides an excellent example of a small punched card installation which is used for production control integrated with purchasing, receiving and costing. The equipment rental is \$1,400 per month and operating salaries are about the same. The unit also prepares the payroll and labour analysis, accounts payable cheques and purchase analysis.

The translation of an order into production documents requires a level-by-level explosion, breaking the order down into major assemblies, sub-assemblies and parts. Literally hundreds of parts may be involved in the manufacture of one item. Master decks of cards are held in the centre so that from the order, punched cards can be prepared for each component part. These master decks have to be kept up-to-date in line with engineering and design changes.

By bringing together requirements for common parts, an 'extended bill of material' is prepared for ordering and production purposes. An ordering card is punched for each purchased part and this goes to the Purchasing Department who mark the Purchase Order Number and Vendor Code. The card can then be used to prepare the order and subsequently can be

included in the regular report of open orders. When the material arrives, a receiving card is punched which is used to certify accounts payable and also to compile the weekly purchase report which compares actual against standard prices.

The production documents prepared by the centre include labour and material cards and a 5-part shop order and routing sheet which lists all the quantities and part numbers, the operations, drawing numbers, etc., and such details as whether a special jig or template is required. As the operations are completed, cards come back to the centre so that cost analysis can be done.

Koehring-Waterous has had punched card equipment for a number of years and is getting a lot of information from it. The next step planned is the incorporation of inventory control.

Application of ADP in
MEAD JOHNSON OF CANADA LIMITED

Mead Johnson provides an example of a company with less than 200 employees that is successfully operating a small computer and made the transition from manual methods directly to the computer without any intervening experience with punched cards. The first installation was an LCP 30 computer in 1961. This was replaced in 1963 by a larger computer from the same manufacturer, an RPC 4000. The replacement was preceded by a careful study of the jobs to be converted and the additional tasks to be taken over. This preparatory work undoubtedly contributed to the success of the changeover.

The company's plant in Belleville manufactures pharmaceutical products that are shipped directly to wholesalers and hospitals throughout the country, and proprietary products for its Edward Dalton division that are distributed through suitably located warehouses. The RPC 4000 computer has a rental of \$3,100 and operating salaries are about \$1,250 per month. It has drum storage of program and data with paper-tape input and output. Results are printed from the tapes on a Flexowriter automatic typewriter. As compared with a punched card installation, programs for the computer take full advantage of the facility to do extra calculations, to take account of exceptions and to decide between alternatives.

The main functions of the computer are for invoicing and preparing associated sales and accounting reports. Belleville sales are pre-billed from the order. A paper tape is prepared showing the customer number, type of sale, product code and quantity. When the tape for a batch of orders has been checked, it can be read into the computer after the program and

master file of customer information has been loaded. The computer does all the necessary calculations and punches an output tape from which the invoices and shipping documents can be printed. These show customer address, freight classification, product description and size, price and value, type of product, weight and number of packages. All this information is derived from the master tape. Invoicing for warehouse sales is done in a similar way except that bills of lading are prepared locally.

The invoice tapes are used for a variety of associated reports. These include comprehensive weekly and monthly sales analyses, such as a weekly analysis of sales by product for each of the 30 regions. Standard costs are applied to the sales information to give management a cost breakdown. The inventory levels of each stock item are updated and items falling below minimum stock are indicated. In accounting work the computer is used for general ledgers, departmental analysis of expenses and budget comparison.

The greatest benefit of the computer has been the provision of timely information that could not be obtained manually. There is potential to accept greater volumes comfortably so the target is an integrated system including production and raw material control.

Mead Johnson has proved that it is feasible for a small company to operate a computer successfully.

Application of ADP in
PARKE, DAVIS AND COMPANY LIMITED

This company manufactures pharmaceuticals in its plant at Brockville, and distributes them to hospitals and drug stores through five warehouses in major cities from Montreal to Vancouver. There are about 170 employees at the Brockville location and a similar number in the sales offices and warehouses. The product range comprises about 300 different items (600 if size is taken into account).

An IBM 1401 computer with disk storage was installed in November 1963. Rental is \$6,000 and operating salaries are about \$2,500 per month. The computer is used on one shift for a number of operations including payroll, costing and accounting work. However, its major uses are in sales applications, ranging from sales analysis to inventory control and sales forecasting.

Invoices are prepared locally at the warehouses. Montreal and Toronto use small punched card installations for this purpose and forward the cards to Brockville after the invoices have been issued. For the other warehouses, the computing centre punches cards corresponding to the invoices. These enable the calculations to be checked and then form the basis for a comprehensive range of sales analyses. For example, a weekly statement to the branch and sales managers shows the value of shipments by salesmen this month and this year to date, and a comparison with the corresponding figures for last month and last year. Another analysis shows the sales in selected products broken down by class of trade. Results of sales contests and promotion campaigns are assessed twice monthly.

The same punched cards are used to look after accounts receivable statements and customer records. They also serve to update the inventory records. A central replenishment system is operated using a maximum inventory concept: if the stock level of an item falls below 50% of the maximum, the computer prints out shipping tickets for the replenishment of the stock. The tickets are marked if the stock level is below 30% so that express shipment may be arranged. Records of stock levels and usage of the control plant stocks enable replacement orders to be scheduled when required.

An interesting feature of the system is the use of the computer in sales forecasting. This is done monthly by product groups so that each item is reviewed at least three times a year. The method used takes account of the seasonal nature of the trade in general: the computer has sales stored for the last 24 months and selects from this information the sales in the corresponding month last year plus the sales in the preceding and following month. It calculates the average of these figures and those for the similar period from the previous year and then applies various factors including an allowance for the trend in sales of the item and the anticipated effect of promotion campaigns. In this way, forecasts are prepared for each of the next ten months and these are particularly useful to production and sales management. They are also used to adjust the inventory limits for the stocks in the warehouses.

Apart from the regular duties of the computer, Parke, Davis has experimented with specific studies. These include, for example, a forecast for the next ten years of storage capacity required at one of the warehouse locations, the seasonal adjustment of sales information to determine long-range trend, and inventory simulation.

While it is difficult to specify benefits exactly, at least 20 clerical staff have been saved by the computer operations. Further, more information is available, information which is more accurate and more useful.

Application of ADP in

ROBBINS AND MYERS CO. OF CANADA LIMITED

This company is located in Brantford where it employs about 300 people and manufactures electric motors ranging from 1/20th to 150 horse-power. Its products include special application motors for business machines and motor parts for hand tools. Most production is to customers' orders, but there are some stock items, about 30% of output.

The punched card installation rents for about \$1,400 and salaries are about \$1,200 per month. It is operated on one shift, with overtime when necessary, and performs various tasks, including sales, voucher and labour analysis, accounts receivable and payroll. Its main use, developed over the last 18 months, is for production control; this takes up about 50% of the time on the equipment.

When an order is received from the Sales Department, it goes first to the Engineering Department to determine the material requirements and processing (if it is a new item) and then, via the Production Scheduling Department to the data processing installation for punching of an order card showing Order Number, Product Number, Schedule Date and Quantity. For each product number there is a master deck comprising:

Header card	--	Product Number and Name.
Material cards	--	Part Number and Name - 1 card for each component.
Operation cards	--	Operation Number and Description, Piecework Price, Account Code - 1 card for each operation.

The appropriate master deck is selected and reproduced and then common information is duplicated from the order card. The total requirement, which is the quantity ordered multiplied by the number of parts per unit, is then punched into each material card.

The resulting deck of cards now contains all the information needed for the production of the order. This is used in various ways:

1. An 'Extended Bill of Material' and a 'Routing Sheet' are prepared for each order. One copy travels with the order through the shop and describes exactly what material and operations are required. A second copy is used for Planning and Production Control.

2. The material decks are summarized by part number to obtain the total requirements for each part. This information is used in conjunction with inventory cards to prepare an 'Inventory Status Report' which shows the usage to date, the reorder quantity, the quantity on hand, quantity required and on order, the quantity available and the reorder point. The report indicates items where the available quantity is below the reorder level. The leading digit of the part number indicates whether the part is purchased or manufactured, so it is easy to prepare separate weekly reports for action by the purchasing and production control departments.

3. A 'Job Completion' card, which is issued to the shop with the order and returned on completion, enables the inventory position and the card decks to be updated.

Before this system was introduced, production control depended largely on information memorized by the foremen and operators. A careful program of education was undertaken in which the proposed methods

were described to everyone concerned, asking for questions and suggestions. This proved well worthwhile and resulted, for example, in a suggestion to include operator instruction cards in the master decks.

Robbins and Myers has successfully applied punched cards to production control in a medium-sized business and has a system that can be steadily expanded and integrated with other functions. The company admits that it costs more than the previous arrangements, but feels that it has a better knowledge of what is going on and a better ability to make decisions. There have been tangible benefits in the leveling out of production by utilizing spare capacity, shorter manufacturing lead times and improved inventory control.

Application of ADP in

ROBERTSTEEL (CANADA) LIMITED, ROBERTSON-IRWIN LIMITED

Robertsteel (Canada) Limited is a processor and distributor of steel. The main warehouse is in Hamilton, with smaller outlets in Montreal, Edmonton, and Kingston. Steel in coil or sheet form is purchased from mills and held in stock as a service for quick delivery to about 3,000 customers across Canada, mainly in Ontario. Facilities are available for slitting or shearing the steel to specific requirements. The company also fabricates steel culverts.

At Hamilton, the preparation of 50,000 invoices a year is done by punched cards and the operation also provides the accounts receivable and product cost information. Regular analyses show the profitability and turnover rates for each of the stock lines.

Management services, including the data processing installation, are shared with an associate company, Robertson-Irwin Limited, which manufactures and installs metal building products, including wall sections for factories and offices. The punched card equipment has a rental of \$2,400 a month and operating costs of about \$1,500 a month. It prepares the payroll for about 950 employees, including Robertson-Irwin's sales force and on-site construction workers, and Robertsteel's warehouse personnel. Sales statistics, accounts payable, accounts receivable, overhead analysis, all provincial and federal sales tax calculations and ledger accounts are also undertaken by the installation.

Group sales are expanding rapidly and budgetary control plays an important part in the successful operation of the companies. The budgeting

procedure has been refined and developed over a number of years and line management finds particular value in the regular comparison with budget statements prepared by the punched card installation. Management focuses its attention on the exceptions in the full knowledge that the remaining cost elements are in control.

Production control for the main Robertson-Irwin plant is a manual system with some interesting features. The plant comprises about 75 production centres, including roll forming lines, brake presses and ancillary equipment for fabricating profiled metal products. Each order is broken down into its component parts and the manufacturing methods are determined. Standard manufacturing times are estimated for the key plant units and are noted on the order master. The production control documents which are duplicated from the order master include the working documents, material requisition, labour ticket and route tag. These are punched cards on which the operators record the work performed; the cards are then punched and processed to produce costing and accounting reports. The forward loading position on the key items of plant is shown at a glance on a specially developed type of Gantt chart that enables optimum use to be made of plant and manpower. Special stress is laid on preventive maintenance, which is arranged between the engineering and production control personnel.

The company makes use of a computer data centre to perform engineering calculations that would be particularly tedious by hand. These are concerned with the deflection and loading characteristics of different metal floor sections. To date, seven FORTRAN programs have been written by the product development engineer and have provided valuable information. A salesman bonus scheme determined on a sliding scale from the profit contribution of each product sold is also handled by the data centre.

Application of ADP in
SNAP-ON TOOLS OF CANADA LIMITED

Snap-on Tools of Canada Limited, in Toronto, is making good use of a small punched card installation. It manufactures about 500 types of mechanic's hand tools and distributes an additional 5,000 items purchased from its parent U.S. plant and outside suppliers. All but a small proportion of total sales are made through nine branch locations in Canada.

Snap-on Tools uses data processing equipment in a variety of applications, of which three are particularly interesting:

1. The way branches order finished goods from the central warehouse in Toronto.
2. The use of a punched card system for inventory control at Toronto.
3. The reports and analyses produced for manufacturing control.

The equipment at Snap-on Tools comprises an accounting machine, calculator, reproducing punch with mark-sense feature, collator, sorter, key punch, verifier, and a data collection unit for entering plant data. The total cost of this equipment on a rental basis is \$1,600 per month and salaries of data processing personnel are about \$1,100 per month.

Branch Ordering Procedure

Each of the nine branches has a file of prepunched cards with information such as stock number and description prepunched and printed on the cards. To order an item, the corresponding card is marked for quantity required and sent to Toronto. The marks are read by a machine that punches

the quantity into the card. These order cards are then ready for the inventory control and shipping procedures without typing, filing or keypunching.

Inventory Control Procedure

The first step updates the inventory records and checks stock availability for the branch orders. At this time, a 'Stock Status Summary' report is prepared covering each active item. There are 15 numbers shown for each item but the important ones are:

a) Available Stock

This is stock on hand plus factory orders not yet delivered minus branch orders not yet shipped.

b) New Requirements

This is the 'Order Point' or expected lead time usage, minus the available stock. This column shows when a new factory order is required.

The other information in this report identifies the item and provides the supporting data for the above two decision-making numbers. A weekly report called an 'Availability List' shows similar information for all items. The data processing equipment also produces order acknowledgements, packing slips, invoices and accounts receivable statements.

The management at Snap-on Tools is pleased with the benefits of data processing for inventory control because:

a) There was a personnel saving of two clerks but perhaps more important, the remaining people have time to review information and make decisions instead of updating records.

b) Fewer arithmetic errors and automatic pricing provide better control.

c) The summarized reports give management new information not previously available, for tighter control of investment, shortages, etc.

These worthwhile gains were made in a plant with 85 employees. Investment in raw material, process and finished goods is \$1,380,000.

Production Control

The Toronto plant has about 40 direct employees making 500 finished items from 1,200 parts. Each part involves an average of 20 shop operations. The production department uses the data processing equipment to control costs, efficiency and schedules.

The inventory reports mentioned above are used to determine when a new order is necessary. A sales report showing monthly and year-to-date sales helps to determine the order quantity.

A group of punched cards exists for each end product, with one card for each shop operation. When an order is initiated, the quantity and order number is automatically punched in all the operation cards. The calculator computes the labour time as set-up plus quantity times unit time. These cards are then used as job tickets. A rack on the shop floor has a slot for each machine and the cards are placed in the rack in desired job sequence.

The data collection unit is located beside the rack. This unit reads cards and has a dial for manually-entered data. Information picked up here is automatically punched into a card in the data processing department.

The following information is picked up on the data collection unit from the operations card, an employee identification card and manual entry:

date, order number, part number, operation, work centre, time job finished, labour rate, set-up time, standard time per hundred, and quantity completed.

The following figures are then calculated by data processing:

elapsed time, standard time, standard dollars, bonus dollars.

Many valuable reports are machine-produced with this data:

a) The cards in the rack represent the work to be done. They can be totalled and listed by work centre for a load analysis.

b) A 'Daily Job List' details the quantity and financial information for each job performed.

c) A 'Gross Pay Summary' is a weekly report that results from incentive payroll calculations.

d) A weekly 'Productivity Report' summarizes the performance of each man and for the entire plant, including standard hours, elapsed hours, down-time hours and productivity (standard hours \div elapsed hours).

e) A weekly 'Attendance Report' is produced.

f) The 'Closed Order Report' is particularly valuable. Variances are calculated for each order immediately upon completion.

To be of value, reports such as these must be available to management without delay. This is one of the advantages gained through the use of

data processing equipment. Much of the information was not available at all with a manual system.

In addition to the clerical savings achieved, the new reports have contributed to higher labour efficiency through improved scheduling, labour allocation and tighter controls.

Application of ADP in
SUNSHINE UNIFORM SUPPLY CO., LTD.

An example of automatic data processing in a service industry is provided by Sunshine Uniform Supply Co., Ltd. which has recently installed a Honeywell H 200 computer at its Toronto headquarters. The company manufactures work garments (coveralls, shop coats, etc.) and its main activities are renting and laundering of work clothing for a complete range of industries and of linen supplies to restaurants, motels and offices. The company operates ten laundries and has branches and depots for its rental services in Ontario and three other provinces. A relatively new development is the rental of dust control equipment and cloths.

Invoicing and accounts receivable are the principal applications of the computer and the volumes are considerable. Invoicing for the Ontario activities involves the computer in printing 8,500 invoices per day. Details of items picked up for laundering are sent to the computer centre from out-lying branches by truck, bus or mail and the computer processes the information to prepare the invoices. These must be at the branches in time for the regular weekly call on the customer, when the delivery man collects cash or a signature for the laundered articles and picks up another batch for cleaning.

This is an old established company which has grown considerably in a very competitive field. The decision to investigate the use of a computer was made by the President and Directors in the belief that costs and customer service would benefit. They appreciated that application of modern equipment in the office is just as important as the use of new techniques in the laundries. It was anticipated that the careful planning of work and

review of all procedures which was implied would provide improved control of all aspects of the business.

The first step was to engage an experienced systems man and set up a Systems and Procedures Department. This systems group undertook a feasibility study to establish the economics of a computer and to evaluate alternative suppliers. It was decided that auxiliary storage in the form of magnetic disks or tapes was required, as the volume of information was too much for a system using only punched cards for input and output. The merits of alternative systems were carefully assessed, taking into account price, service and delivery, before a recommendation was made.

An order was placed in the summer of 1964 for a Honeywell H 200 computer with four magnetic tape units, to be delivered in February of this year. A detailed program was drawn up of all the work that had to be done in the intervening period. Targets were set for progress on each item and this careful planning paid off in that when problems did arise and targets were not met, action could be taken to correct the situation. The company was ready to take delivery of the computer on February 15th, only two weeks behind schedule. Throughout this period, the General Manager set aside one day a week for consultations with the Comptroller and the systems group so that prompt decisions could be made on the proposed concepts, systems and forms. Almost everything was redesigned as the company was not satisfied with merely translating the existing punched card systems to the computer but wanted to take advantage of any improvements possible. There was full communication with everyone who would be affected by the changes, to explain the benefits and problems, and to ask for co-operation and understanding.

Careful planning continues to apply in the months following installation. Apart from invoicing and accounts receivable, the computer is being used for accounts payable, payroll and inventory control. New applications which will follow include the analysis of fleet information, relating vehicle costs to route revenues and introducing cost control on these operations. The management intends to use the computer for other new reports, experimenting in the use of statistical ratios not previously available, that may give clues to developing new methods of control.

The rental of the computer and associated equipment is about \$6,500 per month. The feasibility study showed that initially total costs would increase but that direct savings in clerical costs would pay for the installation over a period of four or five years. It is believed that intangible benefits will at least equal the clerical savings.

Sunshine Uniform Supply Co., Ltd. is pioneering the application of a computer in its industry but has not taken this step without careful preparation. It anticipates that this will help to maintain and improve its competitive position.

Application of ADP in

XYZ LIMITED

This description is based on fact, although the name of the company has been deliberately disguised. This example is of a company that has considered automatic data processing equipment but does not feel it is an economic proposition.

The company has about 200 employees and its products serve a range of industries. The Comptroller is familiar with a punched card installation in his previous company and up to three years ago was enthusiastic about the application of ADP to most situations. Now he feels that it depends on the particular circumstances.

An installation for his present company could be used in accounting, payroll, sales analysis, inventory and production control. Some of the reasons why an installation would not be justified are:

(a) He prefers the flexibility of manual methods. These have permitted a simplification of customer ledger records and reduced clerical costs to a minimum.

(b) Payroll is straight day-work with no incentive bonus calculations.

(c) Paperwork for inventory and production control has been streamlined and the existing systems are efficient.

The company used to have sales analyses run monthly at a computer centre but, because the data was not adequately prepared, the results were

often inaccurate. The reports looked nice and the President liked them but he rarely took action on the figures. The Comptroller substituted, with the President's permission, a manual summary at less cost.

The situation may change as the company expands but, after careful evaluation, this company is not installing ADP equipment at the present time.

D. OBSERVATIONS

In the applications described in Sections B and C, three levels of change are evident:

(a) Invoicing and Accounts Receivable, for example, represent little change in the management of the function, though there may be a re-allocation of clerical effort. The input is unchanged; the output documents (shipping note, invoice and accounts receivable statement) are the same, except in detailed design.

(b) Inventory Control represents a greater degree of change in both clerical and management functions. There is a radical change in the documents used and the manual posting of receipts and issues disappears. The manager is less concerned with detail: he is free to concentrate on exceptional conditions and on defining the operational rules.

(c) Production Scheduling involves changes in various departments. The manufacturing methods and material requirements for each product have to be specifically defined. Superintendents, foremen, timekeepers, expeditors and production control personnel find their jobs changing. Even the machine operators receive instructions in a different manner. Management personnel have more time to concentrate on wider issues and exceptional problems.

The full use of ADP techniques relieves a manager of many routine problems but calls for a new approach on his part. The manager of today must be increasingly concerned with such questions as 'what information do I need for control?', 'what factors should I pay particular attention to?', 'how should I manage?'. The equipment will not do the managing for him but it can provide a factual basis for decisions.

Benefits

The examples we have given show how automatic data processing and systematic methods are being used by Ontario's manufacturing industry, with benefit to productivity in all its aspects. Applications are reaching into an increasingly wide variety of business operations, as is evident from this survey.

Specifically, a successful ADP system can contribute to the more efficient use of resources in the following ways:

1. Better utilization of plant and office staff.
2. Reduction of working capital through improved production and inventory control.
3. Higher utilization of fixed asset capital.
4. Reduced costs of manufacturing and clerical operations.
5. Better product quality and reduced wastage.
6. Better control of all phases of the business.

Major Problems

These benefits are not achieved without careful planning and some companies have incurred unnecessary expense and caused organizational upsets by deciding to install ADP equipment before making a careful study of its effects. The major problems to be faced include:

1. People's natural reluctance to change.
2. Top management's unwillingness to be involved directly.
3. Resistance by middle management, who fear the installation will reduce their importance.
4. Lack of qualified systems staff, resulting in poorly designed systems.

5. Systems staff reporting to the wrong executive, making it difficult for them to study problems that affect more than one department.
6. Preoccupation with equipment aspects and insufficient attention to accuracy and flow of data.
7. Bias in the evaluation of proposed equipment and applications.

Positive Steps

Many companies have avoided these pitfalls by following certain steps, such as:

1. Establish definite goals for ADP in the company.
2. Set up a competent organization to implement these goals, with direct responsibility to the senior level of management.
3. Evaluate the economics of potential applications.
4. See that there is effective teamwork between operating management in all departments and the systems personnel.
5. Ensure that systems design work is of a high quality.
6. Explain the changes to all personnel.

It is particularly important for smaller companies to plan carefully their first applications of ADP. An incautious approach may seriously affect profits and upset the financial position of the company; a refusal to try the new techniques may reduce the company's competitive power. Such companies will not be able to justify the employment of a full-time systems expert and they should either train an existing employee or hire short-term outside help.

Any ADP system is likely to cost at least \$2,000 a month for equipment and salaries. It is reasonable for a company to spend an amount

equal to 2 or 3 months' operating cost to investigate the feasibility of using an ADP system. Although equipment suppliers are often willing to provide free help for such an investigation, it must be realized that there is no substitute for a clear, impartial look before a capital investment is made.

General Guidelines

Because each organization has its own characteristics, it is difficult to develop yardsticks or rules-of-thumb that will help a company to decide whether it should seriously consider having its own ADP installation. Nevertheless, the following rough guide may be useful to many companies. It is presented here with a cautionary note that the rules are not universally applicable and are a guide only.

With this proviso, we believe that a company should investigate the use of an ADP system when one or more of the following conditions exist:

1. It has more than 100 employees.
2. Paper work salaries exceed \$3,000 per month.
3. Customer service is inadequate.
4. Inventory investment exceeds \$250,000.
5. Product lines have many variations.
6. Expediting expenses are high.
7. Efficient use of manpower and machines is not being achieved.
8. Large amounts of data are available but not in a coherent form.

Automatic Data Processing will not be feasible in situations where rules of procedure cannot be specified. For example, if prices can be changed at will to meet each condition separately, an ADP system will not

work effectively, even though volumes and costs are apparently high enough to justify an installation.

The Future

Large companies pioneered the use of business computers because they had large clerical staffs and the major justification was clerical savings. Every year, there is a reduction in the average size of companies using computers. This is partly due to increasing understanding of how computers can be used and the development of profitable new areas of application. It is also strongly influenced by the lower prices of computer systems: recent announcements by leading manufacturers of business computers renting for as little as \$2,000 a month make it practicable for many small- and medium-sized businesses to consider use of a computer. By 1970, it is predicted that most companies with \$5 million or more annual sales will have computer installations and smaller companies will use punched card or paper tape equipment.

The next five years will bring major changes in the philosophy of management and the use of automatic data processing. We have tried to show what is involved and how companies can benefit by the experience of others. It would be unfair to underestimate the problems and changes which a company must face in making use of these techniques; or to overlook the benefits that are possible.

Examples we have quoted show that automatic data processing can be used successfully in a range of manufacturing industries and in companies of varying size. We do not suggest that ADP will be an economic proposition for every company, but we do believe that management should obtain an understanding of the principles and seriously examine the potential for ADP

in their company. Automatic data processing can be an important business tool in maintaining and developing a company's position in competitive business today.

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OTHER PAPERS PREPARED FOR THE CONFERENCE

"PRODUCTIVITY THROUGH NEW TECHNOLOGY"

TORONTO, MAY 27-28, 1965

The following papers prepared for the Conference are also being published by the Economic Council of Canada. They are available from the Queen's Printer, Ottawa. A brief description of the papers begins overleaf.

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A PRACTICAL APPROACH TO AUTOMATIC PRODUCTION, by D. J. Clough, J. W. Abrams and R. W. P. Anderson; Price 50¢; Cat. No. EC 22-4/3

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The following two addresses delivered at the Conference are available without charge from the Economic Council of Canada, Post Office Box 527, Ottawa.

OUR CHANGING ECONOMY, by John J. Deutsch
Chairman, Economic Council of Canada

TECHNOLOGY AND PEOPLE, by William Dodge
Executive Vice-President
Canadian Labour Congress

MODERN MANAGEMENT, by Gerald G. Fisch

Mr. Fisch is Managing Partner of P. S. Ross and Partners, Management Consultants, and a Principal of Touche, Ross, Bailey and Smart, Chartered Accountants.

This paper is a concise account of the widespread successful application of some of the new techniques, new approaches and new concepts of business management now being used in or available to businesses in Canada. The author points out that these new techniques involve greater precision in management. He argues that this precision -- and an end to the old "seat of the pants" approach to management -- is demanded by the accelerating tempo of change, the demands of a growing ambitious population, and the pressures of rapidly developing technology.

ADVANCES IN METAL WORKING, by Dr. John Vande Vegte

Dr. Vande Vegte is Assistant Professor of Mechanical Engineering at the University of Toronto, and a Principal in the consulting firm of Systems Engineering Associates Limited, Toronto.

His paper is designed to acquaint owners and managers in the metal-working industry with a wide range of new developments in manufacturing technology. Discussed at length is one of the most important of these new developments, numerical control of machine tools. There are about 5,000 of these machine tools in operation in the United States, and the U.S. Labor Department estimates that 12,000 may be in operation by 1967. Canada at the start of 1965 had 46 "NC" machines in operation. This paper also reviews developments in cutting and forming, and discusses improvements in the productivity of machine tools by the addition of modern attachments and accessories.

IMPROVING MATERIAL MOVEMENT THROUGH THE MANUFACTURING CYCLE, by James A. Brown and B. D. Beamish

Mr. Brown is a Partner in Woods, Gordon and Company, Toronto. Mr. Beamish is an automation consultant in Toronto.

This paper is broad in scope, describing how firms might reduce or eliminate material handling and minimize the movement of material through the manufacturing process and to the customer. It pays particular attention to the new developments in the shipment of raw materials and finished goods, warehousing, in-plant handling, and handling at the workplace. One of the authors' findings from a survey of manufacturing companies in Ontario was that few if any of the firms had useable data on their material-handling costs.

A PRACTICAL APPROACH TO AUTOMATIC PRODUCTION, by J. W. Abrams, R. W. P. Anderson, and Donald J. Clough

Mr. Abrams and Mr. Clough are Associate Professors, and Mr. Anderson an Assistant Professor, at the University of Toronto. All are members of Systems Engineering Associates Limited, Toronto.

Their paper is designed to focus attention on some of the thorny, practical problems faced by small Canadian manufacturing companies as a result of technological change. The objective is to give small companies some indication of the major factors in mechanization. The paper includes a definition of automation and mechanization; a discussion of ways that automation was approached by 12 representative Ontario firms surveyed by the authors; certain observations and conclusions resulting from that survey; and an outline of the more important technological, economic and other factors that must be considered as mechanization is implemented.

THE ECONOMIC JUSTIFICATION OF NEW EQUIPMENT, by C. G. Edge

Mr. Edge is Director of Management Services for Chemcell (1963) Limited, and Assistant to the President, Columbia Cellulose Limited.

This is a paper on how to appraise capital expenditures through the use of sound methods of relating the future benefits to the outlay, estimating future benefits, and administering and controlling projects. Various methods of determining the economic justification of capital expenditures are discussed but emphasis is given to the use of the Discounted Cash Flow method. Three ways of using the DCF general method are described — internal rate of return, present value, and equivalent annual costs. Adequate examples plus tables and charts provide sufficient information for the understanding of the significance of each of these methods.

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