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CHAPTER 1

The Need for Punched Card Data Processing

Punched card data processing is the profession in which data is processed and reports are prepared by the use of punched cards on equipment designed to read holes punched in the cards.

The purpose of punched card data processing is to transcribe data from source documents into a punched card form and to process the data into reports suitable for management consumption. This sounds quite simple. In fact, data can be processed into reports manually; so why use machines? To answer this, let us explore the reasons for having punched card data processing.

The Clerical Worker Shortage Problem

During the forty-year period 1919-1955, there was a 700% increase in the number of clerical workers in the United States. This increase of white collar (office) workers was four times the rate of blue collar (factory) personnel. It is estimated that if this rate of growth in clerical personnel continues to the year 2050, there will not be enough people in the labor force to process the clerical work load.

The clerical worker shortage problem is not the only reason for the existence of punched card data processing. Other reasons are:

Increased volume of data.
Accuracy and control.
Economy.
Improved Report Schedules.
Engineering and Scientific Applications.

Increased Volume of Data

Assuming that there were a sufficient number of workers to process the growing volume of data, it still would not be practical on a manual basis. There is a limit as to how much volume of work may be divided and how many people can participate without causing undue delays or excessive errors. The processing of data usually requires repetitive operations to be performed on one document after another with a few variations depending upon variations shown on the source data. For example, in computing the payroll dollars for each employe, a clerk would multiply the number of hours worked times the man's hourly pay rate. A variation might be encountered if an employee worked the second shift. In this case a bonus would be added to the base rate before the extension is made.

If a clerk or a group of clerks were making extensions such as this all day the work would become quite monotonous and the chance of an extension error or a failure to notice that an employe had worked a second shift would increase. As the number of variations increases, the possibility of error increases. On small volumes, humans can exercise sufficient care to minimize errors, but as the volume grows the practicality of the operation breaks down because of the inherent characteristic of humans to become bored with repetitious work.

This type of work is a natural for machines. A machine can be depended upon to react exactly the same time after time to a given set of conditions. The machine does not think, it just performs according to the instructions given to it by the operator. In our previous example, the clerk might overlook the fact that an employe had worked the second shift and failed to add the bonus, but the machine would not do this. It would doggedly and stupidly eat its way through the data and each time a second shift employe appeared the machine would automatically detect it and add the bonus before making the extension. The human being has a mind and makes a decision each time he performs an action. Because he is not a machine, he will not always make the same decision under the same set of conditions. The free will of the human mind is certainly an advantage that mankind has over all other creatures, but in the drudgery task of plodding through reams of paper it is a disadvantage. Man realizes this and has invented machines to do the drudgery tasks for him. After all, why should man who has the ability to think, to analyze, to make decisions, do mechanical operations that can be performed by a lower type intelligence?

Accuracy and Control

Accuracy cannot be overemphasized. Errors add to the confusion. The volume of data to be processed plus the shortage of people to process it is a serious enough situation, but intermingle erroneous data with good data and chaos results. Human beings make mistakes; no one is perfect. *The more the human element can be removed from the processing of data the more accurate the results will be.*

Punched card machines have a high degree of accuracy. Of course, the human element is still involved but to a more limited degree. Errors still occur, but in a much lesser degree. As machines become more automatic (machines running machines), the human element is decreased and accuracy is perfected.

Control is essential to a machine operation. The machines do not think; consequently, if conditions are not under control they will not detect it as might be the case under manual systems.

It is customary to send source documents to the data processing department with adding machine tapes of the critical fields attached. For instance, payroll clock cards would have tapes attached with totals of the straight-time hours, overtime hours and double-time hours.

Punched cards are prepared from the source documents and balanced back to the control tapes. These control figures are entered in a control book and from that point forward all reports must balance to these figures.

Note that the control of the source documents rests in the responsible department, and the *responsibility of the data processing department is to process the volume of data and issue reports which balance to the predetermined control totals. Likewise, the reports issued by the data processing department will not be any more accurate than the source documents it receives.*

One disadvantage of punched card machines is that they process incorrect data just as fast as correct data. Even obvious errors which would easily be detected by humans will go unnoticed by the machine as it doggedly does the job exactly as it has been told to do it, perceiving nothing else.

Great care should be exercised in auditing source documents for accuracy before they are introduced into a machine system.

Economy

For many years, economy was one of the big selling points for punched card equipment; however, in recent years it has not been stressed nearly as much. In former years the machines were simpler and were mainly used on high volume, low complexity type jobs. The rental was considerably less and the machines were used primarily on jobs where a maximum number of clerical workers would be saved. As business became more complex and factors other than economy became paramount, the machines were engineered to perform more complex operations. This had the effect of increasing the cost of the equipment but it also increased its flexibility. The machines could now be used on a wider variety of applications, thereby gaining some of the other advantages of mechanization such as accuracy, control, and speed.

As machines became more complex, the science of punched card data processing became more technical. More capable people were required to mechanize the systems and operate the equipment. More capable people demand higher salaries which further de-emphasizes the economy factor.

AVERAGE HOURLY EARNINGS BY YEAR

YEAR	1909	1919	1929	1939	1949	1953	1956	1960
AVERAGE HOURLY EARNINGS	.193	.477	.566	.633	1.401	1.77	1.98	2.35

Figure 1—Average Hourly Earnings by Year (*Handbook of Labor Statistics*)

Another phenomenon was occurring during the period when the cost of punched card departments was on the rise. This was the increase in labor rates. See Figure 1. Labor rates increased faster than machine rentals, consequently the displacement of personnel accounted for a larger savings to the company.

There was a time when labor was cheap. It was not costly to check and doublecheck data, and it was more economical to hire people than to buy or rent equipment. As the price of labor rose and labor problems became more acute, this philosophy became less practical.

Today labor is a major cost factor to be reckoned with in every business, and even the highest-priced hardware can be shown to compete effectively on appropriate applications. It is quite common for the existence of punched card departments to be questioned by skeptical executives. Consequently, practically every punched card department has to prove its value to the company periodically. Unfortunately, the most common basis that the skeptic uses is dollars and cents. Therefore, all other benefits are ignored, and charts are prepared showing what it would cost to do the work manually compared to the cost of the punched card method. Usually substantial savings are shown and the department is allowed to go along its merry way until another skeptic pops up.

Economy has always been a reason for having punched card equipment, and it still is. However, it is no longer stressed to the same degree by the manufacturers in their sales approach, for they realize that the principal value to a company having punched card equipment is not in the savings of clerical personnel but rather in the other benefits which are derived from mechanization.

The manufacturers of equipment realized that every company, especially the smaller ones, could not afford and did not need the high-speed, high-flexibility, high-priced machines. Consequently, in 1959, IBM introduced a new line called the Type 5050 (Fifty-Fifty) series, which duplicates their regular line except that speed is reduced (approximately one-half) and rental is greatly reduced. Remington-Rand also introduced a similar line of equipment.

With these new lines it is possible (at 1962 rentals) to have a "basic" punched card department starting at about $300 per month rental, less than the pay of one clerk. This basic installation would be very limited in speed, machine capacity, and flexibility. It can probably be utilized best by small companies with one or two problem applications. For instance, a distributing company might use it for billing, sales analysis and inventory control. It is anticipated that this new "economy" line will promote almost universal utilization of punched card equipment throughout business and industry.

There are other types of economy which are realized because of the control inherent in punched card methods, but they are hard to measure. An example of this would be in inventory control. By accuracy, control and speed in processing orders, inventories can often be reduced considerably. This reduction can represent a savings which would dwarf any personnel savings that might result from the mechanization of the inventory control application. By a reduction in inventory, capital savings can be realized on stock, floor space and handling expense, all of which cost money that can be freed to be used elsewhere.

The dollar sign has always been important and it probably always will be important. Companies are in business to make a profit, and profit is measured in money. It is apparent that machines must be able to justify their existence on the basis of economy in the future as in the past, in addition to providing more and better services to their masters.

Better Report Schedules

One of the predominant forces at play in our day-to-day lives is speed. Everything is done in a hurry. People run hither and yon, each intent on accomplishing his task with the utmost speed. Nevertheless, most foreign countries do not operate at the same frenzied pace as does the United States. Medical authorities warn us that this is not good for us. The human body is neglected and abused. Frequent heart attacks among the comparatively young, high blood pressure and ulcers bear out the truth of the medical warnings.

Be it good or bad, this seems to be our way of life. It is not our purpose here to condemn or condone it, but rather to show its influence on punched card data processing. The blistering pace exists not only with people, it also exists with data. Executives who drive themselves expect immediate answers to their questions. They make split-second decisions all day long, and facts are required upon which to base these decisions. An executive who does not have the facts is operating under a serious handicap. Facts include the day-to-day happenings of a business. They are recorded on the various documents which flow through the company; they tell what the company is doing.

At one time, the emphasis was on production. It seemed that anything that could be produced could be sold. The problem was to produce enough, but gradually the supply of almost everything from soup to nuts caught up with the demand. Competition became prevalent and the weaker companies were forced out of existence. Keen competition placed even greater demand upon executives to get the facts and get them quicker. Decisions made without adequate facts are risky and decisions made too late are useless. Therefore, faster reporting systems were demanded. The feedback of the company operation to management had to be stepped up.

The addition of clerical workers can speed up most reporting systems to a degree, providing the work can be distributed efficiently. The addition of more clerical workers presented other problems which we have already discussed. Even if more clerical employes can be added, there is still a limit to the speed at which a manual reporting system will operate.

Punched card equipment has helped to solve the problem. Most of the machines operate at fantastic speeds, consequently reports for management can be produced on a timely basis. A common example of this is a factory efficiency report. This report is intended to report the labor expended on each job and the standard hours applicable. By a division operation, the percentage of efficiency of each section can be ascertained. This type of report is most practical on a daily basis; the report for the preceding day should be on the factory manager's desk at 8:00 a.m. each morning. In this way he can analyze the previous day's activities and spot trouble areas. The activities are still fresh in everyone's minds, so that discussions can be held intelligently and the excuse, "I don't remember," just isn't valid. This reporting speed is common. It can be easily accomplished by a second shift operation in the punched card department. Second shift and even third shift operations are not unusual, because they have several advantages. One of these is, of course, faster reporting. Another is economy. IBM charges 50% of the primary shift rental for equipment *used* on another shift. Therefore, it is usually more economical to add another shift than to rent more equipment when the work load becomes too great for existing equipment.

Stepped-up reporting coupled with increasing volumes of data have certainly given impetus to the rapid rise of punched card data processing.

The last reason given for the existence of punched card data processing is certainly not the least, but was listed last because it envelopes a complete field in itself and will not be made a part of this book. It refers to the engineering and scientific requirements.

It is sufficient for our purposes here to point out that the huge punched card and computer departments which appear as an integral part of almost every scientific and engineering organization in the country stand as a dynamic tribute to the impact these fields have made on our subject.

In summary, the principal reasons for having punched card data processing have been stated as being:

The Clerical Worker Shortage
Increasing Volume of Data
Accuracy and Control
Economy
Better Report Schedules
Engineering and Scientific Applications

End of Chapter Questions

1. What is punched card data processing?
2. What is the purpose of punched card data processing?
3. What are the solutions to the clerical worker shortage problem?
4. Define the term *integrated data processing.*
5. What effect does automation have on systems?
6. What are some reasons, other than the clerical worker shortage, for the existence of punched card data processing?
7. How do the reactions of a machine to large volumes of data compare with those of a human?
8. What can be removed from the processing of data to make the results more accurate?
9. What is the first responsibility of the data processing department?
10. Will punched card equipment correct erroneous data appearing on source documents?
11. What factors have caused an increase in the cost of punched card equipment?
12. What have equipment manufacturers done to bring punched card data processing within the economic sphere of small companies?
13. What has been the effect of rising labor costs on mechanization?
14. What equipment rental policies make extra shift operations attractive? What effect does extra shift work have on schedules?

CHAPTER 2

History of Punched Card Data Processing

One of the major solutions to the paperwork problem has been the use of punched card equipment and the refinement of systems to adapt them to punched cards. This did not occur in a revolutionary manner; in fact, it has developed very slowly. Again the reason has been overemphasis of mechanization in the factory. Management just was not interested in devoting time and money to the paperwork problem. But they cannot be blamed too much: it is psychologically easier to spend money to *make* money rather than to spend money to *save* money.

Early Uses of Punched Card Equipment

The use of punched card equipment for data processing dates back to the year 1887. It was in that year that Dr. Herman Hollerith, a statistician employed by the United States Government, developed the first statistical machine operating on the principle of holes punched in cards.*

This was not the first device to employ punched cards to activate a machine, but it was the first one developed to record, compile and tabulate data.

The first successful machine to operate from punched cards was a textile loom invented in 1801 by a Frenchman named Joseph Marie Jacquard. This loom was capable of weaving beautiful intricate designs into cloth according to instructions given it by punched cards. The machine was not accepted at first; in fact, in Lyons, where Jacquard attempted to introduce it into general use, he was mobbed and his loom burned. Jacquard, not easily discouraged, managed to gain the interest of Napoleon. With the support of the government the loom soon became a tremendous success and, in 1840, a monument was erected to Jacquard on the exact spot where his first loom had been burned. This benevolence on the part of the people of Lyons is largely attributable to the prosperity that the Jacquard loom brought to Lyons. The French government was so grateful to Jacquard for his invention that it granted him a pension for life, and he was made chevalier of the Legion of Honor.

It would seem that the success of this first punched card machine and the

*In actuality, the first machine employed a piece of paper with holes punched according to a code similar to a player piano roll. However, this was soon found to be impractical and a standard-sized card was developed.

financial independence enjoyed by its inventor would have inspired the invention of punched card machines for other purposes. Such was not the case.

There was one attempt made by Professor Charles Babbage, English mathematician and scientific mechanician at Cambridge University. In 1882, he conceived the idea of a new type calculator (not by punched cards) which he called a "difference machine." Through the recommendation of the Royal Society he received a grant from the British government to work on his machine. After eight years' work, the eccentric genius abandoned the idea of the "difference machine" and turned his attention to a much more complicated "analytical engine" based on the punched card principle and patterned after the Jacquard loom. This switch alarmed the government, and it withdrew its support, thereby dooming the project to failure. Like so many others in history, Charles Babbage had the misfortune to be born 100 years ahead of his time. He was constantly plagued in trying to adapt his twentieth century ideas to the nineteenth century machines, materials and techniques. Babbage's "analytical engine," of which he made over 200 engineering drawings, would have operated very similar to today's electronic computers with stored programs and punched card input and output.

It was not until 1887, 86 years after the fabulous success of the Jacquard loom, that another successful punched card machine was developed. The compilation of the United States Census had grown into a monumental task, and it was obvious that the 1890 census could not be processed under existing systems. Dr. Herman Hollerith, who was working on the census, became interested in the problem and started inventing a machine. By 1887, he had developed a machine, very crude by today's standards, designed to record, compile and tabulate census data by the use of a punched paper tape. As a result of Dr. Hollerith's invention, the 1890 census was completed in one-fourth the time required for the 1880 census.

Development of Punched Card Equipment Companies

Dr. Hollerith organized the Tabulating Machine Company in 1896 to develop his machines for commercial sales. Railroads were among the first customers using the machine for compilation of freight statistics.

In the meantime, S. N. North, director of the Bureau of the Census, was still not completely satisfied, and desired better equipment to use in the 1910 census. Consequently, he selected James Powers, a little-known statistical engineer who had displayed some originality in ideas for processing masses of statistical data to develop a new system. Powers shrewdly obtained agreement to retain his right to patent any machine which he might develop.

In 1908, Powers patented his first punching machine. It was capable of punching a 20-column card and employed two previously unknown principles of operation which are still used on Powers' machines. These two principles are "simultaneous punching" and "metal to metal contact."

In "simultaneous punching," the operator keys in all of the information to be punched in the card, and then presses a key to cause all of the punching to be done simultaneously. This permits the operator to correct an error before the card is punched, a process not possible under the serial-punching principle whereby a column is punched each time a key is depressed.

"Metal to metal contact" is the positive contact of the punch dies with the stud which provides a high degree of accuracy in registration. These two principles of operation were so successful that as late as 1954 both were still being employed in all punching machines built by Remington-Rand.

These developments of Powers so pleased North that he had 300 punches, related sorters and tabulators installed for the 1910 census. The success of these machines encouraged Powers to start the Powers Accounting Machine Co. in 1911. William Lasher, Sr., was employed as design engineer and later assumed control of the company when Powers' health failed.

IBM Organization Formed

In the same year, 1911, the 15-year-old Tabulating Machine Co. organized by Dr. Herman Hollerith merged with the International Time Recording Co. of New York, and the Dayton Scale Co. The new company was called the Computing-Tabulating-Recording Co. In 1914, this company managed to attract a highly successful executive named Thomas J. Watson to manage the company. Ten years later, in 1924, the name of the company was changed to International Business Machines Corp.

In the meantime, a selling company called the Accounting and Tabulating Machine Corp. was organized to distribute the products of the Powers Accounting Machine Co. internationally. In 1913, a set of Powers machines was successfully demonstrated in Europe, and sales agencies were established immediately in several countries. Among these was the Accounting and Tabulating Corp. of Great Britain, Ltd.

One of the early users of Powers machines in Great Britain was the Prudential Assurance Co. Not wishing to become dependent upon a factory in America, the company purchased the patent, manufacturing and marketing rights of Powers machines in the British Empire. Thus, on January 1, 1919, the Accounting and Tabulating Corp. of Great Britain (forerunner of Power-Samas) separated from the Powers line (forerunner of Remington-Rand). The two companies wisely agreed to maintain a reciprocal exchange of patents and technical information.

During this same period another sales agency was operating in France to distribute Powers machines. This company was called SAMAS, the abbreviation for the company's full name, Societe Anonyme des Machines a Statistiques. In 1929, the French and British companies consolidated, becoming the Powers-Samas Accounting Machines, Ltd. In 1945, the Prudential Assurance Co. sold to Morgan, Grenfell and Co., Ltd., and Vickers, Ltd. In 1955, Powers-Samas became a wholly owned subsidiary of Vickers, Ltd. In 1958, the Powers-Samas Accounting Machine, Ltd., and the British Tabulating Machine Co. merged and organized the International Computers and Tabulators, Ltd. The Samas Punched Card Division of Underwood Corp. is the sales agency for this line of equipment in the United States and Canada.

Meanwhile, the American side of the Powers line merged with several other office supply companies in 1927 to form the Remington Rand Co. In 1955, Remington Rand merged with Sperry Gyroscope to form the Sperry-Rand Corp. The punched card equipment is marketed through the Remington Rand Univac Division of the Sperry-Rand Corp.

Over 100 years have now passed since Charles Babbage dreamed of an "analytical engine," and in 1944 another professor, Howard Aiken of Harvard, developed the automatic computer. In 1943, the Army became interested in computers and awarded a development contract to the University of Pennsylvania. Dr. John Mauchly, who had become interested in the possibilities of electronic computers for compiling weather data, and J. Presper Eckert, chief project engineer, completed an electronic digital computer in 1945. It was called the ENIAC (Electrical-Numerical Integrator and Computer). The ENIAC was delivered to the Army Ordnance at the Aberdeen Proving Ground, where it is still in operation.

In 1946, Eckert and Dr. Mauchly resigned from the University of Pennsylvania and set up their own company, which was purchased in 1950 by Remington Rand. Prior to this, in 1946, Remington Rand used a staff of engineers who had been involved in a guided missile project during the war to do research on electronic computers. They produced the "UNIVAC," which is probably the best known electronic computer to the general public.

In 1943, International Business Machines, the descendant of the Hollerith line, sold the Dayton Scale Division to the Hobart Manufacturing Co. In 1933, it acquired Electromatic Typewriters, Inc. In 1949, the IBM World Trade Corp. was organized as a wholly owned subsidiary to handle foreign business. Under Watson's wise leadership, the company's products spread to seventy-nine countries. Twenty-three manufacturing plants are located in 15 countries. Sales offices are maintained in virtually every principal city of the world. In 1958, the total income of IBM passed the one billion dollar mark. Thomas J. Watson placed tremendous emphasis on engineering and sales and, as a result, IBM became so powerful in the punched card equipment field that the U.S. Government began to eye it as a monopoly. The company was threatened by anti-trust suits. Thomas J. Watson, Jr., who took over the helm upon retirement of his father, wisely took actions to avoid being prosecuted. The IBM Service Bureau Division was split off and made a wholly owned subsidiary of IBM called the Service Bureau Corp. Service bureaus throughout the country were physically detached from the IBM office and moved into separate quarters, where they set up their own management and began to operate as separate businesses.

Other companies were encouraged and even assisted by IBM in entering into competition with them. This was especially true in the manufacturing of cards, control panels and wires.

IBM also sold the Time Recorder Division in 1959 to Simplex, in order that it might devote even more attention to the engineering of more and better punched card equipment and computers.

Great Growth Recorded by IBM

The gross income of IBM doubled every five years from 1940 to 1955. In 1955 it was not anticipated that it would be possible to double by 1960, because the income in 1955 had reached $560 million. Obviously, the larger income becomes, the more difficult it is to double. But IBM was not deterred by this mathema[illegible] phenomena, and its income skyrocketed over the one billion dollar [illegible] not five years, but *three* years.

With the record of IBM, it is little wonder that the name of Thomas J. Watson is legendary in the punched card field. A powerful executive with high moral standards and positive aggressiveness, he made the IBM trademark "THINK" famous throughout the world. By constant emphasis on the engineering of a better product and a dignified, positive approach in sales, he placed IBM in the envious position of several months', even years', backlog on orders. Waiting periods of six months have been, and still are, common from the time an order is received until the machine is delivered to the customer. During World War II, waiting periods of one, two and even three years were sometimes quoted, and some companies without any kind of defense priority just could not get a machine. This constant backlog obviously places IBM in a very favorable condition in its production plants. It would seem that the quotation of a long lead time would dampen their sales; however, this has not had any noticeable effect. Customers seem to be willing to wait to get IBM equipment, and the company has captured the lion's share of the conventional punched card equipment market.

Computers

IBM entered the electronic computer field all the way. The result was the IBM Type 701 electronic computer, which was a leader in large-scale electronic computers produced in quantity on a production line. IBM certainly had a great deal in its favor when electronic computers became popular. Its huge engineering staff was already highly skilled in the use of electronics and the development of punched card equipment. Electronic computers followed as a natural progression.

It is interesting to note that the advent of computers brought many new companies into the field. A good example is the Electrodata Division of Consolidated Electrodynamics Corp., which was organized in 1952. It grew from 30 to 300 employes in two years, when it was sold to Burroughs Corp. and expanded to 1800 employes by 1958. The Burroughs line of electronic computers, with the Type 205 and 220 in the foreground, now ranks in the top three with UNIVAC and IBM in computer sales. Other companies such as Minneapolis-Honeywell, General Electric, National Cash Register, Bendix, Philco, RCA, Royal McBee, Monroe Calculating Co., – are also involved in the engineering and production of electronic computers for data processing purposes.

Many of these companies obtained computer capability through government contracts for "special-purpose" type electronic equipment. In the process of engineering this equipment to serve a special purpose, they obtained experience in computer development and construction. It was only natural that this capability should be directed toward the lucrative "general-purpose" field, and many companies proceeded to organize data processing divisions to engineer and market both specific and general-purpose machines.

One of the problems encountered in the computer field is obsolescence. Technical advancements are being made so rapidly that most computers are obsolete by the time they are installed. A company must have sufficient capital to continue research for new and better hardware, production and sale of current models, and absorption of older models being replaced [illegible]urrent models in the field. If costs are cut in any of these areas, the compa[illegible]rely doomed.

Some of these computers have punched card input and output. Some have only punched tape or magnetic tape. Others have all three. Chapter XIV explains the basic principles of computers. But it is not the intent of this book to explore extensively the computer field, as this is a topic in itself. It is sufficient to say here that all punched card equipment manufacturers are also leaders in the electronic computer field, and that punched cards continue to be the most prevalent media for introducing data into computers.

Development of Machines

The first machines used by both Hollerith and Powers were very crude compared to today's high-speed equipment. There was one machine used to punch the cards and another one to sort them into the desired sequence. The third machine was a tabulator through which the cards were passed, but all it could do was add and print totals. The first sorters were vertical, but it soon became obvious that a change was necessary, as the operators complained of backaches from constant stooping to lift the cards out of the lower pockets. Consequently, horizontal sorters were introduced in 1912 which ran at the rate of 200 cards per minute (1,000 cards per minute sorters are in use today, and 2,000 cards per minute sorters have been announced).

These first machines were used chiefly for government work in statistical areas such as the Census Bureau, where large masses of data had to be tabulated for totals. The census reports were keypunched onto punched cards. The punched cards were then sorted to the desired sequence and passed through the tabulator for a total. They would then be sorted in another field of data and passed through the tabulator for totals of that field. The tabulator only printed the total, so it was necessary for the operator to write on the report the information being totaled.

In 1913, tabulators were developed which overcame this obstacle by printing the information being totaled as well as the total. "The "printing tabulator" opened the door for commercial applications. All of the printing on these early tabulators was of numbers, and it was not until ten years later that the alphabetical tabulator was introduced. This machine gave further impetus to commercial uses by its ability to print both alphabetical and numerical data.

A major disadvantage of the early machines was that they could only add. It was not until 1928 that a tabulator was developed which could subtract. In the 1930's, calculators capable of multiplying were introduced. Division posed a real problem to the engineers, and it was not until 1946 that a punched card calculator was announced which would divide. As these major breakthroughs were being scored, other auxiliary equipment was being developed, and all existing equipment was undergoing constant improvement in speed, accuracy and styling.

Electronics was developed in the 1940's. The electronic computer, introduced [illegible] was capable of internally transporting data at electronic speed [illegible]eously).

[illegible]tors came along in the 1950's and offered improvement over electron[illegible] [illegible]ey are m[illegible] [illegible]er and do not produce as much heat; consequently, [illegible] facilit[illegible] are [illegible] electronic equipment are not required
car[illegible] to[illegible]
w[illegible]

The growth of punched card data processing has been phenomenal. Inspired by two world wars and the tremendous demands which they created, the engineering of new and better equipment proceeded at a breakneck pace. Necessity drove the manufacturers to daring breakthroughs and, as we have already seen, the companies engaged in the field underwent many changes in management until today the manufacturers of punched card equipment stand with the great corporations of America.

The advancement of this field brought job opportunities of a higher level. High-caliber people are required to engineer, produce, sell and service this intricate equipment. In addition, the machines must be operated, and systems personnel are required to apply applications to the machines. A supervisor is required for each punched card data processing department in each company to coordinate all efforts and manage the department effectively.

The growth of this field can be appreciated by these figures, which represent the approximate number of punched card data processing management personnel employed during the years shown:

1947 – 10,000
1952 – 20,000
1957 – 35,000
1960 – 60,000

Terminology

A major problem encountered in the fantastic growth of this profession has been terminology. The scope of the profession has expanded extensively, and a much higher caliber of personnel is now required to manage and staff these operations. This has resulted in obsolete terminology which no longer is applicable to the type of effort being expended or to the types of organizations and capabilities of personnel.

The term *TAB* was once used to identify the department which consisted of punched card equipment. This term was probably appropriate because the early machines were capable of little else than the tabbing of statistics. These early *installations* (as they were usually called) were usually hidden away in the most obscure locations of the office area, and the Tab people seldom got out to mingle with others. Tab was considered a workhorse, and the opinions of the tab personnel were neither solicited nor expressed.

This was largely due to the fact that the people engaged in this type of work usually did not have sufficient background and were too busy in detail work to investigate the other functions of the company. This is not to imply that all tab people were incompetent. On the contrary, there have been many brilliant people engaged in this type of work. Generally speaking, however, the tab installation was considered to be a lesser function of the company.

Improved equipment, greater emphasis on systems, the clerical worker shortage and other reasons mentioned previously have resulted in an [illegible]n of this type of work. The opinions of tab personnel were once ignor[illegible] they are sought after. These people are expected to be systems expe[illegible] their sphere of activity reaches into every corner o[illegible] business [illegible] dustrial world.

The term *tab* just does not fit the [illegible] attempt to overcome this, the National Machine Accountants Association, an organization of managers and supervisors of punched card departments, publicized the term *machine accounting* to describe the profession. Personnel engaged in the functions of the machine accounting departments were labeled *machine accountants.*

This attempt met with a fair degree of success. Tab installations came to be known as machine accounting departments. Most people in business at least know what a machine accountant is. Even yet, however, the word *tab* hangs on. Habitually, the people in the field continue to use the term and, consequently, those outside the field use it too. The equipment manufacturers have been lax in their terminology. In fact, their continued use of inappropriate terms has been a deterrent to reform. If they had aggressively sponsored more appropriate terms to suit the technical growth of their products, the problem would be less acute. Such terms as *tab, accounting machines, electric accounting machines, installations,* etc., just do not have the proper depth and significance. Some of these terms are also in common use to describe much less complex equipment which is used in semi-mechanical systems and booking operations.

Search for an Adequate Term

Unfortunately, the term *machine accounting* also proved to be inadequate. The word *machine* is rather crude and derogatory; it certainly lends no dignity to the equipment used or to the personnel using it. The word *accounting* is too restrictive. It implies that only accounting operations are performed, which is untrue and misleading.

The National Machine Accountants Association was further confronted with the problem that their organization had become international in scope, so that the word *national* was no longer appropriate either. For these reasons, a movement was started to change the name to Data Processing Management Association.

Unfortunately, there was sufficient opposition to the movement to retard action for a time. In mid-1962, however, the progressive thinkers won out and the name was changed to Data Processing Management Association despite terminology confusion and the cost of replacing letterheads, envelopes, certificates, banners, awards, etc.

The term *data processing* came into general use with the growth of computers. Computer techniques were described as electronic data processing (EDP). People tend to associate data processing only with computers but actually, data processing was being performed for centuries before computers were invented. The handling and recording of facts by any type of system can be referred to as data processing. This even includes a strictly manual system.

Another term which has come into use to distinguish a system using some type of mechanical, electrical or electronic equipment to process data is *automated data processing* (ADP). This book is concerned with that phase of ADP utilizing punched card equipment which is designated as punched [illegible] processing. This term is certainly more descriptive of the type of [illegible] performed than the earlier terms *tabulating* and *machine accounting.*

It has the proper degree of professionalism and glamour that is essential to modern classifications.

Integrated data processing (IDP) is another popular term. IDP is used to describe the process whereby data is recorded at its source by some manual method, but is simultaneously captured in a machine language by means of punched cards or tapes. All subsequent processing of the data is performed on machines capable of reading the language in which the data is recorded.

Unfortunately, the terms *punched card data processing, integrated data processing,* and *automated data processing* are too long and cumbersome for general acceptance. Consequently, the shorter term *data processing* is being used in their place even though, strictly speaking, this term is much more inclusive. Frequently the term *data processing* will be used to describe that segment of information handling involved with the use of punched cards. Thus a data processing department is the department responsible for the processing of data and issuance of reports by the use of punched card equipment. The term *data processing department* is gaining rapid acceptance as the proper title for a punched card data processing department because it is more modern and more descriptive than the former terms of *tabulating department* and *machine accounting department.*

The terms *punched card accounting* and *machine accounting* are being reserved strictly for the identification of accounting functions using punched cards. Their use as an umbrella term for the over-all concept is fading.

Relationship of Data Processing Methods

The layman and student often find it difficult to make the transition in their thinking from manual systems to mechanization and automation. The processing of data by any system is fundamentally the same – only the methods are different.

To explain the relationship between the manual and the mechanical systems let us take the example of a retail store. The store is started by one man who does all the work himself. The records are skimpy, but he does record all of his expenditures and receipts. Each time a sale is made, he adds up the items on a piece of paper and collects the sum of the items from the customer who also receives a carbon copy of the sales slip. At the end of the day, the sales slips are added and balanced to the cash received for the day. Other records such as inventories and customers' charge accounts can also be posted. This recording has been done with paper and pencil, yet it is a form of data processing because it is the recording of facts about a business transaction.

Now let us assume that sales reach such a volume that manual recording is no longer adequate, so a cash register is installed. The sales clerk now keys in the price of each article being purchased, and the machine automatically records it on a tape. When the last item is recorded, the clerk hits a key causing the machine to take a total of all of the transactions. This is a form of automated data processing (ADP), because a mechanical or electrical device is being used to record data. The result is a faster and more accurate recording of sales and automatic totaling. A further refinement is the recording of the amount of money received from the customer and the automatic calculation of the amount of change to give the customer. At the end of the day, the total of all sales recorded is automatically calculated and printed for balancing with the cash in the register.

Another system, which is even more automated records the sale in a punched-hole form for processing on high-speed equipment. A cash register which has a device attached that punches a paper tape as the sale is recorded on the sales slip is used. Another attachment accepts credit cards and perforated tags so that data can be automatically recorded.

To illustrate, let us visualize a customer buying a dress in a large clothing store. The dress has a perforated Kimball or Dennison price tag attached to it which is punched with the price, department and class. The clerk inserts the tag in the recorder, and this data is automatically recorded on the sales slip and punched into a paper tape. The clerk then inserts the customer's credit card in the recorder, and the customer's account number is automatically recorded on the sales slip and the paper tape.

Other data can be manually inserted on the keyboard by the operator, and totals are automatic. All of this data is also recorded on the sales slip and the paper tape. At the end of the day, or even periodically during the day, the punched paper tape can be taken to the data processing department, where it is either automatically converted to punched cards or introduced directly into a computer system. All of the data about each sale has been recorded on these tapes in a machine language. Consequently, rapid processing of customer accounts, inventory and other retail applications is possible.

Obviously, the latter system has automated not only the recording of the sale, but also the updating of inventories and other data processing operations which follow. Note that in all of these systems a clerk is involved and a customer is buying and paying for or charging an article. The data is recorded and the customer is given a sales slip, and the recorded data is used to process the store's records. The same results have been accomplished, but the methods used are radically different. All of these systems could be classified as data processing because each system, including the manual one, was involved in the recording and processing of data. The fact that the methods of doing this are different does not alter the fact that they are data processing systems.

End of Chapter Questions

1. What was the first machine invented that employed the use of punched cards? What year was it invented? Who was the inventor?
2. Why did Charles Babbage fail to build the "analytical engine?"
3. Who invented the first successful punched card machine to process data? When? For what specific government task?
4. What was the first company organized to market punched card equipment commercially? Who organized it? What industry was the first customer?
5. What is "simultaneous punching?" Who originated the idea?
6. How did the Computing-Tabulating-Recording Co. come into being? What executive was placed in charge of this company in 1914? What

was the name of the company changed to in 1924?

7. What action was taken by the Prudential Assurance Co. to make it less dependent on American activities? What present-day company emerged from this action?
8. What companies market the Powers line of equipment today?
9. Who developed the automatic computer? When?
10. What electronic computer was developed by Mauchly and Eckert? Where is it used? What happened to the company they organized?
11. Who produced the UNIVAC?
12. What actions were taken by IBM to avoid anti-trust action?
13. What is the famous IBM trademark?
14. What is one of the major problems encountered by the many companies that have jumped into the manufacturing of computers?
15. What were some disadvantages of early tabulators?
16. In what year was the problem of dividing on a computer solved?
17. What are the advantages of electronics? of transistors?
18. Why has terminology been a major problem?
19. What is wrong with the term *Tab*? With the term *machine accounting*?
20. What is the relationship between the subject matter of this book and automated data processing?
21. Define integrated data processing.
22. Explain the relationship of manual, mechanical and automated data processing.

CHAPTER 3

Principles of Punched Card Data Processing

Problems in Processing Source Documents

The attempt to process business documents mechanically presents many problems. The most direct method would be to use each source document in its original state without converting it into a code or transcribing the data on it into another form. Ideal as this would seem to be, it is impossible for the following reasons:

1. Too many different document sizes and shapes.
2. Too many different transactions on a single document.
3. Too many different styles and methods of recording data on documents.

In order for documents to be processed by machines, it is imperative that they be at least similar in size, shape, and thickness. The problems of engineering a machine capable of feeding all of the various documents used by a company are obvious. It might be possible, however, to standardize the size of source documents if this were the only problem involved. Indeed, the task of standardizing throughout industry in order that machines could be used interchangeably by all companies would be tremendous, but it could be done. Some attempts have been made at this on individual types of source documents. An example of this is checks. Most checks written today fall within accepted dimensions, and high-speed machines have been developed to sort these checks at the banks. This shows that progress has been made, and if this were the only obstacle in the processing of source documents by machines, it might be possible to overcome it.

The second obstacle is more forbidding. One source document may contain several different transactions. This makes sorting and tabulating impossible by machines. For instance, let us consider a machinist who fills out a job time card each day to record the different jobs on which he works and the time spent on each job. Assume that he worked on Jobs A, B, and C during the day, spending four hours on job A, three hours on job B and one hour on job C. He would record three lines on his job time card and the total of the three would be eight hours.

If we desired a total by employe, it would be easy to obtain one from the source document, because all charges for each employe are on the same source document. Let us suppose, however, that totals are desired by job. Our machinist was just one of many employes throughout the company who worked on jobs A, B, and C. It is not possible to sort the source documents to job because our machinist's card would have to position in three different places at once. One logical solution to this problem is to write each transaction on a separate document but this might add so greatly to the volume of documents processed that it would be unwieldy.

The third obstacle is presented by the infinite number of characteristics in styles and methods used to record data on documents. If all documents could be typewritten, it would be possible to standardize on a block-type letter which could be machine sensed. However, it is neither economical nor practical to typewrite all documents. Some progress has been made in the development of machines that will read hand-written documents; however, a satisfactory product has not been achieved as yet.

The reading of data recorded on a source document is extremely important, because the machine is useless unless it can sense and "understand" the recorded data and perform desired operations with it. Even if a machine was developed which would feed all sizes and shapes of source documents at high speeds, and even if there were a separate document for each transaction, it would all be in vain unless the machine was capable of sensing the data recorded on the documents and possessed the "machine intelligence" to know what to do with it.

Punched Card Solves Problems

Much of the success of punched card data processing can be attributed to the fact that it has hurdled all three of these obstacles.

The size and shape of the document has been standardized. The document is a card measuring 7⅜ by 3¼ inches. These measurements and the thickness are held to very close tolerances in order that they can be machine processed at extremely high speeds. High quality pulp is used in their manufacture to prevent excessive expansion or contraction with temperature and humidity changes. See Figure 3, page 26.

Each transaction is recorded on a separate card. This permits the cards to be sorted and tabulated on any field of data. The recording of each transaction on a separate document is known as the *unit record principle*. Each transaction must be completely identified because it stands independently. This lack of relationship between transactions is difficult for the layman to understand because he relates transactions mentally. For instance, let us suppose that Part X is ordered on a purchase order. But, then a purchase order change notice is made to substitute Part Y for Part X. Under the manual system a person realizes the relationship of Part X to Part Y and mentally associates them. Under the unit record system, a card must be punched for Part X with all of the necessary data selected from the purchase order. This transaction now becomes a permanent record and must not be changed. When the purchase order change notice is received, another card is punched which is a duplicate of the original card for Part X, except that it is processed as a

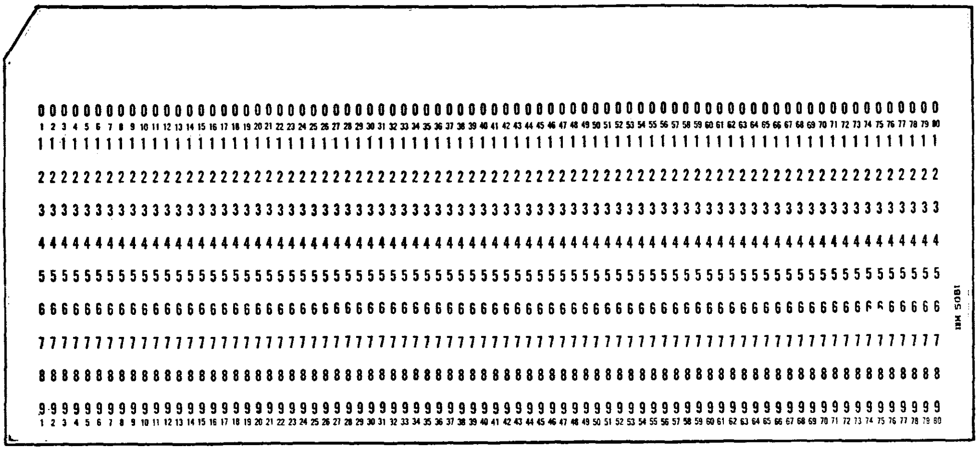


Figure 3—Standard Sized Document Used in Mechanization

credit or reverse entry which has the effect of nullifying the first card. Another card is now punched for Part Y. Thus three records are prepared, each completely independent of the others, but when sorted together by part number, the net effect will be to set up Part X with the first entry, credit it out with the second entry, and then set up Part Y with the third entry.

The last and major obstacle is overcome by a standardized method of recording data. This method is the *punched hole*. Holes punched in cards in a coded pattern are used instead of conventional methods of recording data, because of the ability of machines to read and understand them. Once a hole is recorded in a card, it becomes a *permanent record* and cannot be altered. If it is correct, it will be read by each machine through which the card is processed and properly recorded. If, however, the hole is incorrect, then the incorrect data will be recorded just as rapidly as though it were correct. Thus, it is absolutely essential that the data be correct on the source document and that it be correctly transcribed from the source document to the card.

Introduction to Machine Languages

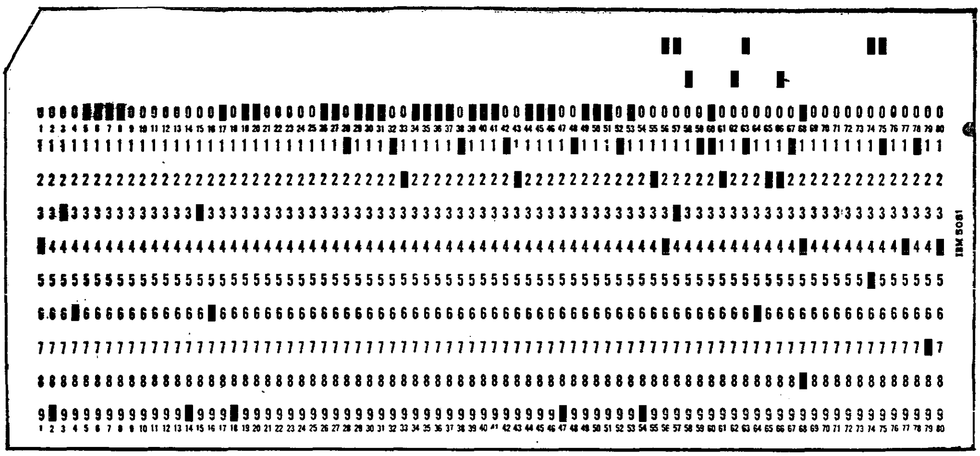
While all of the obstacles have been overcome, there is still a problem involved because a transcribing operation has been introduced. It is necessary to take the source documents and doggedly record, digit by digit, every iota of data needed from every source document. This is done by a process called *key punching*. However, an error may be made while key punching, so the transcription is completely repeated to assure a high degree of accuracy. This process is called *verifying*.

Key punching and verifying are very similar to typing. The operators are usually girls who read the source documents and "type" on a keyboard, except that a card is being punched instead of a sheet being typed. This transcription of data from source documents to the punched card form is the slowest process in the punched card system. Its importance is paramount for all that follows but is dependent upon the initial operation being performed to perfection.

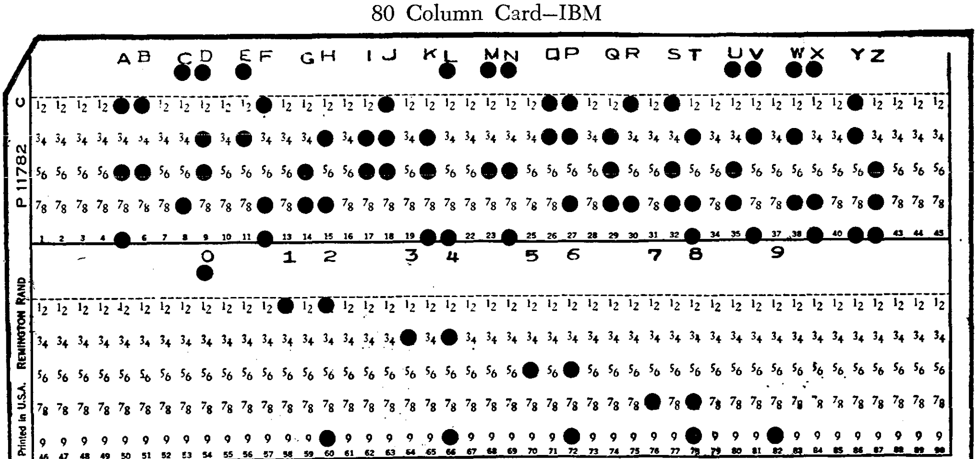
Once the data has been recorded in punched card form, all punched card machines can read it and be made to manipulate it in almost any fashion. The holes are punched in a coded pattern which can be called "machine language." The machines understand it just as you and I understand the English language, except they are much more proficient.

Let us look more closely at the punched card in order to comprehend this "machine language."

There are two types of punched cards in common use in the United States today. They are the IBM 80-column card and the Remington Rand 90-column card. See Figure 4. The IBM card has 80 vertical columns across the card, and the Remington Rand card has two rows of 45 vertical columns each for a total of 90 columns. Also, observe that the shape of the holes is different. The IBM holes are rectangular in shape and the Remington Rand holes are circular.



80 Column Card—IBM



90 Column Card—Remington Rand

Figure 4—Two Types of Cards Most Widely Used in the United States

The reason for this is the principle upon which the two different lines of equipment operate. The IBM line, which developed from the Hollerith machines, operates on the principle of electrical impulses passing from a contact roller to a wire brush through the holes in the cards. A rectangular hole is the most adaptable to provide good electrical contacts without shorting between columns.

Remington Rand, which descended from the Powers line of machines, uses a mechanical principle of small pins dropping through the holes to activate a series of levers. Round holes are best suited to provide access to the tiny pins.

The Samas line (also a descendant of the Powers line) uses round holes but features a smaller card of 40 columns which measures 4⅝ inches x 2 inches.

Both types of holes are adaptable to the electronic beam which is now being used as a reading device on the ultra-high speed equipment.

The IBM and Remington Rand lines vary considerably in the coding systems used to identify numbers, letters, and special characters.

IBM indicates a number by punching out the position for that number. In Figure 4, the numbers "49360000" are punched in columns 1 through 8. In Figure 5, the printing over the columns identifies the data punched in each column. The number "1" is punched in column 1; "2" in column 2; and so on. A numeric "0" (zero) is punched in column 10.

The Remington Rand coding system is shown in Figure 5a. Note the numbers printed over some of the columns on the lower half of the card. Column 54 has a zero punched in it. Column 58 contains a "1" which is indicated by a punch in the 12 row. Column 60 contains the coding for a "2" punch. It has the same 12 punch as a "1" but it also has a "9" position punch. Thus we see that the coding formula is for odd numbers to be indicated by one punch in the proper column and for even numbers to be indicated by two punches. A nine punch is used to designate an even number, except when it is the only punch in a column, at which time it designates the number "9."

The alphabetic coding is somewhat more complex. In the IBM system, a letter coding always consists of two punches in one column. This coding is in a definite pattern which makes it fairly easy to memorize. The card is composed of twelve horizontal rows. The top row is called the "12" row, the next row is called the "11" row (sometimes called "X" row because it is used for control "X" punching); the next row is the "0" row; and the other 9 rows are numbered 1 through 9. The three top rows of all 80 columns are called the "zone" portion of the card and the other nine rows are called the "numeric" portion of the card. Figure 5 portrays this division of the card by the horizontal line which has been drawn across it.

An *alphabetic character* requires one numeric punch and one zone punch in a column. Notice the pattern in Figure 5. The letters A-Z have been punched in columns 20 through 45. The "A" in column 20 has a "12" position punch and a "1" position punch. The "B" in column 21 has a "12" punch and a "2" position punch.

Note that the alphabet has been blocked into three groups, each of which is designated by a different zone punch. A "12" punch is used to indicate letters A-I, an "11" punch indicates J-R, and a "0" indicates S-Z.

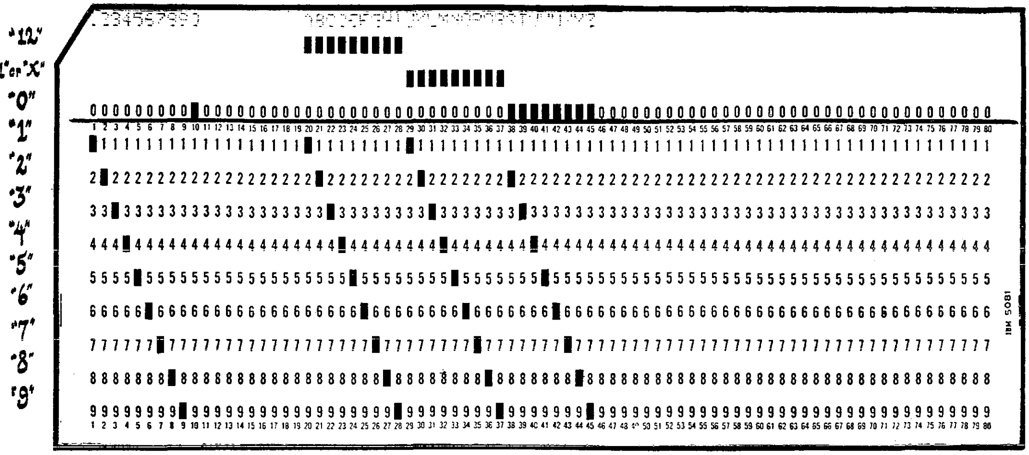


Figure 5—IBM Punched Hole Codes. Zone portion of card is above line; numeric portion below it. Names of the 12 horizontal rows are indicated at left.

IBM Alphabetic Coding Table

Letter	*Zone*	*Numeric*
A	12	1
B	12	2
C	12	3
D	12	4
E	12	5
F	12	6
G	12	7
H	12	8
I	12	9
J	11	1
K	11	2
L	11	3
M	11	4
N	11	5
O	11	6
P	11	7
Q	11	8
R	11	9
S	0	2
T	0	3
U	0	4
V	0	5
W	0	6
X	0	7
Y	0	8
Z	0	9

Since there are 27 possible combinations (three sets of nine each) and only

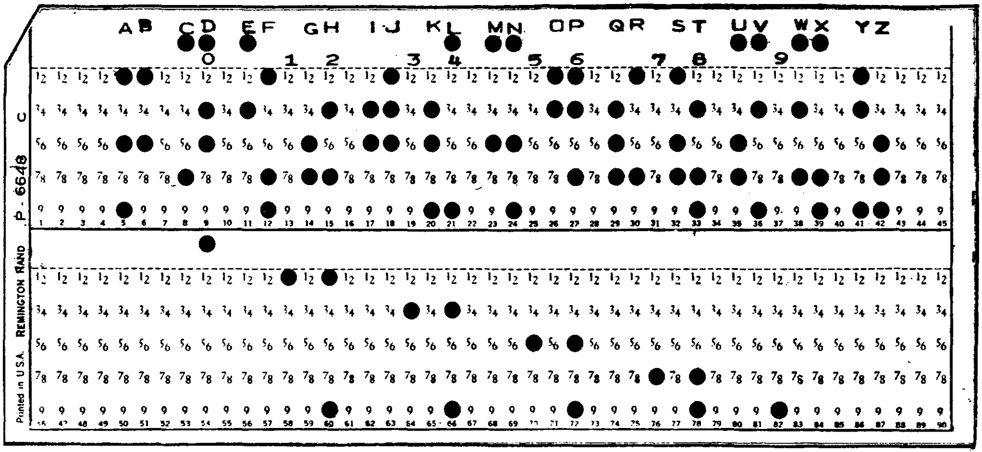


Figure 5a—Remington Rand Punched Hole Codes

26 letters in the alphabet, one combination must be omitted. That is why the 0 and 1 combination is not used for a letter.

The Remington Rand alphabetic coding is a combination of 2 or 3 punches in the same columns and does not follow a definite pattern, as can be seen on the top portion of the Remington Rand card in Figure 5.

IBM utilizes individual zone punches and combinations of numeric punches to indicate eleven different special characters as illustrated by this chart.

IBM Special Character Punching Chart

Character	*Zone Punch*	*Numeric Punch*
.	12	8 and 3
□	12	8 and 4
&	12	none
$	11	8 and 3
*	11	8 and 4
-	11	none
/	0	1
,	0	8 and 3
%	0	8 and 4
#	none	8 and 3
(a)	none	8 and 4

Assignment of Fields

The data must be punched into the card in a standardized manner so that corresponding data appears in the same card columns for each transaction. In order to accomplish this, the card must be divided into groups of columns each of which is used to record a single fact pertaining to the transaction. A group of columns reserved for the recording of a single fact is known as a *field.* In Figure 6, an IBM card is shown which is used for an accounts payable application. Observe that columns 12-16, are reserved for invoice data. Every card for this accounts payable application will have invoice date punched in card columns 12-16, and no other facts will ever be recorded in this field. All machines will be set to read invoice date from columns 12-16.

Standardization is vital because the machines do not think. If a key punch operator accidentally recorded invoice date in another field, the machines would not detect it. They are completely dependent upon invoice date being in exactly the same place on each and every accounts payable transaction card regardless of whether there are ten cards or ten million cards. In like manner, other facts about the transaction are grouped in fields across the card. Note the columns reserved for each fact in the card pictured in Figure 6. The fields used in each card form must be determined before cards are key punched. Since the number of columns is quite limited (80 on IBM cards and 90 on Remington Rand) it is important that the absolute minimum number of digits be allowed for each field, yet it is equally important that there be sufficient columns to accommodate the largest number of digits ever to be punched in that field. Certain fields will be of a set number of digits and no question will arise. If the employe number in a company is comprised of six digits, then a six-digit field must be used in every card which contains employe number.

The size of some other fields may not be so easy to determine. For instance, hours, dollars, quantity and amount fields are often quite difficult to determine. If quantity in an inventory control application were 1,000 or more, at least four digits must be reserved. This is sufficient to accommodate all figures up to and including 9999. If quantity could reach 10,000 or more, five digits must be reserved to accommodate all numbers up to and including 99,999. Whenever an application is being mechanized, the data processing people will press for answers to questions pertaining to the size of fields. They must conserve columns by establishing fields with the minimum number of columns in which to record the maximum number of digits. Columns must never be wasted.

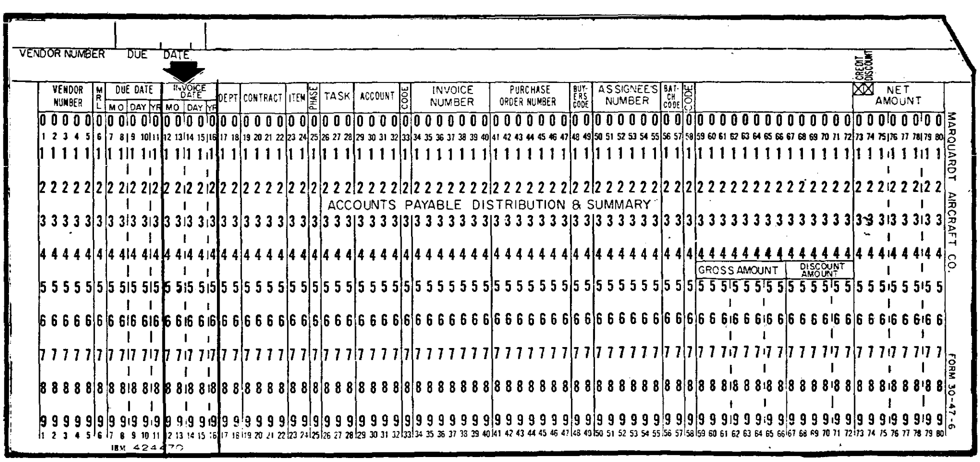


Figure 6—IBM Accounts Payable Card. The card is divided into fields. Each field is used to record a fact about the transaction.

The layout of the fields upon the card is relatively unimportant to the machines, because they are capable of reading facts from fields placed anywhere on the card with very few exceptions. Fields are normally laid out on a card to conform to the sequence in which they will appear on the source document from which they are keypunched. This allows the keypunch operator to find facts on the source document easily, as the card advances through the machine. It is very important to the speed and efficiency of the keypunch operation that the card layout of fields correspond closely to the sequence in which the facts appear on the source documents. It is equally important that the source documents be clearly written and that the data be properly recorded. *The keypunch operators should not be required to analyze source documents.* Their job is to record data from source documents into punched cards. This in itself is a slow operation and it becomes extremely expensive and inefficient if she must stop to analyze or hunt for data. She should be able to record each fact just as it is written on the source document. If she cannot do this, the department originating the document is not doing its job.

Some people seem to have the mistaken impression that mechanization is the way to clear up messy source documents. This is not true! The documents must be cleared up first and then mechanization can take place.

Recording of data from the source documents into punched-card form is the first of the four machine functions of punched card data processing. All of these functions will be explored in detail in the succeeding chapters. The four functions of punched card data processing are recording, classifying, calculating, and summarizing.

Once data has been captured in punched-card form, it can be processed and understood by all machines in that line. These machines operate at high speeds and with an extremely high degree of accuracy.

Basic Philosophy of Processing

Probably the most difficult thing for the layman to comprehend about punched card data processing is the basic philosophy of processing.

Under the manual system of processing, a clerk picks a fact about a transaction from a source document and records it. Each fact is analyzed, to a degree, as it is posted. If the same fact must be posted elsewhere, the operation is repeated. Each time the fact is needed, it is analyzed, posted and checked. Any error probably will not be repeated on all postings.

In punched card data processing, the transaction is handled *individually*, one time only. This is at the time the data is recorded into punched-card form by the keypunch operator and verified by the verifier operator. After this initial operation, the transaction is a card, buried in a deck with thousands of other transaction cards. The machine operators will sort these cards, calculate them, and prepare reports, but this will all be done according to a predetermined set of instructions for setting up machines and processing cards through them. He can be completely unaware of the significance of the data in the cards and still do his job. This is not to imply that a knowledge of the data is unnecessary because it can be extremely helpful. The point is that the philosophy of processing is not to work with the facts themselves as in the manual system but rather to process cards through machines according to a predetermined set of instructions called a procedure. The sheer volume of data processed by one operator precludes any type of individual transaction analysis. This is not expected of an operator because it would slow the system down too much. It is expected that the data has been audited before it is recorded in a permanent record form on punched cards.

It is well for the layman to clear his mind and be prepared to take a complete new approach to data processing. It becomes difficult to comprehend machine system peculiarities with manual concepts. Each condition must be examined in the light of what happens in the machine operation cycle, not the manual cycle.

Standardization is an absolute necessity. It is the most difficult thing to impress upon the layman because he is familiar with manual systems which can bend to accept almost any exception. This flexibility tends to make the manual system inefficient. In fact, standardization is recognized as one of the greatest advantages of mechanical systems. We have already seen that the source document must be standardized for ease of key punching. Facts must always be recorded on the document in exactly the same location so that they can be located quickly by the keypunch operator. All data must be recorded; nothing can be taken for granted regardless of how obvious it is to the person preparing the source document. Source documents must flow in a standard manner and on schedule in order that they can be scheduled into the data processing department.

End of Chapter Questions

1. What are the three major problems encountered in attempting to develop a machine that will process all business documents?
2. How has the punched card overcome each of these problems?
3. What is the *unit record principle?*
4. What is the standardized method of recording data in punched card data processing?
5. By what method is data inserted in cards? How is it checked?
6. What is "machine language?"
7. How many vertical columns in the IBM card? The Remington Rand card?
8. How do the IBM and Remington Rand principles differ in the shape of the holes in the card and in the methods of reading the holes?
9. Explain the language used for indicating numbers in the IBM line. In the Remington Rand line.
10. What is the zone portion of the IBM card? The numeric portion?
11. Explain the IBM principle of alphabetic punching.
12. What is a *field* in a card? How large should a field be?
13. In what sequence are fields usually assigned across a card?
14. Should keypunch operators be expected to analyze source documents or make corrections to them?
15. What are the four functions of punched card data processing?
16. Explain the punched card data processing philosophy of processing data.
17. Why is standardization necessary?

CHAPTER 4

The Recording Function

As stated in a previous chapter, a machine has not been developed which will accept the wide variety of source documents encountered in the business world today. Consequently, it is necessary to transcribe the data from the source document into a "machine language" form. In punched card data processing, the punched hole is the machine language. Any machine which punches holes in cards is performing the recording function.

Card Punching

The most significant machine used for this purpose is the card punch (usually called key punch). See Figure 8. To operate the machine, an operator depresses

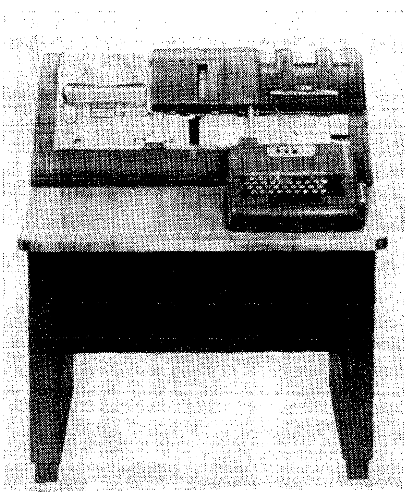


Figure 8—IBM Type 24 Card Punch *(Courtesy of International Business Machines Corporation)*

keys on a keyboard quite similar to that of a typewriter. The depression of a key causes the number, letter or symbol which that key represents to be punched into the card feeding through the machine. The card advances one column each time a key or the space bar is depressed just as the platen on a typewriter advances one space each time a key is depressed. Each time a transaction is recorded, the operator causes a card to be fed from the hopper into postion so that column 1 of the card is positioned under the punch dies (the machine can be set to do this automatically). The operator then proceeds to punch each position of each fact about the transaction into the desired columns of the card. If a field of the card is not to be punched, it can be spaced over or the machine can be programmed to skip automatically to the next column which is to be punched. After column 80 is passed, the

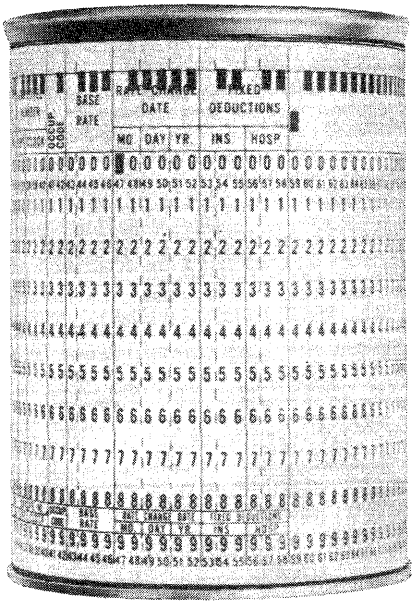


Figure 9—IBM 24 Program Drum *(Courtesy of International Business Machines Corporation)*

card ejects into the hopper. The keyboard is electric and built with the convenience of the operator in mind. A light touch to the keys will cause the punch to be activated. The keyboard is attached by a cable to the punch unit and can be positioned on the key-punch table to suit the operator. A unique program card device makes the machine about as automatic as such an operation could conceivably be. The program card is key punched with code numbers which tell the machine what to do as each column of the card passes the punch dies. See Figure 9. This card is punched at the time the application is being key punched. The program card is wrapped around a program drum and locked into position. The drum is inserted into the top of the machine where it is visible to the operator through a small window. Tiny starwheels ride along the card as it rotates. It moves one position each time a key or space bar is depressed and operates in unison with the card which is being punched. As the drum rotates, the starwheel drops into the holes punched into the program card. The drop of a starwheel acts as an instruction to the punch unit.

The most common instruction tells the machine to allow the operator to insert data into this column through the keyboard. Another instruction, which has already been mentioned, tells the machine to skip that column and there is another instruction that tells it to stop skipping. Consequently, any number of columns can be rapidly passed over and the card will position at the next column to be key punched. This is done by punching one code number in the program card in all columns that are not to be key punched and another code in the first column that must be punched, thereby causing the skip to stop at that column.

Duplicating is a very valuable function of this machine which greatly increases its productivity. Duplicating is the automatic punching of repetitive data from one transaction card into the following transaction cards. To illustrate this, visualize an operator about to key-punch labor distribution cards from a stock of job time cards. She knows that "date" is one of the fields which must be punched in every card, and she knows that all of the job time cards are for one date, "Jan. 2, 1960." This must be punched into the cards as 010260 in columns 70-75. (01 signifies January, 02 is the day and 60 is 1960). The program card can be set to cause the machine to duplicate columns 70-75. The duplicating function is under the control of a switch on the keyboard which takes precedence over the program card. The operator turns the *duplicating switch* off with her left hand to prevent the machine from duplicating the date field and punches the first card completely. She then turns the switch on and proceeds to punch the second card. The machine is set to duplicate columns 70-75, so when column 70 is reached the machine automatically reads the punch in the first card (which is now at the read station) in column 70 and punches the same thing into column 70 of the second card. This is repeated for each column until column 76 is reached,

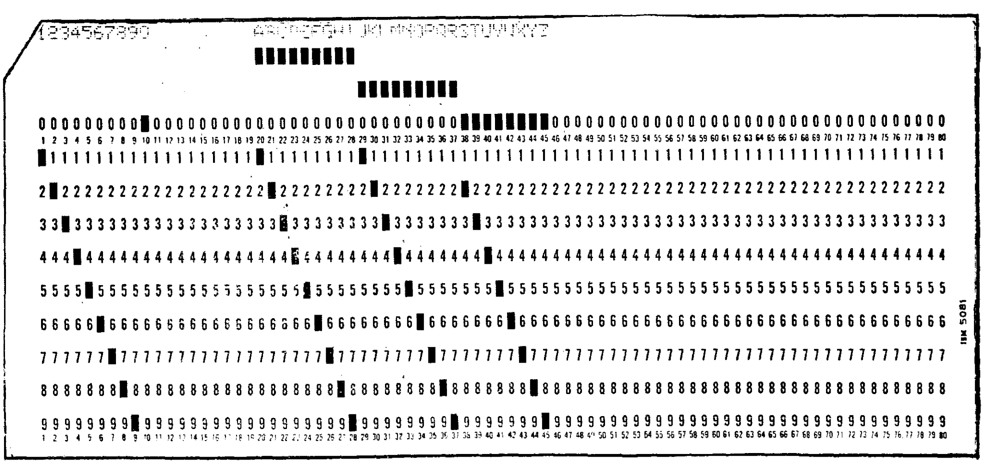


Figure 10—IBM Type 026 Printing Punch. Data is printed directly over column in which it is punched.

at which time the program card has another instruction which stops the duplicating. Duplicating is exceedingly fast (much faster than an operator can keypunch) and greatly speeds up the recording operation.

The characteristics described are those of the card punch in most common use today, the IBM Type 24. Other punches have similar characteristics. One punch, the IBM Type 26, operates like a Type 24 card punch, except that it has a printing device which prints the data punched in the card along the top edge of the card directly over the columns in which it is punched. See Figure 10.

The Remington Rand punch differs in operation in that it utilizes the "simultaneous punching" principle. On this punch, the columns are not punched as the keys are depressed. Instead, the dies are set up by the depression of the keys and when *all* data to be punched in the card has been recorded on the keyboard, a key is depressed which causes all columns of the card to be punched simultaneously. If she realizes that she has made an error, this system allows the operator to make a correction without spoiling a card or punching any other data.

Factors for Consideration in Key Punch Time

In computing time requirements to key punch transaction cards on the IBM Type 24 card punch, the average figure of 10,000 key strokes per hour is commonly used. This means that if the average number of columns to be punched per transaction is 50, the operator will punch 200 cards per hour.

Because a great many factors affect the speed of key punching, the figure of 10,000 key strokes per hour should not be used arbitrarily without analyzing these factors. The condition of the source documents will affect the speed of punching. Neat, well-written data can be read faster and requires fewer inquiries. Poor handwriting and written-over figures slow down the process and breed errors. Delay will also be caused if the document is not laid out in the same manner as the fields in the card. Whenever an operator has to skip around visually over a source document rather than punch data as she comes to it, her efficiency will go down. Alphabetic punching, that is, the punching of alphabetic characters, is slower than the punching of numeric data. Intermingled alphabetic characters, numeric data and special characters are the most difficult to punch and greatly decrease the speed of the operation.

Another factor to consider is the volume. A large volume can be punched on a faster average time per card basis because there is less set-up time involved and the operator gains speed as she becomes familiar with the job. A series of short duration jobs requires more setup time on the part of the operator. This includes finding the proper program card and inserting it on the program drum. She then begins to punch and is just getting accustomed to the job and beginning to pick up speed when she is finished. On a large volume job, there is only setup involved; the operator has time to become accustomed to the procedure and can pick up speed until she is punching at maximum efficiency.

A final factor, but an all-important one to be considered, is the experience of the operator doing the work. A new operator will be slower and make more errors than an experienced operator. Obviously, the computation of time required to keypunch a job requires careful analysis and should be done only by persons experienced in the field and familiar with the capabilities of the operators who will perform the work.

Assuming that a keypunch operator will punch 10,000 columns per hour on a given job, it follows that she will punch approximately 80,000 columns of data per day. This is 80,000 chances for error. If her error factor is only one hundredth of one per cent, eight errors will be made and inserted into the mechanized system. As infinitisimal as this error factor seems to be, eight errors a day would create havoc. Most operators have a much higher error factor than this. Therefore, it is obvious that a checking operation must be provided to assure the purity of data entering the system.

It is very important that all errors be caught and corrected at this point, because once data is incorrectly entered into the system, it is more difficult and costly to correct them.

Verifying

The function used to check the accuracy of the keypunching is called *verifying*. The verifier is a machine which looks and operates almost exactly like a card punch except that it does not punch holes in a card. The verifier operator performs every operation that the key-punch operator performed. Every column of data is repeated. It is a 100% duplication of effort. As the verifier operator depresses a key, the machine senses the hole punched in that column of the card and compares the two impulses. If they are the same, the keypunch operator and the verifier operator are in agreement concerning the digit to be recorded in that column and it advances the card to the next column. If the two impulses are not in agreement, the machine stops and a red light flashes on. The verifier operator rechecks the data and depresses the key again. She may have made an error the first time; consequently, she is given an opportunity to check herself. Continued disagreement indicates a keypunch error, and the machine places a notch over the column in error. The verifier operator checks the transaction in error on the document and marks it so that the keypunch operator can punch a new card to replace the card punched in error. If there are no errors in the card, the machine notches the right edge of the card as it is ejected, indicating that it is correct.

Every card released by the keypunch section must be notched at the right edge to indicate verification. This verification operation practically doubles the time required to record data in punched-card form, but the high degree of accuracy makes it well worthwhile. The only way that an error can get through is for two operators to make exactly the same mistake. Of course, it can happen and does, but it is highly unlikely if both the keypunch and verification operations are properly performed. It is not perfect but is about as close to perfect accuracy as it is possible for a transcribing system to be.

Example: Let us assume that job time cards are being keypunched and verified. The job number field is in card columns 15-20 and the hours worked are to be punched in card columns 21-23, column 21 and 22 being reserved for whole hours and column 23 for tenths of an hour. A specific job time card has one entry recorded on it as follows: job number 785461, hours 7.6. The keypunch operator should punch "785461" in card columns 15-20 and "076" in card columns 21-23. Let us assume, however, that she punches "795461" in columns 15-20 and "076" in columns 21-23. An error has been made in card column 16.

The verifier operator will repeat the same operations when she gets to this card, but when she depresses the "8" key for card column 16, the machine will stop, indicating an error. A notch will be placed over column 16 and the verifier operator will pass this card along with any other cards in error back to the keypunch operator for correction, after which she will again verify them so that eventually all cards have a notch at the right end.

If the verifier operator had made an identical error on card column 16, the error would not have been detected. The possibility of this is rather remote. It is most likely to occur when documents are poorly written. If a five is written

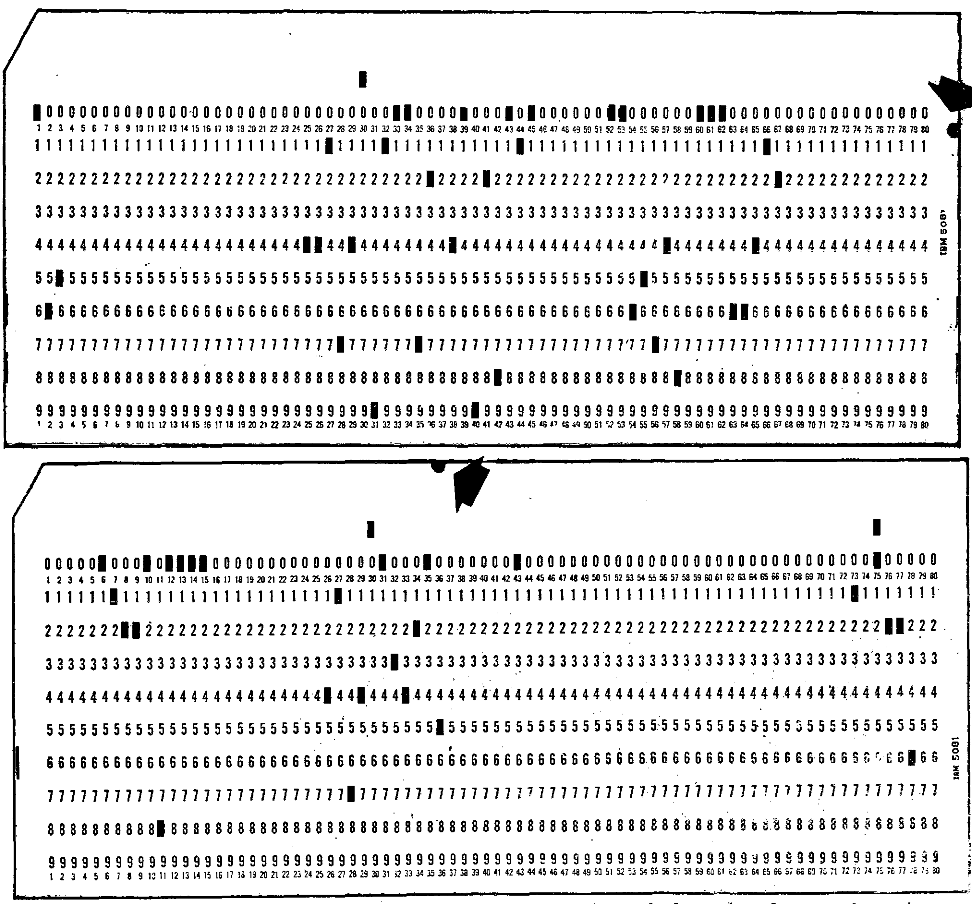


Figure 11—Use of Notches. Notch at right end of verified card indicates that all punches in card are correct. Notch over column 36 indicates that the "5" punched in that column is incorrect.

to look like a three, as some people are prone to do, both operators may read it incorrectly. But this is really not their fault, because it represents a flaw in the preparation of documents rather than in the recording operation. See Figure 11, page 39.

The system just described is that used by an IBM Type 56 verifier. Remington Rand utilizes another system whereby the same machine is used for both operations. A round hole is punched on the punching operation, and when the verifier operator is ready to verify, she sets a switch on the card punch which causes a hole to be punched slightly off center. After a column has been punched and verified, an oblong hole is present rather than a round hole. If the column is in error, there will be two round punches in the same column. The cards are then taken to another machine, which operates at a very high rate of speed and selects the cards which have round punches rather than oblong punches in any column.

This system has the advantage of being able to use the same machine for either punching or verifying. It has the disadvantage of requiring another operation and another machine to select erroneous cards. However, this is a very fast, economical operation. Another disadvantage is that when a card is selected with an error in it, the entry on the source document must be found in order that the proper punch can be determined. Searching for a particular transaction buried in documents that are not filed in any sequence can be quite time-consuming.

Both systems accomplish the same result and assure an extremely high rate of accuracy.

Reproducer

Another machine used to perform the recording function is the reproducing punch. See Figure 12. This machine does not have a keyboard but is directed by a control panel which is wired to give the machine instructions for each application. This machine will perform several operations. One of the most common is called *reproducing*.

There are two feed hoppers on the IBM Type 514 reproducing punch, which is in common use. There are also two stackers which receive the cards from the hoppers. The cards from the hopper on the left feed into the stacker on the left and the cards from the hopper on the right feed into the stacker on the right. In the reproducing operation, data is copied from one deck of cards into another deck of cards. The cards from which the data is to be read are placed in the left-hand hopper (called the read feed). The cards to be punched are placed in the right-hand hopper (called the punch feed). The control panel is wired to cause the machine to read the data punched in certain columns of the cards in the read side and punch the same data into the corresponding cards in the punch feed.

For an example of this operation, let us assume that we have one deck (Deck A) of punched cards which represents the hours worked by each employe in the company the past week. In another deck (Deck B) the hourly rate of each employe is punched. We desire to put the hourly rate of each employe into the corresponding card in Deck A for that employee. Deck B is inserted in the read feed. Deck A is inserted in the punch feed. A control panel is wired to read the rate columns punched in Deck B and cause the same data to be punched in the desired columns of Deck A. The control panel is inserted in the reproducing punch and the start key is depressed. Decks A and B feed one card at a time in unison until all cards have moved from the hopper to the stackers. Deck A now has the hourly rate punched on every card.

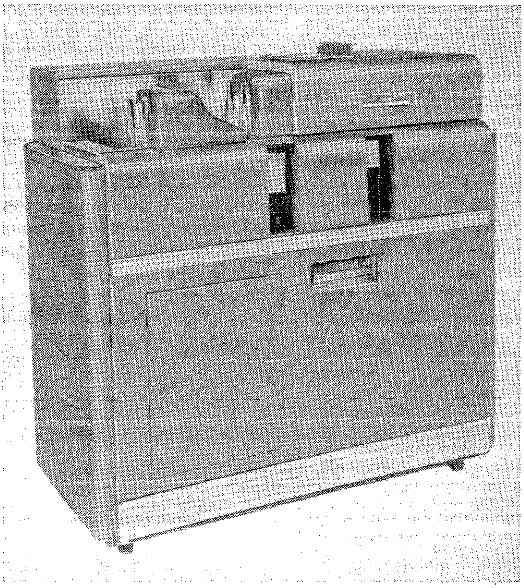


Figure 12—IBM 514 Reproducing Punch *(Courtesy of International Business Machines Corporation)*

This is an example of reproducing only one field; however, it is very flexible and the whole card can be reproduced if desired. When an exact copy of an existing deck is to be made, the control panel is wired to reproduce columns 1-80 of the punched decks in the read feed into columns 1-80 of a blank deck inserted in the punch hopper. This is referred to as an "80-80" reproduction and is quite common. A permanently wired panel is usually kept in the punch card data processing department for this purpose.

In reproducing from one field into another field, any column in the read-feed deck can be reproduced into any column of the punch-feed deck. The data punched in column 1 can be reproduced into column 80 or any other column. Regardless of what type of reproduction is performed, the data punched in the deck in the read side remains unchanged. Since this machine performs a recording function, it is important that the data be accurately recorded. To assume complete accuracy, comparing units have been built into the reproducing punch which compare the data in the original deck with the data reproduced into the deck in the punch side. If the punches in the two cards do not agree, the machine stops, a light flashes on, and an indicator falls down and points to the number on a scale which indicates the column in error. The operator can then remove the cards from the stackers, determine the error, and make the necessary correction.

In order to accomplish this dual operation of punching and comparing, two stations are necessary in each feed. The first station in the read feed is composed of 80 brushes (one for each card column) which ride on a contact roller carrying an electrical impulse. See Figure 14. The corresponding station in the punch feed is composed of 80 punch dies (one for each column of the card) which cause a hole to be punched in the card when impulsed from the read brushes. See Figure 15. The second station in the read feed is composed of 80 brushes riding on a contact roller. The second station of the punch feed is also 80 brushes riding on a contact roller. These brushes can be used to read the data which was punched on the preceding cycle and impulse the comparing magnets to compare it with the data on the card at the second station in the read feed.

Figure 16 is a schematic of a wire brush and a contact roller with a card being fed. Notice that the card acts as an insulator so that no current passes from the roller into the brush. Figure 17 is a different view which shows the brush making contact with the roller as it drops through a hole in the card. Note that current is constantly feeding into the contact roller but only gets to the brush to complete the circuit when a hole appears in the card. Figure 14 shows the cards feeding from the hopper on the read side of the reproducing punch. On the first card cycle, they pass through the first station of 80 brushes. On the second cycle, they pass the second station of 80 brushes, and on the

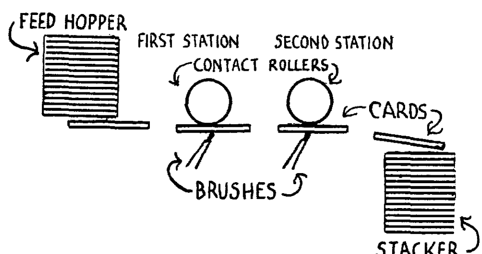


Figure 14—Read Feed of Reproducer

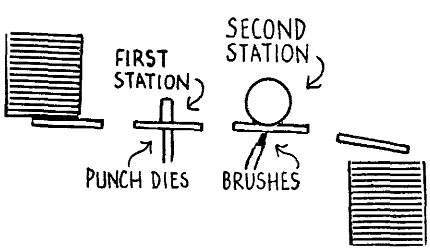


Figure 15—Punch Feed of Reproducer

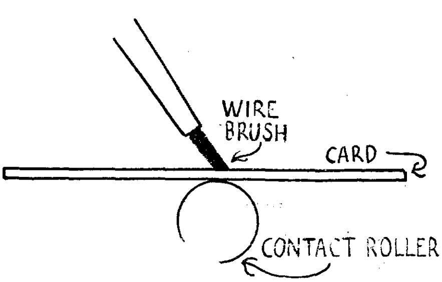


Figure 16—Card Between Brush and Contact

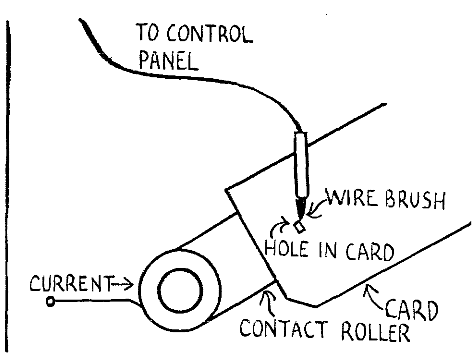


Figure 17—Brush Making Contact Through Hole

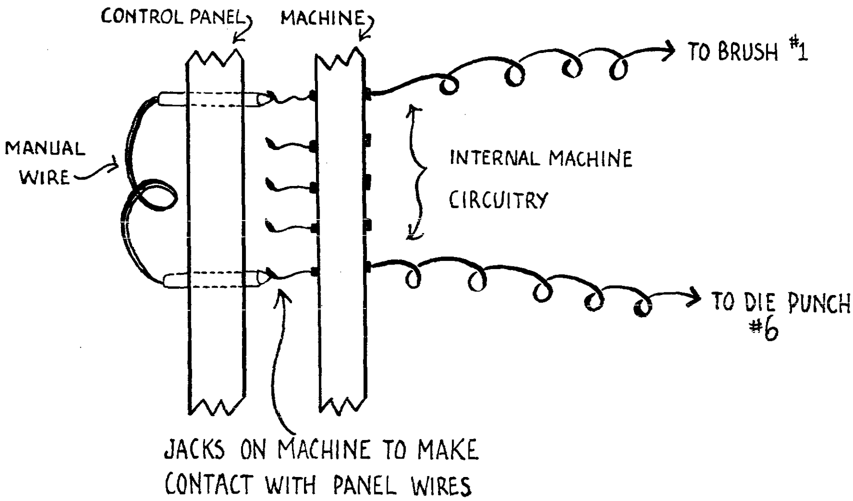


Figure 18—Circuit Completed Between Control Panel and Machine

third cycle, they drop into the stacker. As they pass the reading stations, the 80 brushes are dropping into the holes punched in each column and electrical impulses are available.

These brushes are each connected by internal wiring to hubs which make contact with the control panel. By manual wiring on the control panel, these impulses can be directed to other hubs. For instance, if column 1 of the card at the first station in the read feed has a 5 punched in it, that 5 impulse is carried to the contact hub representing column 1 on the control panel by internal wiring. If column 1 is wired to punch die 6 on the panel, the 5 impulse will flow through this wire and be carried back up to punch die 6 at the first station on the punch feed, causing it to punch a 5 in column 6.

Figure 18 shows how the circuit is completed from read brush 1 to punch die 6 by means of internal wiring, contacts, and external wiring.

It is not the intent of this book to delve into the technical aspects of punched card data processing. However, an understanding of certain principles is required for the layman to grasp the fundamentals of punched card data processing.

The basic principle of wiring is quite simple; it is merely the completion of an electrical circuit, just as switching on a light is the completion of an electrical circuit. Basic wiring can be ridiculously simple, but wiring in its most complex state can present extremely challenging problems and require a high degree of skill and several years' experience.

Control panel wiring is of such a technical nature that it should be performed only by experienced personnel. People not directly employed in data processing should certainly never tamper with control panels or do any wiring unless they have been authorized to do so by the manager of the data processing department. Even personnel who are employed in the data processing department must be very careful, especially in changing control panels which are permanently wired. The safest rule to follow by all personnel is never to tamper with a permanently wired panel unless specifically authorized to do so.

It is sufficient for personnel outside of data processing to have an understanding of the basic concepts of wiring. Intensive exploration into this phase will be of little benefit to them unless they intend to pursue it to the point of securing a position in data processing.

The reproducing punch can perform other recording functions. One of these is known as *gang punching*. Gang punching is the recording of data from one card onto the card or cards following it. Strangely enough, the reproducing punch on this operation performs as though it were two separate machines. One machine does the punching, the other checks to see that the punching was done correctly. The *punching machine* is composed of the punch hopper, punch dies, reading brushes and punch stacker. These are at the right when facing the machine. The *checking machine* is composed of the read feed, comparing brushes, read brushes and read hopper, which are located at the left as one faces the reproducing punch.

The cards are first passed through the punch side. They are then removed from the punch stacker and placed in the read feed. The machine will simultaneously perform punching and reading operations.

An Example of Gang Punching Utility

Let us assume that we have a deck of cards representing the transactions chargeable to one account and we wish to insert the account number into all of the transaction cards. (This operation could be performed on the card punch by duplicating, but gang punching is faster and does not require a separate verifying operation.) The account number is punched into a blank card on the card punch, and this card is placed in front of the transaction deck, which is then placed in the punch hopper. The control panel is wired to read data from the cards as they pass the second station of the punch side and direct these impulses back to the first station, which contains the punch dies. The data is thus punched into the second card, and on the next card cycle that card moves to the first station and the next card moves under the punch dies. In this manner the data is carried back from card to card. The last card on the deck can be visually examined and, if it is punched the same as the first card, all intervening cards must be correct.

Note that the machine does not memorize the number that is to be punched in each card. It merely reads from one card to the card which follows it. Only two cards are being acted upon by the punch feed at one time. The first card is being read and the second card is being punched with the data which was read from the first card. The machine then feeds another card cycle. The card being punched at the last cycle is now the card being read, and another card is at the punch dies. The original read station card has now dropped into the stacker.

This operation is very similar to an operation on the card punch which was discussed earlier: duplicating. Gang punching is much faster than duplicating, and more adaptable to a deck of cards.

A variation of gang punching occurs when cards (called masters) are interspersed throughout the deck and the data being gang punched is changed at each master card. To explain this, let us again take the example of punching hourly rate from an employe master card into labor distribution cards for each employe. In the reproducing operation, there was one employe master card for each labor distribution card. But, if there are several labor distribution cards for each employe, the reproducing operation is no longer feasible. An operation called *interspersed gang punching* can be used.

In this operation, the master card for each employe is placed in front of the labor distribution cards for each employe. The master cards are thus interspersed throughout the labor distribution deck. The cards can now be fed through the punch feed with the control panel wired in such a way that the masters will not be punched. Each time a master card (which contains an X punch in a certain column) passes the first station, punching is suspended; on the next cycle the master is at the second station and the hourly rate punched in it is carried back into the card at the first station. Thus, a whole series of gang punch operations are performed one after the other, each one punching different data. See Figure 19.

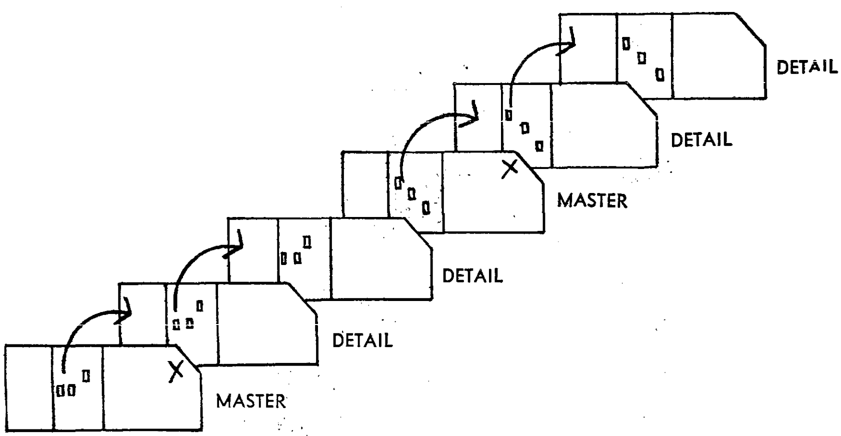


Figure 19—Interspersed Gang Punching

It is not possible to check this operation by looking at the last card, because the last card of the deck bears no relationship to the first card, as it does in straight gang punching. In order to verify interspersed gang punching the read side of the reproducing punch can be used.

After the cards are punched, they are removed from the punch stacker and placed in the read hopper. The panel is wired so that the card at station 1 is compared with the card at station 2. If they are not the same on the fields being compared, the machine stops, a light comes on and a pointer indicates the column in error. The panel is wired to suspend comparing whenever a master card is at the first station.

Master cards must all have a common "X" in a certain column or the other cards (details) may have a common "X" which can be used to tell the machine to punch or not to punch and to compare or not compare. Other columns besides those punched can be compared. The masters in the example would have the same employe number as the details which follow them. The columns in which an employe number is punched could also be compared to insure that the masters were in front of the details for the same employe number. The checking operation can be done while other cards are being punched on the punch side, because the two sides are unrelated when the panel is wired to gang punch. They act as two separate machines and have no relationship as they do during a reproducing operation.

The reproducing punch just described is the IBM Type 514. There are several other similar punches in common use, each of which performs certain basic operations. Many have special devices. A common special device is the *digit emitter,* which is installed on the punch and permits the operator to punch a given number into a group of cards by means of control panel wiring.

For instance, let us suppose that the labor distribution cards for a week's labor are needed to prepare labor distribution reports. The same data is also needed in performance reports showing standard hours versus actual hours expended on each job. Since the deck of labor distribution cards is needed in two places at the same time, another deck can be reproduced. In reproducing the duplicate deck for performance, it is possible to place an identifying punch such as an "X" in column 80 in the new deck at the same time that it is being reproduced.

Other data, such as the week-ending date, can also be punched in by using the digit emitter. Actually, the same thing can be done by gang punching these particular columns, but this requires that a card be punched with the desired data and placed in front of the deck. The use of the digit emitter is much more convenient.

Note that the Reproducing Punch is quite flexible. It can perform several operations on the same cards simultaneously. For instance, one could repro-

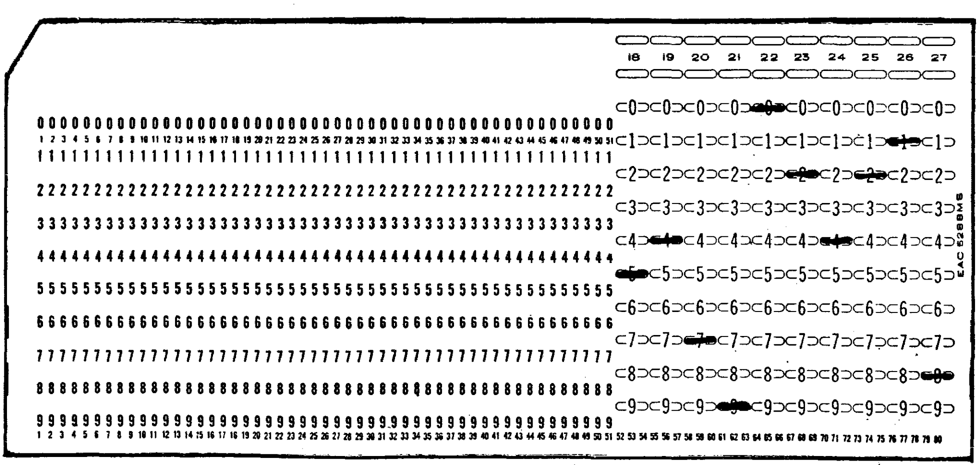


Figure 20—Mark Sensed Card. This card has been mark sensed with the numbers "5479024218." This number can be punched into a field of the same card by passing it through the document originating machine. No key punching is necessary.

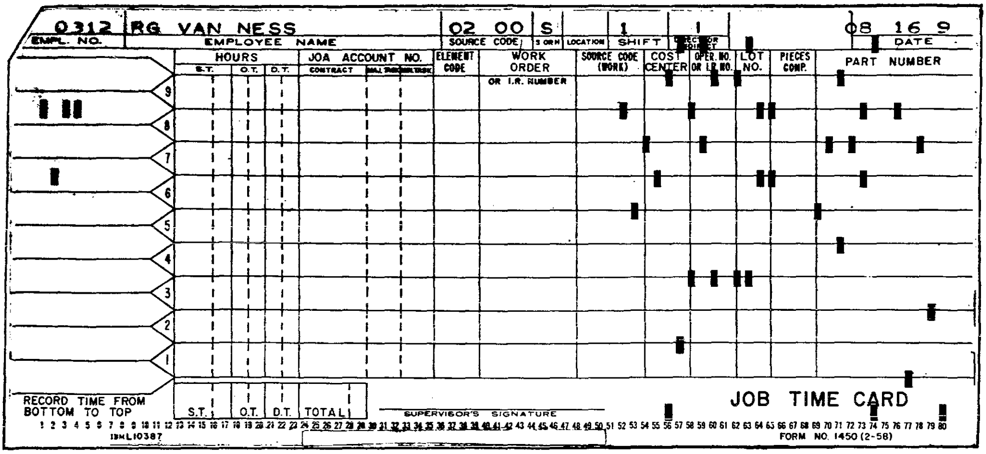


Figure 21—IBM Type 552 Interpreter Printing. Job time cards are prepunched and distributed to all direct workers in the company each day to be used to record their time spent on each job. The IBM 552 Interpreter is used to print the top line with the data that is punched in the card so that it can be read by human beings.

duce columns 1-40, gang punch columns 41-79, and emit an "X" in column 80 at the same time.

Another special device is for *mark-sensed punching*. This device is used to punch data in cards in accordance with marks made on the card. See Figure 20. This operation is attractive because it eliminates the key punching and verifying operation. The card is used as a source document, and data is punched in it also. A card serving these dual functions is called a *dual card*.

The marks must be made on the card in certain specific spots and with a special pencil containing electrographic lead, which is a conductor of electricity. Unfortunately, the marks must be made so precisely that the operation is extremely delicate. The punching device can be used successfully, however, when a limited number of trained people are doing the mark sensing and a relatively few columns of data are being mark sensed.

Recording speeds on the reproducing punch are about 100 cards per minute, depending on the type of punch used. The number of columns being punched has no bearing on the speed, as all 80 columns are punched simultaneously by punch dies.

Interpreting is the recording of data punched in the card along the top edge of the card. We have already observed that the IBM Type 26 Card Punch will perform this function at the time the cards are being punched. There are many operations where the data punched in cards must be read by laymen or file clerks. These decks are often made on the reproducing punch. Job time cards are usually reproduced from a master employe deck and sent to the employes for the recording of their time on each job. They must be interpreted because they are handled by many people. See Figure 21.

The IBM Type 552 interpreter is in common use. The machine is very simple and will do little else except print data across the top of the card. There is an inconsistency in the IBM line between the IBM Type 26 printing and the Type 552 interpreter printing, as they have different-sized characters; consequently, all the cards in a deck must be printed on one machine or the other. It is not practical to mingle the two. The 26 has a matrix unit which prints 80 characters (one over each column) across the top of the card. See Figure 10. The interpreter only prints 60 characters per line but can be printed on two lines.

This machine is slow – about 60 cards per minute and, if two lines are to be printed, the cards must be passed through the machine twice.

A greatly improved interpreter, the IBM Type 557, has been introduced which will print twelve lines on a card and can be used for punched-card check preparation and certain posting operations.

Transfer Posting

Historical records of transactions are sometimes required. An example of this is in an inventory control application where a stock ledger card is maintained for each part. The stock ledger card is posted with all of the transactions for that part each day, thereby affording a historical record of transactions in chronological sequence. Under the manual system, transactions are hand posted to a Kardex record or some similar document.

Under mechanical systems, all of the transactions are keypunched. These transaction cards are then merged with previous balance cards for those parts that have activity, and a transaction register is prepared on transfer posting continuous form paper with a carbon backing. A new balance card is summarized for the card file at the same time. The transaction register is then sent to the inventory control office where the transfer posting machine is located. It is threaded into this machine and a clerk pulls the proper stock ledger card for each part that has activity, inserts it into the machine and pushes a lever

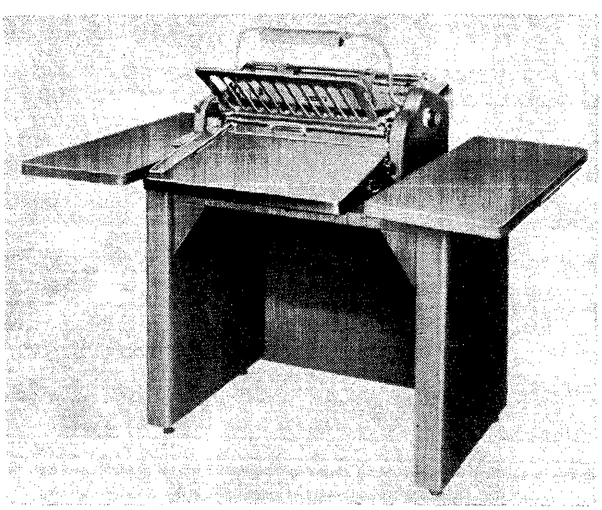


Figure 23—IBM 954 Facsimile Posting Machine

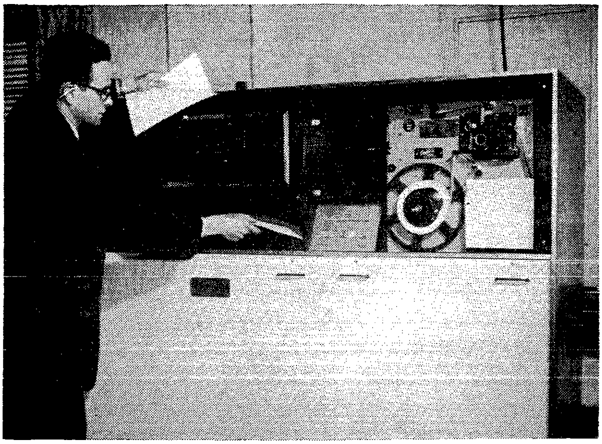


Figure 23a—Farrington Optical Page Scanner *(Reprinted from "Business Automation".)*

which causes the whole line to be posted on the stock ledger card at once by a method similar to dittoing. See Figure 23.

The transfer posting machine is completely different from the other IBM machines described here, because punched cards are not processed through it. In fact, it is usually physically located away from the data processing department. The posted records are thereby retained where they are needed.

The machine just described is the IBM Type 954. There are many machines available for this type of an application. Some use heat application rather than posting fluid. Others are especially adaptable to addressing envelopes and pieces of mail. They all perform basically the same operation – recording a line or lines of data from continuous forms to a record document.

Optical Scanning*

Optical scanning is the most advanced form of equipment in use today that performs the recording function. Optical scanning is performed by a machine that is capable of "reading" source documents and transcribing the data into a machine language form such as punched cards. See Figure 23a. The advantages of such an operation are evident; it eliminates the keypunch and verifying operation and greatly speeds the flow of input data.

Disadvantages are:

1. It will read only certain kinds of type.
2. It will not read handwriting.
3. Production cost of scanners is high because each machine is custom built for specific applications.

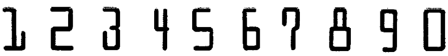
It should be pointed out that the input bottleneck is a critical problem in today's data processing world, and tremendous emphasis is being placed on the development of better input equipment. The problems of developing a machine that will read handwriting are obvious when one observes the hand-

*See Optical Scanning—An Unlimited Horizon in "Management and Business Automation" page 23, September, 1960.

Typical Scanning Type Faces

Farrington Selfchek: Already available on various types of business machine, Selfchek characters differ from each other by at least two strokes. Thus poor quality cannot cause an error unless two parts of the character are changed.

General Electric 69-A: All characters are composed of only horizontal and vertical lines constructed on a 6 by 9 zone grid. The right edges of all characters have a minimum height of five zones to facilitate character presence detection.

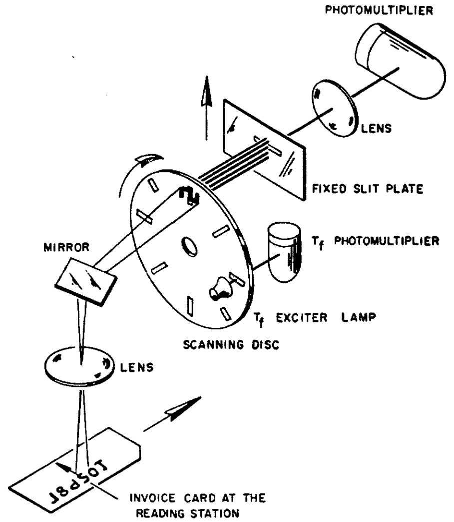


National Cash Register Co.: Each character has a code "within the character" combining two languages in one. The code, uniquely different for each character, makes complete self checking possible and is said to have a remarkable tolerance for relatively poor printing.

Radio Corporation of America: The R.C.A. 5 by 7 font is based on a 5 by 7 position matrix technique. The font has five points for recognition. The two dots contained in the zero distinguish a zero from the letter "o," as the font comprises both numeric and alphabetic characters.

Figure 23b—Typical Scanning Type Faces

The Mechanics of Scanning



The scanner makes a rapid vertical scan. Due to document motion (or in some cases the motion of a sweep mirror) the vertical scans progress across the character. Output of the scanner is a video signal.

Figure 23c—The Mechanics of Scanning

written source documents that are processed through any data processing department. However, some progress has been made and the future looks bright. It will almost certainly require some standardization of handwriting, which would be a step in the right direction even if optical scanning were not used. Progress has also been made in the development of a general purpose machine.

The scanner, like the transfer posting machine, does not read holes in a card. It reads printed data directly from a source document. This data must be printed in a special type font and these vary with each equipment manufacturer as shown in Figure 23b.

The mechanics of scanning are illustrated in Figure 23c. Note that the output of the scanner is a video signal. These signals are sent to the "truth table" stored in a special purpose digital computer where the various bars and strokes of the data read are compared with the possible combinations that comprise the characters. The computer determines the proper character and stores it for future processing at the proper time.

Speeds of the various types of scanners vary considerably and are influenced by many factors. Generally speaking, one optical scanning unit will perform the work of five keypunch operators. It is most profitable on jobs where tremendous quantities of similar documents are processed.

The other recording functions discussed thus far are in widespread use at this time. However, optical scanning is the latest development and its use is quite limited by comparison. The first application was READER'S DIGEST magazine, which began using a character reader in 1955. By 1959, the scanner had read its billionth character. READER'S DIGEST uses this method to process orders for 15 to 20 million books annually. It has reduced its order processing time from one month to slightly over one day.

By 1960 nine major gas and oil companies had scanners in action daily, processing three quarters of a million credit card invoices. Many other companies of all types are using scanners, but yet their use is much more limited than would be expected when one considers these advantages:*

1. Reduction in transcription costs.
2. Increased speed and accuracy of transcribing source data into machine language.
3. Ability to sort and merge source documents.

This concludes the basic principles of the recording function. The description of the function has been confined principally to the IBM line of equipment as will be the other three functions.** This is prompted by the prominence of IBM equipment and the fear of confusion which might result if more than one line of equipment is explained. You have undoubtedly observed by this time that there are a number of different machines available which perform similar operations. These machines can all be equipped with special devices to increase their flexibility and capacity. This is confusing enough without discussing similar machines made by other manufacturers. The principles of machine operations are what is important, and they are basically the same regardless of which manufacturer's hardware is used.

End of Chapter Questions

1. What machine is used to transcribe data from source documents into machine language? How does it operate?
2. What is the purpose of the program drum and card used on the IBM Type 24 card punch?
3. Explain the *duplicating* function. What are its advantages?
4. What is the difference between the IBM Type 24 card punch and the IBM Type 26?
5. How do the IBM and Remington Rand card punches differ in operating principles?
6. What factors affect the speed of keypunching?
7. What function checks the accuracy of the punching? What machine is used for this in the IBM line? In the Remington Rand line?

*Only 75 commercial systems had been installed from 1955 to 1962.

**Exception to this is the optical scanner in which Farrington Electronics has a head start, but is now being pursued by several other companies including IBM.

8. Explain how the IBM Type 56 verifier operates.
9. Explain the differences between the IBM and the Remington Rand systems for verifying the accuracy of data punched in the cards.
10. What does a circular notch over a column in an IBM card indicate? What does a circular notch at the right end of the card indicate?
11. What machine other than the card punch can be used to punch data in cards? How does the machine know what to punch and where to punch it?
12. Explain the *reproducing* operation.
13. How is the accuracy of reproducing checked?
14. How is an electrical circuit completed as a card feeds through the reproducer?
15. Explain the *gang-punching* operation.
16. How is the accuracy of gang punching checked?
17. Explain the operation of *interspersed gang punching.*
18. How is the accuracy of interspersed gang punching checked?
19. What is a *digit emitter*?
20. What are the advantages of *mark-sensed punching*?
21. What is a *dual* card?
22. What is the purpose of the *interpreting* operation? What machine is used?
23. How does the transfer posting machine differ in operation from other IBM machines?
24. Explain how a transfer-posting system operates.
25. What function of punched card data processing is performed by all of the machines described in this chapter?

CHAPTER 5

Machine Functions

Classifying Function

The classifying function is concerned with the arrangement of transactions into desired sequences. After all of the transactions have been recorded, it is necessary to have a fast, economical method of grouping like transactions. In a manual system, the sorting of source documents is laboriously done by hand or with the assistance of collating mechanisms which systematize it somewhat.

After all similar transactions are grouped, adding machine tapes can be run on each type of transaction for reporting purposes. This can be a major problem with some source documents which have multiple transactions on the same document. This one document should be sorted into several different groups. The punched card data processing system overcomes this obstacle by the *unit record principle*, which is the recording of each transaction on a separate card.

Sorter

The punched card data processing system greatly speeds up the sorting operation by the use of the sorter. The most common sorter in use today is the IBM Type 82 sorter. See Figure 24. This sorter operates at the rate of 650 cards per minute. It has only one brush and will read only one column at a time. The brush can be set by means of a crank in any one of 80 positions corresponding to the 80 columns of the card. It has 13 pockets into which the cards drop. The first pocket is for rejects, which are those cards with no punch in the column being sorted. The other 12 pockets are for the 12 horizontal punching positions on the card.

The cards must be passed through the sorter once for each column in the field being sorted. The last column of the field is sorted first, then each column to the left until all columns of the field are sorted.

To explain this operation in more detail, let us refer to Figure 25. In frame number 1, 10 cards are shown with numbers written on them. Let us assume that the four-digit numbers are punched into columns 41-44 of the cards. The cards are in no sequence, but we desire to arrange them into sequence on the numbers punched in columns 41-44.

The cards are placed in the sorter and the brush is set on column 44. They

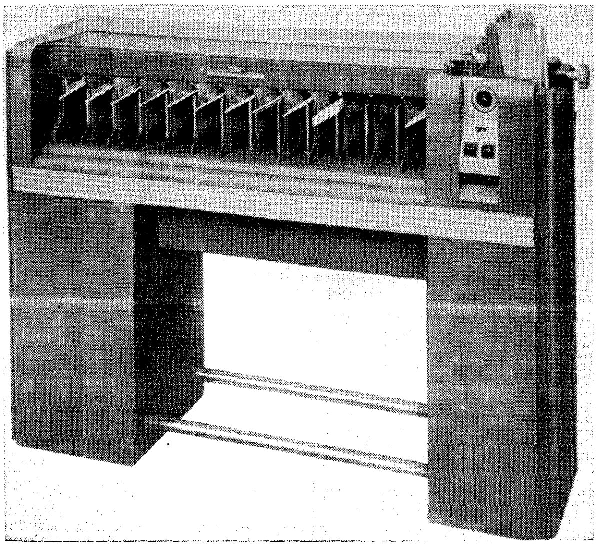


Figure 24—IBM 82 Sorter *(Courtesy of International Business Machines Corporation)*

will fall into the sorter pockets according to the numbers punched in column 44. After all cards have passed through the sorter on column 44, they are removed from the sorter pockets by the operator. He must be careful to remove them in order, so that the cards from the "1" pocket are behind the cards from the "0" pocket and the cards from the "2" pocket are behind the cards from the "1" pocket, and so on until the "9" pocket contents are at the end.

The cards are now in sequence on column 44 as illustrated by frame number 2 in Figure 25. They are then placed in the sorter stacker again, and the brush is set on column 43. After they have passed through the sorter on column 43, they are removed by the operator in sequence. The cards are now in sequence as shown in frame number 3. Note that they are now in order on columns 43-44.

The cards are then sorted on column 42, which arranges them in the sequence shown in frame number 4. Finally they are sorted on column 41, which completes the sorting, and they are now arranged in the desired sequence as illustrated by frame number 5.

Despite the fast speed of this machine (650 cards per minute), the operation can still be slow and tedious because of the number of times the cards must be passed through the machine. A sorting machine has not been developed which is capable of taking a deck of cards in random sequence and arranging them in sequence on any given field in one pass. The manufacturers have been successful, however, in developing faster sorters by substituting an electronic beam for the brush to sense the holes in the cards. These machines are capable of speeds up to 2000 cards per minute.

The sorting discussed thus far has been numeric only. It is sometimes necessary to arrange cards in alphabetic sequence also. For instance, it is desirable to have a company roster in alphabetic sequence. You will recall that a letter is composed of two punches in a column. For this reason, it is necessary to run the cards through the sorter twice on each column of an alphabetic field. The first sort arranges the cards in sequence on the numeric section (1-9) of the card. Only punches 1 through 9 are sensed on this pass. The cards are then placed back in the sorter on the same column and a switch is thrown to cause "zone sorting." This causes the sorter to sense only the three top horizontal rows of holes in the cards. These are the zero, 11 and 12 punches. [A combination of a numeric punch (1-9) and a zone punch (0, 11 or 12) is required to form a letter.]

When sorting cards to alphabetic sequence, such as for a roster, it is usually sufficient to sort on the first four digits of the last name and on the initials. This will arrange them in sequence with very few exceptions and is usually sufficiently alphabetical for such a list. Time in sorting is saved, because the

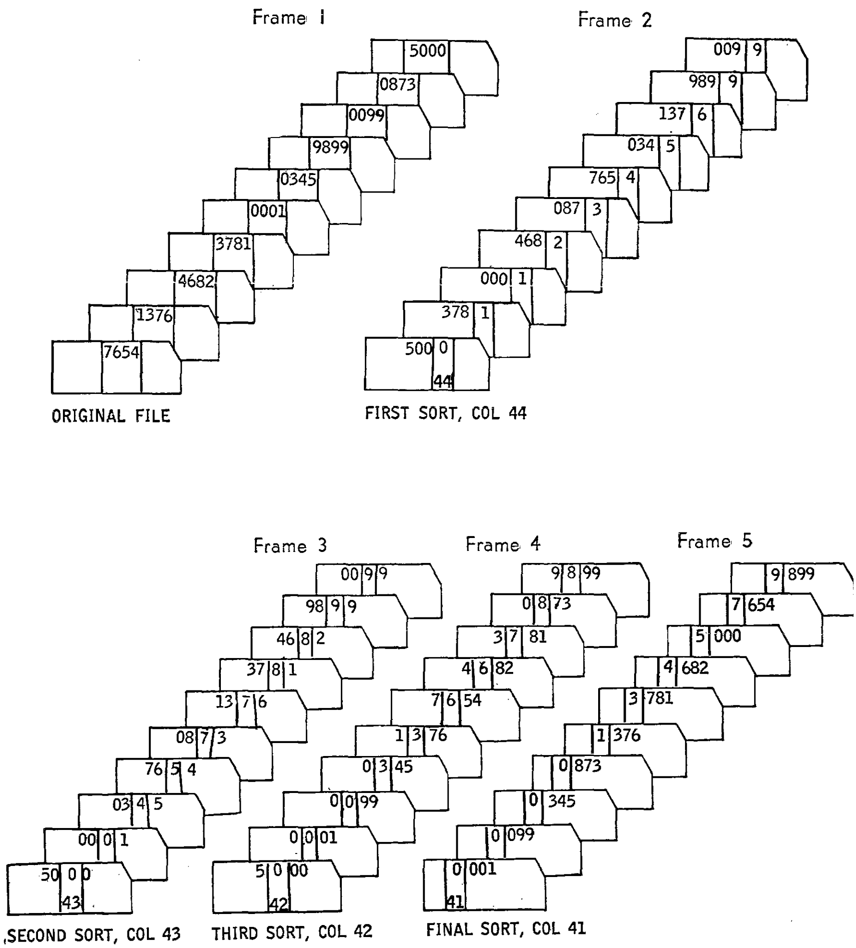


Figure 25—Sorting

name field might comprise 20 columns which would require 40 sorts. The sorting can be accomplished in twelve passes by sorting the initials and the first four positions of last name.

How would you sort this field to arrange it in the proper sequence?

First Initial
Second Initial
Last name

Columns → 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

1. Sort second initial, column 2 numeric.
2. Sort second initial, column 2 zone.
3. Sort first initial, column 1 numeric.
4. Sort first initial, column 1 zone.
5. Sort fourth column of last name, column 6 numeric.
6. Sort fourth column of last name, column 6 zone.
7. Sort third column of last name, column 5 numeric.
8. Sort third column of last name, column 5 zone.
9. Sort second column of last name, column 4 numeric.
10. Sort second column of last name, column 4 zone.
11. Sort first column of last name, column 3 numeric.
12. Sort first column of last name, column 3 zone.

Note that the least important column is always sorted first and the most important column is sorted last. This is sometimes referred to as progressing from minor to major.

A sorter can also be used to select cards with a certain punch in a column. An example of this is the separation of third shift labor distribution cards from a deck that contains first, second and third shift cards without disturbing the sequence of the first and second shift cards. This is possible by setting the brush on the column in which shift is punched and setting switches to suppress sorting all numbers except 3's. The cards with a three (third shift) will then sort out into the 3 pocket and all other cards will fall into the reject pocket. Because of being limited to one brush, selection is possible on only one column.

Collator

Another machine used in the classifying function is the collator. See Figure 26. This machine is very flexible and has a multitude of uses, but it will perform basically three operations. These are *merging, matching* and *selecting.*

Merging is the process of combining two decks of cards into one deck in sequence. Both decks being combined must already be in the sequence desired for the combined deck. Figure 27 shows the two decks, A and B, in employe number sequence. By the merging operation, these two decks are combined into one deck illustrated by deck C.

The same thing could be accomplished by sorting, but this would take longer and require more operator action than the collator operation.

The IBM Type 77 has two feeds known as the primary and secondary feeds. In Figure 26, the two feeds can be seen at the upper-right end of the

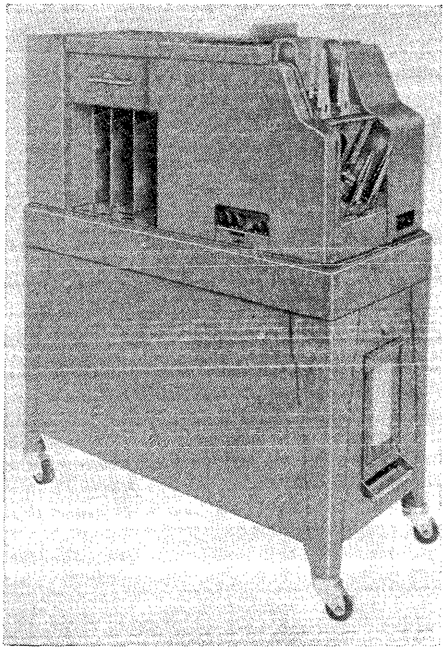


Figure 26—IBM 77 Collator *(Courtesy of International Business Machines Corp.)*

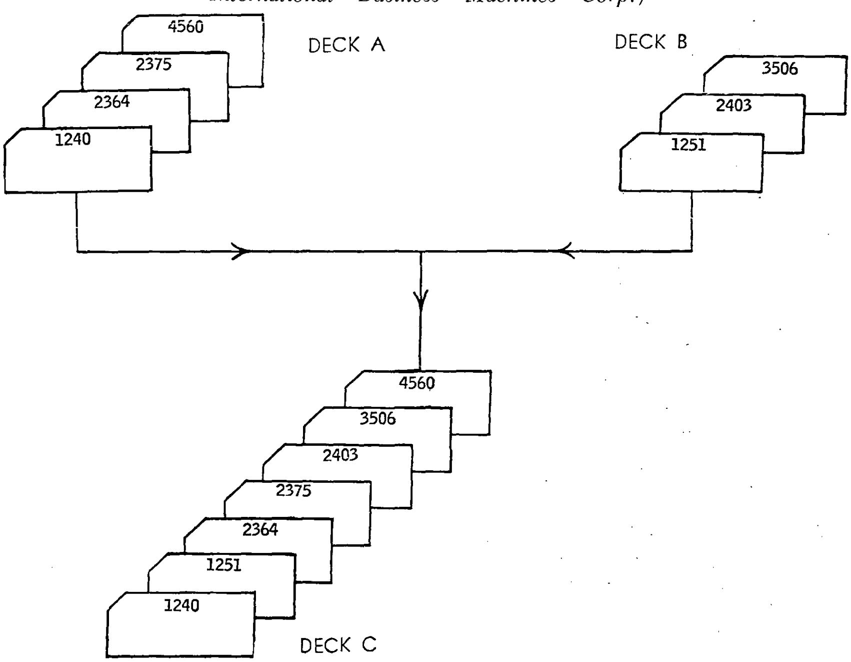


Figure 27—Merging. Decks A and B are merged together to form Deck C. Numbers written on the cards indicate employe number which is punched in the cards.

collator. The top feed is the secondary and the bottom feed is the primary. There are four pockets into which the cards drop. These pockets are side by side in the front of the machine. For the merging operation shown in Figure 27, either deck can be placed in either feed. After all cards have passed through the machine, they will have been stacked in one of the pockets according to instructions given by control panel wiring.

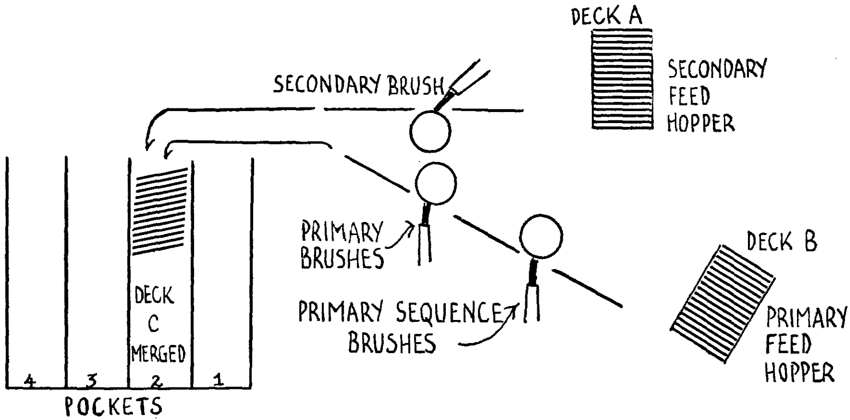


Figure 28—Merging. Decks A and B are merged together to form Deck C in pocket No. 2.

Figure 28 is a schematic diagram of the internal machine operations on this function. There are two sets of brushes in the primary feed, and only one set in the secondary feed. Each of those sets of brushes consists of 80 brushes which read all 80 columns of the card as it passes between them and the contact rollers. In the merging operation, the card with the lowest number punched in it always feeds first, regardless of which feed it is in. The other feed stops until it contains the card with the lowest number, at which time it ejects a card and the other feed stops. This is done at a rate of approximately 250 cards per minute.

The merging operation requires only one set of brushes in each feed. The second set of brushes in the primary feed is used for *sequence checking*. Sequence checking is done to determine if the cards feeding through the primary feed are in sequence on the fields being used. If a card is out of sequence, the machine will stop and a red light flashes on. The operator must then remove the card in question and visually analyze it to determine the cause of its being out of sequence.

Sequence checking can only be done in the primary feed, but it can be done simultaneously with merging or matching operations. In the example given in Figure 27, the normal procedure would be to run the smallest deck (deck B,) through the primary feed first to assure that it is in employe number sequence. Deck B would then be placed in the secondary feed and deck A would be placed in the primary feed. As the decks are being merged, the sequence of deck A will be checked. To assure complete accuracy of operation, the merged deck can then be run back through the primary feed to check the sequence and assure that the merging operation has been performed without error.

Merging is frequently used to combine decks for several reports into a deck for a reporting period to issue recap reports. For instance, the labor distribution decks used for the four weekly labor reports can be combined into one deck for the monthly labor report by merging. When merging four decks together, three passes through the collator are required. Deck 1 is merged with deck 2, deck 3 is merged with deck 4. The merged decks 1 and 2 are then merged with the merged decks 3 and 4 to produce one deck for the month.

When merging weekly decks to prepare for monthly reports, it is usually wise to merge each week as it occurs rather than to wait until the end of the month, which is a critical week. Deck 1 would be merged with deck 2. At the end of the third week, deck 3 would be merged with the combined deck of weeks 1 and 2. At the end of the month, only one pass is necessary. This is the merging of the fourth week's cards into the combined decks of weeks 1, 2, and 3. The cards are merged in the sequence of the first monthly report to be prepared.

Collator Matches Equal Cards in Two Decks

Matching is another basic operation performed on the IBM Type 77 collator. Matching is the process of comparing two decks of cards in sequence and selecting those cards which are equal.

Figure 29 shows a sample of a typical matching operation. One deck is placed in the secondary feed, the other in the primary feed. Both decks are in employe number sequence. As the cards pass through the collator, the equal cards are selected into the two middle pockets. The unequal cards fall into the end pockets.

Probably the most common operation on the collator is a combination of the two operations already described. This operation is known as *match-merging*. Match-merging is the operation in which two decks of cards in sequence are compared and the equal cards are merged. The machine will always merge the primary card ahead of the secondary card with the same number. Figure 30 portrays this operation. Note that the cards fall into three pockets – one for the merged deck and the unmatched from each feed in the two end pockets. The fourth pocket is not used.

An example of this operation is the match-merging of labor distribution cards in employe number sequence behind a payroll master file deck in employe number sequence. The purpose of merging these decks together is so that the hourly rate in the payroll master file card can be multiplied by the hours in the labor distribution cards to determine the labor dollars. This multiplication operation is performed on the calculator and will be explained in more detail later on.

Figure 30 assumes that labor distribution cards are in the secondary feed and payroll master file cards are in the primary feed. The match-merged deck contains all labor distribution cards that had a corresponding payroll master file card. The exceptions – those labor distribution cards with no corresponding payroll master file card are selected out as unmatched secondaries so that

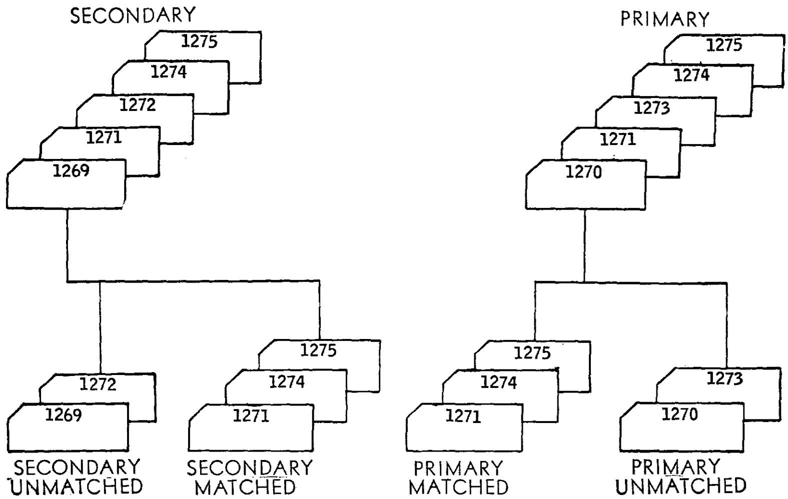


Figure 29—Matching Operation on the Collator. Cards with the same employe punched in them drop into the two center stackers. Cards in either feed that do not have a corresponding number in the other feed drop into the outside stackers.

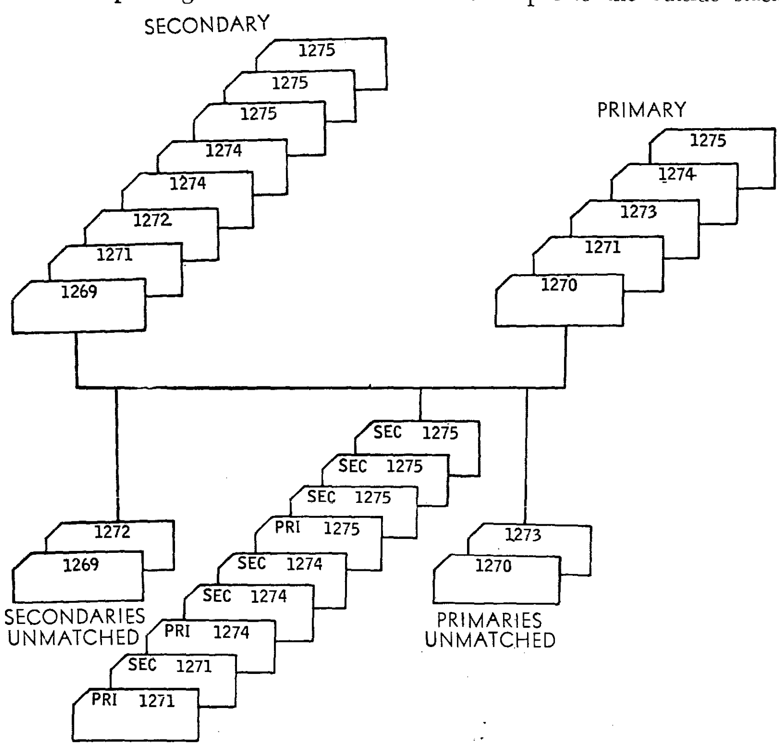


Figure 30—Match-Merging Operation on the Collator. Same as the matching operation except cards with corresponding numbers are merged together in one of the center stackers.

they can be analyzed to determine why there is no payroll master file card for them. Likewise, the unmatched payroll master file cards are selected into the unmatched primary pocket where they can be analyzed.

The third basic operation performed on the IBM Type 77 collator is known as *selection.* Selection is the operation in which cards containing a certain number or series of numbers in a given field are automatically pulled from a deck.

To perform this operation, a card is punched with the number to be selected and placed on the front of the deck. The panel is wired to select all cards from the deck with that number punched in the given field. The deck is passed through the collator, and the cards with that number punched in them fall into one pocket. All other cards fall into another pocket.

The collator can also be wired to select all cards punched with a number higher or lower than a certain number in a given field. For instance, all employes hired after January 1, 1960, can be selected from a payroll master file deck. Likewise, all employes hired between January 1, 1960, and June 30, 1960, also can be selected.

Selection is somewhat limited in that one number can be selected or all numbers over a certain number, under a certain number, or within certain limits can be selected. It is not possible to select several widely separated numbers by this method.

The collator is limited to the use of 16 columns which can be expanded to 32 columns for certain operations. These columns can be divided into any number of fields with any number of columns as long as the total number of columns does not exceed 16 positions. For instance, two work-in-process decks could be merged into one deck on the following fields:

Job number	Columns 26-29	Major
Task number	Columns 31-34	Intermediate
Cost element	Column 25	Minor

In this case, three different fields are being controlled for a total of nine columns. The term *major, intermediate,* and *minor* are commonly used and refer to the rank or importance of the fields. Major is the highest rank and minor is the lowest. The cards will be in a sequence on the major field. They will also be in a sequence on the intermediate field within the major and on the minor within the intermediate. In the work-in-process example, all cards for any given job number will be grouped together. Within the cards for any given job number, they will be in sequence by task and within any given task they will be in sequence by cost element. Thus, any number of fields may be involved with any number of columns as long as the total number of columns being controlled does not exceed 16.

If it is absolutely necessary to utilize more than 16 positions, it is possible to do so on the IBM Type 77 collator. But the capacity of the machine must be used in such a way that it is not possible to sequence check at the same time that a merging or matching operation is taking place. This is a great disadvantage because it is of paramount importance that the cards always be in exact sequence when passing through the collator. It is usually necessary to sequence check both decks of cards first, then run them through again to merge them and then sequence the merged deck. This is quite time-consuming, but can be done if it is necessary to control on more than 16 positions.

All of the collator operations discussed thus far have been concerned with numbers only. It is possible to get an attachment for the IBM Type 77 collator to allow the use of alphabetic characters and special characters. There is also an alphabetic collator which is adaptable to the use of alpha and special characters; however, the cost is more than double the rental of a numeric machine.

The collator is an extremely useful tool and can be used on a wide variety of applications. Its usefulness is based upon its ability to read two cards at once, and by means of comparing magnets that determine whether the numbers punched in one card are higher than, equal to, or smaller than the digits punched in the same field of the other card. The machine is instructed to perform operations based on these high, equal, or low impulses through control panel wiring.

The cardinal rule to remember is that all decks must be in sequence for all collator operations except selection. The selection operation is not dependent upon each card being punched with a number greater than or equal to its predecessor, such as is the case with matching, merging and sequence checking.

Calculating Function

Calculating as applied to punched card data processing refers to the multiplication, division, addition and subtraction of data. This implies the use of mathematics and the solving of problems by the use of formulas. The formula is often as simple as $A \times B = C$ or $A + B = C$. However, it can become quite complex and even develop several different answers, such as in the computation of payroll taxes. This operation determines an employe's federal withholding tax, FICA (Federal Insurance Contributions Act) deduction and SUI (State Unemployment Insurance) in one pass and punches the results in the card.

The most common calculator is the IBM Type 604 electronic calculator. See Figure 31. This machine has only one hopper and one stacker and feeds at a constant rate of 100 cards per minute. There are two separate units which are connected by a cable. The unit into which the cards are fed is referred to as the punch unit. The other unit is the calculating unit. Each unit has a control panel; consequently, two panels must be wired for each job. The punch unit reads data punched in the cards according to instructions from the control panel and feeds it to the calculating unit via the cable. The calculating unit operates with electron tubes and performs operations at electronic speeds according to instructions supplied by its control panel. When the calculating unit has completed all program steps required, the resulting answers are fed back to the punch unit via the cable where they are punched into fields in the card as instructed by the punch unit control panel.

Before applying a problem to the calculating unit, it is necessary to reduce it to a mathematical formula. Many business and industrial problems can be reduced to quite simple formulas which are within the capacity of the calcu-

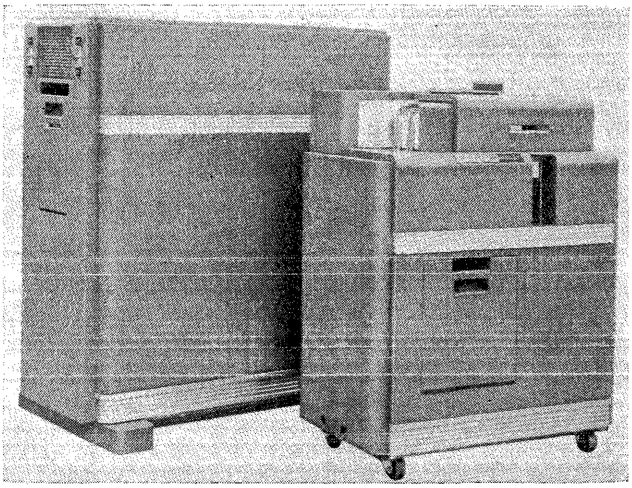


Figure 31—IBM 604 Electronic Calculating Punch *(Courtesy of International Business Machines Corporation)*

lator. Engineering problems, however, can be very complex, and the IBM Type 604 electronic calculator is satisfactory for only simple-type engineering calculations. Electronic computers work much more satisfactorily for engineering problems because of their great storage capacities and increased flexibility.

Let us take a few sample problems and see how they are applied to a punched card calculator.

The processing of material requisitions is a common accounting application applied to punched card equipment. A card is punched for each part shown on the requisition, which is a document used to record the transfer of parts from one place to another or from one accounting charge to another. The card is keypunched with pertinent data about the transaction, including the number of parts involved and the unit price (price per part).

For accounting purposes, it is necessary to obtain a dollar value of the parts being moved; consequently, a calculation is necessary. The formula used is: $A \times B = C$. A is the number of parts being moved. B is the unit price. C is the extended dollar value. Factors A and B are punched in each transaction card. Factor C is calculated and punched into a field reserved for that purpose.

The extension of material requisitions represents a very simple problem and, of course, the panels are quite simple to wire. Now let us look at another calculation which is quite common today and is considerably more complex – the extension of payroll taxes.

In the State of California, there are three types of deductions based upon earnings which are included within the operation of payroll tax calculations. These are the federal income tax deduction, FICA deduction and state disability insurance deduction .

The federal income tax is determined through reducing the gross earnings by the dependents allowance, which is $13 (on a weekly payroll) × the number of exemptions. The result is multiplied by 18%.

The FICA (Federal Insurance Contribution Act) is the deduction for social security. The percentage and the limits change periodically, but for our consideration let us assume that 3% of the first $4800 earnings is deducted for a total of $144 per year.

The SDI deduction which covers state disability insurance in the State of California amounts to one per cent of the first $3600 earnings for a total of $36 per year.

Our example is based upon employes' exemption only. Employers also make contributions based upon amounts paid to employes, but the problem we are illustrating is concerned with making calculations essential to writing employes' paychecks and only employes' deductions are considered.

Factors involved are as follows:

A – gross earnings.
B – number of exemptions.
C – Federal withholding tax.
D – FICA before checking.
E – FICA withheld through last payroll.
F – FICA deduction.
G – SDI before checking.
H – SDI withheld through last payroll.
I – SDI deduction.

Three factors are involved in both FICA and SDI because it must be determined whether the limit has been reached. If it has, either no deduction is to be taken or a sufficient amount is to be withheld to bring the total deductions to date up to the limit.

The formulas are as follows:

The formula for federal income tax is A — (B × 13.00) × 18% = C. The result C is the federal withholding tax and is punched into a field in the card reserved for that purpose. The formula for FICA is .03 A = D. $144.00 — (D + E) = TEST. TEST counter to see if it is negative. When counter goes negative this means that the deduction for the year exceeds $144. If counter is positive, D = F and no further computations are required. If counter is negative, calculate. D — (negative amount in test counter) = F. This reduces F to an amount which will cause the employes' deduction for the year to equal $144. The formula for SDI is .01 A = G. 36.00 — (G + H) = TEST. If counter is positive at TEST, G = I and no further calculations are required. If counter is negative, the amount of SDI to deduct to bring the total for the year to $36 may be determined by this formula: G — (negative amount in TEST counter) = I.

Each employe will reach the limits only once for FICA and once for SDI. This will be when his earnings to date pass the $3600 mark and again at $4800. It is customary to punch an "X" in some column of the card to indicate that the full deduction has been withheld. The panel is wired to skip those formulas relating to that field when an "X" card is sensed.

Now let us substitute amounts as follows:

A – $200 gross earnings
B – 5 exemptions
C – *Unknown,* federal withholding tax
D – *Unknown,* FICA before checking
E – $106.50, FICA withheld through last pay period
F – *Unknown,* FICA deduction
G – $35.50, SDI withheld through last pay period
H – *Unknown,* SDI before checking
I – *Unknown,* SDI deduction

The formula for computation of federal withholding tax on a weekly payroll is as follows: A — (B × $13.00) × 18% = C. By substituting values, we have:

$$\$200.00 - (5 \times \$13.00) \times .18 = C$$
$$200.00 - 65.00 \times .18 = C$$
$$135.00 \times .18 = C$$
$$\$24.30 = C$$

The value of C is placed in a storage unit until the other calculations are completed, at which time it will be punched into a field in the card reserved for federal withholding tax.

The formula for computation of "FICA before checking:" 3% A = D. By substituting values, we have: .03 × $200.00 = $6.00. The value of D is stored and used in the "TEST" computation as follows:

$$\$144.00 - (D + E) = \text{TEST}$$
$$144.00 - (6.00 + 106.50) = \text{TEST}$$
$$+ 31.50 = \text{TEST}$$

Result is a positive answer, therefore: D = F. D is $6, therefore, F is $6.

We can see that this is correct because 3% of 200 is $6, and $6 added to the FICA withheld through the last pay period does not exceed $144.

The formula for "SDI before checking:" 1% A = G. By substituting values in the equation we have: 01 × 200.00 = $2.00. The value of G is stored and used in the "TEST" computation as follows:

$$\$36.00 - (G + H) = \text{TEST}$$
$$36.00 - (2.00 + 35.50) = \text{TEST}$$
$$36.00 - 37.50 = \text{TEST}$$
$$- 1.50 = \text{TEST}$$

"TEST" is a negative answer which indicates that the maximum amount to be withheld for the year will be exceeded if the full deduction is taken. When "TEST" is negative, the following formula applies to compute the proper amount of SDI to withhold:

$$G - (\text{negative amount in "TEST" counter}) = I$$
$$2.00 - 1.50 = I$$
$$.50 = I$$

We can see that this correct by adding the SDI withheld through the last pay period which is $35.50 to the current deduction of $.50. The sum is $36, which is the maximum SDI deduction for the year. At this time an "X" can be punched in an assigned column to indicate that the SDI limit has been reached so that the SDI formulae will not have to be computed for the employe in the remaining payrolls of this year.

All of the tax computations can be completed in one pass of the cards through the IBM Type 604 calculator. Another pass is required to check the accuracy of the computations.

This problem indicates some of the versatility of the calculator. A limited number of logical decisions are possible, as illustrated by the testing for limits on FICA and SDI. Many other operations are possible but all are based on the four arithmetic functions of addition, subtraction, multiplication and division, and some special features such as the ability to detect a negative answer standing in the counter.

Importance of High Speed Calculation

The high speed of calculation can have a significant effect on schedules. For instance, the calculation of payroll taxes just described would obviously be a big task manually for 3000 employes, even with tax tables, but by the punched card method it would require only one hour to extend the taxes and one hour to check them. Six thousand cards are involved because there are two cards for each employe. The first card contains the to-date FICA and SDI, and the second card contains gross earnings and all other data pertinent to the current payroll.

Group Multiplication of Labor Distribution

Group multiplication is a common operation. This entails the use of a master card to supply one or more of the factors used for computation involving the detail cards filed behind the master. As in interspersed gang punching, the master cards must be identified in some way, such as by an "X" punch. They are interspersed throughout the file with any number of detail cards behind them.

The preparation of labor distribution cards by match-merging them behind their respective payroll master cards by employe number was described in the section of this chapter devoted to the classifying function. See Figure 30. After the cards have been match-merged with all of the labor distribution cards for each employe behind his payroll master card, it is possible to group multiply the hourly rate punched in the payroll master cards times the hours worked punched in each labor distribution card and punch the extension which is labor dollars in each labor distribution card.

The formula for this calculation is as follows: $A_m \times B_d = C_d$

A is the base hourly rate.

B is the total hours worked.

C is the total labor dollars.

Sub m indicates the factor is in the payroll master card.

Sub d indicates the factor is in the detail card.

Normally, the labor distribution calculation is not this simple, because many other conditions are involved. Straight time labor hours and dollars might be separated from premium hours and dollars, and a bonus might be added if the employe is working on second shift.

The formula now becomes:

$$\frac{A_m + (.10 \text{ if second shift})_d \times B_d = C_d \quad A_m + (.10 \text{ if second shift})_d \times D_d = E_d}{2}$$

A is base hourly rate.
B is straight time labor hours.
C is total labor dollars.
D is overtime labor hours.
E is premium labor dollars.
Sub m indicates factor is in payroll master card.
Sub d indicates factor is in labor distribution card.

The calculator is wired to read the base hourly rate field whenever a payroll master card feeds, and to place the rate in a storage unit. As each labor distribution card is fed, the calculator tests for shift, which is determined by a "1" or "2" punched in a given column. If a "2" is punched, 10 cents (second shift bonus) is added to the base hourly rate. If a "1" is punched, it indicates first shift, and nothing is added to the base hourly rate. The rate as it now stands is then multiplied by the total hours and the answer is placed in a storage unit. Next, the adjusted rate is divided by 2 (or multiplied by .5) to get the premium rate. In this example, overtime is paid at time and one half. The premium rate is then multiplied by the premium hours worked, which must be punched in a separate field, and the answer is placed in storage. The storage units containing straight time labor dollars and premium labor dollars are then impulsed to read out and punch in the designated fields.

Thus we see that as a payroll master card feeds, the base hourly rate is read out into a storage unit. (The reading that was in a storage unit is wiped out by reading something in on top of it.) This is all that happens on a payroll master card. As *each* labor distribution card is fed through the calculator, all of the formulae described are calculated and answers are punched into each card. Only the base hourly rate is retained from card to card, and this changes whenever a payroll master card passes through the calculator.

The calculations described in this section have related to an IBM Type 604 electronic calculator; however, the same principles apply to other calculators on the market. The speeds and capacities vary considerably, but they perform approximately the same functions.

Summarizing

Summarizing is the function which is concerned with the preparation of reports. Reports are the principle products of a punched card data processing department. The other three functions involve the preparation of punched cards by recording data in them, classifying them in the proper sequence, and calculating them in anticipation of all of this data being shown upon a report in the most usable form.

Tabulators are used to print reports. These machines are often referred to as printers. IBM has an official title of *accounting machine*, which is most inappropriate, as this title usually signifies equipment in the bookkeeping machine class. The term *electric accounting machines* (EAM) is frequently used

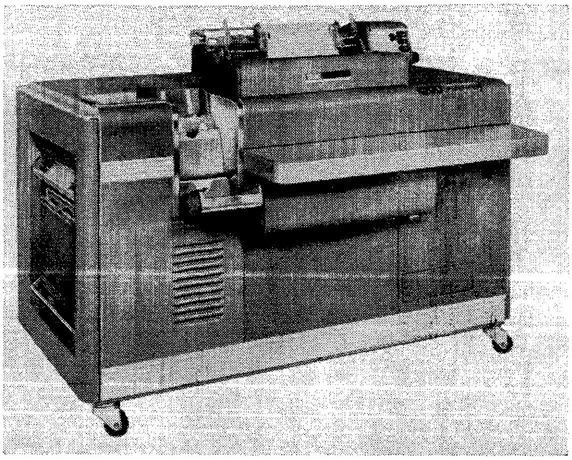


Figure 32—IBM Type 402 Accounting Machine (*Courtesy of International Business Machines Corporation*)

to denote punched card equipment other than computers. Computers are classified as EDPM equipment (electronic data processing machines).

There are two different IBM tabulators in wide use today. They are the IBM Type 402 tabulator (see Figure 32), and the IBM Type 407 tabulator (see Figure 33). The two machines differ considerably in principles of operation, capacity and flexibility. The Type 407 is the superior machine of the two. Our discussion here will be related to the Type 407.

After the cards are ready to prepare the report, they are placed in the hopper of the 407 and the control panel is inserted. The control panel is quite large – about 22 inches square. The paper is inserted in the carriage on top of the tabulator. The paper can be plain or preprinted to indicate the columns

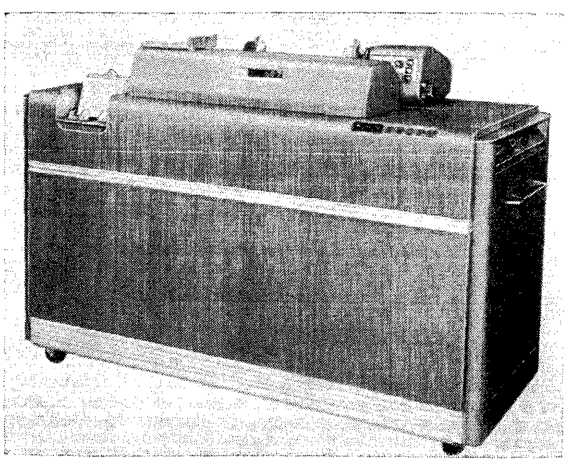


Figure 33—IBM 407 Accounting Machine (*Courtesy of International Business Machines Corporation*) in which the data will print. The paper can be single copy or multiple copies with interleaved carbons to get the required number of copies. Four or five copies will give a good, clear report, but as high as 14 copies can be prepared with very thin paper and special carbons. The paper is fanfolded with perforations along each side which feed through the pin feed devices on the carriage.

The tabulator can be wired to "group indicate" or to "detail print." On the group indications operation, certain data is read from the first card of a group, thus identifying the group. The identification is printed on the report. All the other cards for this group are then tabbed – that is, they feed through the machine but do not print on the report. However, as they feed, data from amount fields is being read and fed into counters where totals are accumulated. When the last card of a group is sensed, the totals print on the report on the same line with the indicative information.

Detail printing is the operation in which the data punched in each and every card is printed on the report. The paper advances one space and a line prints every time a card feeds through the machine.

Group printing is often referred to as *tabbing*, and detail printing is referred to as *listing*.

On the IBM Type 407, there are 120 type wheels which print in a 12-inch width. Thus, the maximum number of characters that can be printed on one line is 120, and they will print on a line one foot in length. These characters can be numeric or alphabetic, and there are eleven special characters such as the decimal, comma, asterisk, etc.

The printing is quite flexible in that data punched in any column can be printed from any type wheel by control panel wiring. Totals can also be printed from counters. This machine is capable of both addition and subtraction, and several classes of totals can be accumulated at once.

Classes of totals are identified by the terms *major, intermediate* and *minor.* These terms are also used when referring to the sequence of cards. These are easy to remember if one keeps in mind that major is the largest grouping, whereas minor is the smallest grouping. Thus, if a deck of cards is sorted to employe number, minor, and then to department number, major, all of the employes for one department will be grouped together. Example:

Department Number	*Employe Number*
01	0123
01	1456
01	2389
02	0459
02	3689
02	4587

Department number is the major sequence and employe number is the minor sequence. If another field were sorted between these two, it would be the intermediate sequence. The IBM Type 407 is capable of accumulating totals and printing the various levels of sequence called classes of totals. In the example we could print total earnings and give totals as follows:

Department Number	*Employe Number*	*Total Earnings*
01	0123	100.00
01	1456	245.40
01	2389	150.00
		495.40*
02	0459	200.00
02	3689	189.00
02	4587	145.50
		534.50*
		1029.90**

Each line has a minor total by employe number, and after all employes for a department have been printed, a total for the department is printed (indicated by the *). This is the major class total. After all cards for all departments have been fed through the machine, a final total is printed (indicated by **). This example assumes that there is more than one card per employe and that they must be tabbed for a total. If there was only one card per employe, the cards could be listed and the total earnings would be read directly out of each employe's card and printed on the report. The totals indicated by an asterisk would then be considered minor totals.

The machine determines when to print a total by a comparison operation which results in a "control break." The field which is to be controlled is wired to the comparing units. The comparing units compare the holes punched in this field in the card at one reading station with the holes punched in the same field of the next card which is at another reading station. If they are not the same, the machine takes a control cycle and prints out totals according to the way the control panel is wired. If they are the same, the cards continue to tab until a difference is detected by the comparing units. Several fields can be wired to compare. This is the way different classes of totals are printed.

Automatic Carriage

The feeding of the paper is governed by the automatic carriage which is mounted on top of the tabulator. The carriage operates according to instructions supplied by the control panel and by a continuous punched paper tape which has holes punched on the spots corresponding to lines on the form where something is supposed to happen. See Figure 34. For instance, on an invoice we desire to skip down to the customer name block and print the customer's name and address. Then the form must skip to a line indicating the method of shipment, method of payment, terms, etc. Next it skips to the body of the invoice and prints all of the items that the customer has ordered. We could then have it skip to a predetermined total line and print the total amount. Each time the form skips to a new printing area, it must be directed by holes in the tape. The panel is wired to tell it what to do according to the tape channel in which the hole is punched.

The spacing of forms was once a major problem on tabulators, but this has been solved by the use of the paper tape just described. The paper tape method applies almost unbelievable flexibility in spacing, skipping, and ejecting of forms.

The 407 operates at a speed of 150 machine cycles per minute. This means that on a straight list report with no totals and no control breaks it will feed and print out the data punched in the cards at the rate of 150 cards per minute.

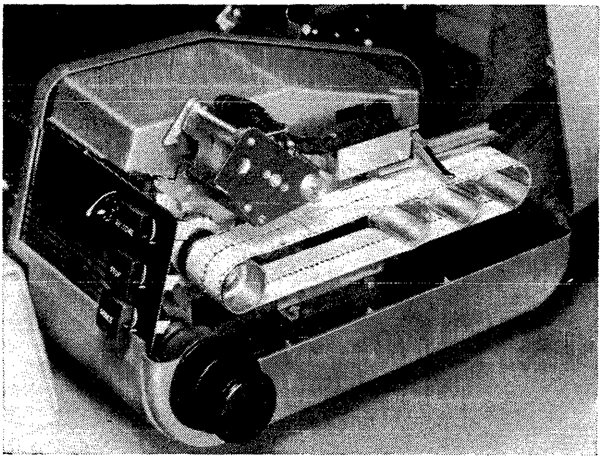


Figure 34—IBM Carriage Tape in Operating Position. Continuous punched paper tape governs the feeding of continuous forms through the tabulator. Holes punched in channels 1, 5, and 12 are read by carriage brushes and transmitted internally to the control panel where wiring starts and stops skipping and ejecting. *(Courtesy of International Business Machines Corporation)*

Extra operations, such as control breaks, totaling, summarizing, special programing, etc., require machine cycles and thus reduce the number of cards per minute which can be processed. The machine is capable of only 150 machine cycles per minute. A card feed cycle is equivalent to a machine cycle. However, for each machine cycle that is used for something else such as a total, a card cycle is sacrificed and one less card per minute is fed into the machine. Despite this, the average 407 operation will usually exceed 110 cards per minute, and speeds of more than 125 cards per minute are quite common.

Summary Punching

Summary punching is the process of punching a summary card as totals are printed on a report. The reproducer is connected to the tabulator by a cable to accomplish this. The report is run on the tabulator, and each time a designated class of total prints, the reproducer punches a card with all indicative information and the totals. In the example previously stated, summary cards could be cut at the minor level with the indicative information of department number, employe number and the minor total which is total earnings. Thus the first card would have department number 01, employe number 0123 and earnings of $100. Summary cards can be cut for any class of total but minor class is the most common. If summary cards were required at the major level in the example, the first card would have department number 01 and earnings of $495.40. Employe number would not be punched, because the total is representative of several different employe numbers and this level of detail is being dropped.

Summary punching is used to reduce card volume and to update master files with current data.

One of the biggest problems in setting up new reports is the wiring of the tabulator control panels. The IBM Type 407 is a very sensitive machine and the timing is quite critical. A great deal of training and experience is necessary to successfully wire a complex 407 control panel. It is not unusual for a complex panel to require several days and even weeks to wire and test out.

Changes in reports are also a problem. What appear to be very simple changes in the sequence or format of a report can require days of work on the control panel.

It is very important that sufficient time be allowed for wiring and testing, because all reports issued are dependent upon these tasks being performed correctly.

The tabulators, like all punched card machines, have many checking features to insure accuracy. One of these features on the 407 is known as "echo print." This feature guarantees that a total printed on the report is the same as the total standing in the counter. By proper wiring of the 407 control panel, one can be assured that all totals printed on the report are correct if the final total is correct. Final totals should always be balanced to predetermined totals if such totals are available.

The tabulators are the punched card machines which are most often taxed to their capacity. The limitations of counters, selectors and print wheels are a constant problem in setting up reports.

This concludes the examination of the four basic machine functions. These are very difficult to understand by just reading about them. At this point it would be well to go through a punched card data processing department and have the machines explained and demonstrated so that you can see what happens at each function.

The next chapter, a case study of an application on punched cards, is intended to familiarize the reader with the flow of work from machine to machine and to review the operations of each machine.

End of Chapter Questions

1. Explain the *classifying* function.
2. What IBM machines perform the classifying function?
3. What obstacle is overcome by the unit record principle?
4. How many columns are sorted on each pass through an IBM Type 82 sorter? Why does the sorter have 13 pockets?
5. If each of the following numbers were punched in different cards, and these cards were sorted in a normal manner, what would be their sequence after each pass through the machine?

1456	3761
9872	9871
4397	0456
2198	

6. How many passes are required to sort alphabetically? Why?
7. How is a sorter limited on the selection operation? How does the machine know which column to sense?
8. What basic operations are performed on the collator? Define each.
9. Define the term *sequence checking.*
10. How many pockets will the cards fall into on a matching operation? What cards will fall into each pocket?
11. Explain the *match-merging* operation. How many pockets do the cards fall into on this operation?
12. What are some limitations of the *selection* operation on the IBM Type 77 collator?
13. Explain the terms major, intermediate and minor.
14. What is the disadvantage of controlling on more than 16 columns?
15. What is the cardinal rule to remember in collator operation?
16. Explain the *calculating* function.
17. How does the IBM Type 604 calculator receive instructions?
18. What is group multiplication?
19. Explain the *summarizing* function.
20. What IBM machines described in this book perform this function?
21. Explain the terms *accounting machine, EAM* and *EDPM.*
22. How do the tabulators receive their instructions?
23. Explain the terms *list* and *tab.*
24. If a report is prepared that accumulates totals at each control level and the controls are as follows, which level will have the larger total:
    Department Number – Minor
    Division Number – Major
25. What is a *control break*?
26. What controls the feeding of paper through the tabulator?
27. What is *summary punching*? What machines are used?
28. What are the purposes of summary punching?
29. Are changes to reports usually simple to incorporate into the tabulator control panels?
30. What are the functions of punched card data processing?

CHAPTER 6

Case Study

The application which will be explained in this chapter in detail is accounts payable. This is a fairly common application on punched cards and flows through most of the machine operations. Each operation will be explained in detail and keyed to a flow chart by number. The application selected is an actual procedure of the Marquardt Corporation-Pomona Division, Pomona, California.

Requirements

Let us first visualize what is needed before any attempt is made to determine the method of achieving it. First and foremost, checks must be written to pay the company's bills. When the company receives goods or services and is invoiced by a vendor, a check and remittance statement must be prepared for the vendor. For the company's own records, a check register which serves as a record of checks written is needed. The company also needs a distribution report which shows what the money is being expended for. This report is grouped and totaled by account number for posting in the general ledger. Subsidiary account numbers and job numbers can also be used to post to subsidiary ledger accounts. Thus, we see that three different things are required:

1. Checks and remittance statements
2. Check register
3. Distribution report

The next thing which must be determined is the method of capturing the source data needed to accomplish these three requirements. The source document that contains most of the necessary data is the vendor's invoice. Unfortunately, these invoices are found to be unacceptable for key punching because there is no standardization among vendors. The required data is located in a different position on each invoice. The key punch operator would have to spend too much time analyzing the document to perform an efficient transcribing operation. Another problem is that all of the data needed is not always shown on the invoice. Consequently, it was decided by this company to have the accounts payable section copy the necessary data from the invoice onto a worksheet. This seems like a wasted operation, but a certain amount of copying was also required under the manual system, and savings in other areas more than offset the transcribing time. The document upon which the data is recorded has been called an accounts payable audit block. See Figure 36.

Another requirement presents itself in the writing of checks: the need for a vendor name and address file. The vendor's name and address must print on the check. The cards used to write the checks must be keyed to the vendor name and address cards to assure that payment is made to the proper vendor.

ACCOUNTS PAYABLE AUDIT BLOCK

VENDOR NO.	ACCOUNTING MONTH	PAY DUE DATE	ACCTG. DISTRIBUTION	DATE	AUDITED	DATE
10673	4	4-14-60	BY O. J.	4/4	BY R.S.	4-5

INVOICE NO.	INV DATE	COST ELEM	JOA OR ACCT NO	ELEM CODE	WORK ORDER NO	SOURCE CODE	ERROR CODE	DISTRIBUTION AMOUNT	TAX CODE	GROSS AMOUNT	DISCOUNT	NET PAYABLE AMOUNT
7195	3/16		16335		46715	09 00		84 48	3			
✓	✓		16394		✓	✓ ✓		3 36	6	87 84	—	87 84
9350	3/31		16485		47012	06 60		151 98	3	154 96	2 98	151 98

EXTENSION VERIFIED AND P.O. POSTED	DATE		DISTRIBUTION AMOUNT		GROSS AMOUNT	DISCOUNT	NET PAYABLE AMOUNT
BY R.S.	4-5	TOTALS	239 82		242 80	2 98	239 82

MAC D-5023

Figure 36—Accounts Payable Audit Block

The method of accomplishing this is to assign each vendor a code number and to set up a punched card deck of vendor names and addresses. The methods of assigning numbers vary and will be covered in another chapter of this book. In the sample application which is being presented here, the vendor code is a five-digit number which is assigned to cause the vendors to be in alphabetic sequence when they are sorted to vendor number.

Source Document for Key Punching

Let us now examine the audit block used by Marquardt. See Figure 36. Each block will be examined proceeding from left to right. The audit block is prepared when the accounts payable clerk has a purchase order, vendor's invoice and some record indicating that the goods or services have been received. Upon receipt of all of these required documents, the accounts payable clerk proceeds to fill out an audit block as follows:

Vendor Number—The accounts payable clerk looks at the vendor's name and address on the invoice. She then refers to a deck of cards

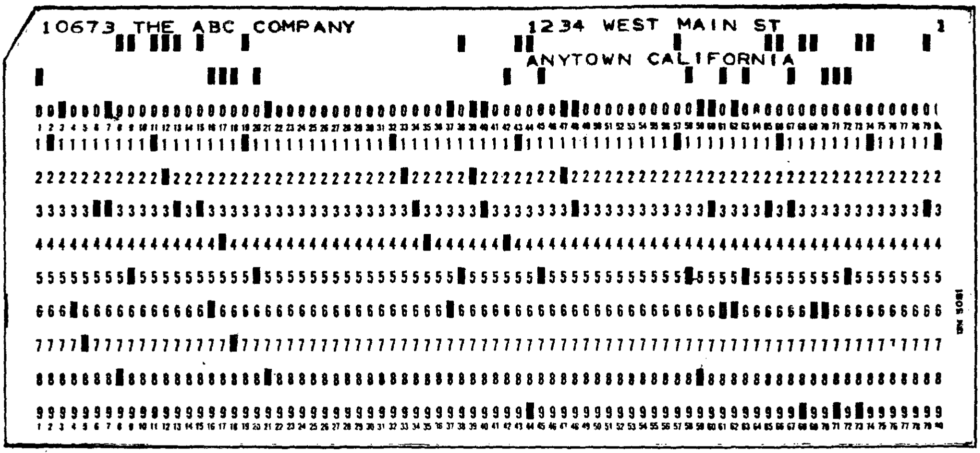


Figure 37—Accounts Payable Name and Address Card

that she has in vendor name sequence. For an example, we will use The ABC Company

Anytown, California

When the clerk receives an invoice for the ABC Company, she looks in her vendor file under the A's until she finds The ABC Company. The vendor name card has the vendor number printed on it also, which in this case is 10673. See Figure 37. She then writes 10673 in the vendor number block.

Accounting Month – The accounts payable clerk enters the number of the accounting period in which the distribution costs are to be recorded. The accounting periods vary from one company to another. At Marquardt the year is divided into 13 accounting periods, each of which contains four weeks. Thus the clerk merely records the number of the current accounting period. The information is useful if it is necessary to check this charge in the future.

Pay Due Date – The accounts payable clerk writes due date shown on the invoice. The policies of payment also vary among companies. The policy of Marquardt is always to take a cash discount. Therefore, the date written here is the last date on which the check can be written and still take advantage of cash discounts for paying within a certain period of time.

By – The accounts payable clerk places her initials in this block.

Date – The accounts payable clerk writes the current date in this block.

By – Another clerk checks the document after it is completed and initials this block.

Date – The clerk who audits the document places the date of checking in this block.

This concludes the data on the first line. Now move down to the body where one line is recorded for each separate distribution required. Recording is as follows:

Invoice Number – The vendor's invoice number is recorded in this block.

Invoice Date – The date of the vendor's invoice is written here.

Cost Element – This is a number used as part of the company's job cost system. The charges illustrated on the sample are charged directly to account numbers; therefore, nothing is written on this block.

JOA or Account Number – The JOA (job order authorization) number or account number is recorded here. The JOA is used to collect costs against jobs. The charges illustrated here are expense items; therefore, account numbers are used. The accounts payable clerk notes the account number written on the purchase order, checks it with the chart of accounts for accuracy and records it. Note that the first two lines are for the same invoice (check marks in the invoice number and invoice date blocks on the second line indicate that the same data is carried down). The first line is charged to account number 16335, which is classified as "operating supplies" in the chart of accounts. The second line is charged to account number 16394, which is "sales tax" in the cahrt of accounts. Thus we see that the accounts payable clerk is predetermining the distribution of this money before it is ever recorded on punched cards.

Element Code – This code, like the cost element, is part of the company's job cost collection numbering system and is not needed on this particular transaction.

Work Order Number – The purchase order number is recorded in this block. It was originally used to record work order number, but the system has been changed to permit purchase order number to be inserted in this block.

Source Code – This is the company's organization code; the first two digits represent department; the last two digits represent section and group. The accounts payable clerk records the source code against whose budget these supplies are being charged. She determines this from the purchase order.

Error Code – If there is an error on the vendor's invoice, the accounts payable clerk corrects it and writes the code number in this block. See the remittance statement in Figure 45 for a breakdown of the codes and their meaning.

Distribution Amount – This is the amount to be distributed to each account number.

Tax Code – This is a code number assigned to each distribution line to permit the preparation of a monthly sales tax report by the data processing department.

*Gross Amount – This is the total amount of each invoice before any discounts are taken.

*Discount – The accounts payable clerk calculates the amount of the discount and records it.

*Net – The accounts payable clerk subtracts the discount from the gross and enters the difference.

*These three blocks are recorded on the last line for each invoice. They are recorded for check and remittance statement writing only and are not used for distribution purposes.

The third line on the audit block in Figure 36 represents another invoice from the same vendor. Any number of invoices can be recorded on an Audit Block as long as they are for the same vendor and have the same due date.

When the accounts payable clerk has completed the audit block for a vendor, she staples the audit block to the front of all invoices and other documents involved, then adds the four amount columns and enters the totals in the bottom block labeled "Totals."

At the end of each day, the accounts payable clerk assembles all audit blocks and runs an adding machine tape of each of the four amount blocks. She checks her figure by taking the total of the gross amounts minus the total of the distribution amounts; the result must also equal the total of the net amounts. Accuracy is extremely important in this application, because it involves the expenditure of the company's money. These tapes verify the accuracy of some of the work done by the accounts payable clerk and supply the data processing department with predetermined totals to which they must balance.

This application, like almost every other application which is being mechanized, will have some exceptions. These exceptions cannot be ignored. However, every effort should be made to minimize them and get them into the standard flow of the application as soon as possible.

The exception problem in accounts payable is the impossibility of writing every check by machine. Some checks are needed between processing dates, and a manual check must be supplied in these cases. If there are too many of these, it may be profitable to write checks in the data processing department more often than once per week. At any rate, whenever a manual check is written, there must be some method to incorporate the necessary data into the data processing system for the preparation of the check register, bank reconciliation card, and distribution reports.

The method used by Marquardt-Pomona is as follows: The accounts payable clerk types the check and remittance statement for the vendor and assigns a check number in the 9XXX series, which is a series of numbers assigned specifically for this purpose. The system is such that these check numbers will never be used by the data processing department.

This separate series of numbers supplies an immediate identification of manually written checks that is useful in checking out problems most of which are generated as a result of this clerical operation.

The accounts payable clerk then fills out an audit block, following the same procedure as for normal processing with the following exceptions:

1. An "X" is placed in the due date block.

2. The check number assigned is written in the work order block.

The "X" in the due date block is the signal to data processing that a check has already been written. The department identifies the cards and handles those manually paid as exceptions, as will be seen in the explanation that follows.

Data Processing Procedure

The source documents are now routed to the data processing department. The processing through that department will be illustrated by a flow chart (Figure 39, pages 82 and 83) and a detailed explanation that accompanies each step. The numbers assigned to the following paragraphs correspond to numbers on the flow chart.

1. The keypunch operator punches one account payable distribution card for each line on the audit block. The three cards that she punches for the audit block shown in Figure 36 are pictured in Figure 39A. The top card is punched from the first line in the body of the audit block; the second card is punched from the second line; and the third card is punched from the last line. Note that the data punched in the various fields of the cards corresponds to the information recorded in the various blocks on the audit block. The only extra data recorded is the Batch "letter" which is punched in column 1. This "letter" is assigned within the data processing department to each batch of documents, and it is also written on the accompanying adding machine tapes so that anything that goes wrong during the processing can be traced back to the batch of documents from which the data originated.

The verifier operator repeats the operation of the keypunch operator. She reads from the source document (audit blocks) and depresses keys on the

ACCOUNTS PAYABLE AUDIT BLOCK

VENDOR NO	ACCOUNTING MONTH	PAY DUE DATE	ACCTG. DISTRIBUTION BY	DATE	AUDITED BY	DATE
27450	4	X	[illegible]	4/4	[illegible]	4/5

INVOICE NO.	INV DATE	COST ELEM	JOA OR ACCT NO	ELEM CODE	WORK ORDER NO	SOURCE CODE	ERROR CODE	DISTRIBUTION AMOUNT	TAX CODE	GROSS AMOUNT	DISCOUNT	NET PAYABLE AMOUNT
65821	3/12		16335		90532	04 00		200 00	3	200 00	—	200 00
EXTENSION VERIFIED AND P.O. POSTED BY [illegible]	DATE 4/5					TOTALS		200 00		200 00	—	200 00

MAC D-5023

Figure 38—Accounts Payable Audit Block for Check Prepared Manually

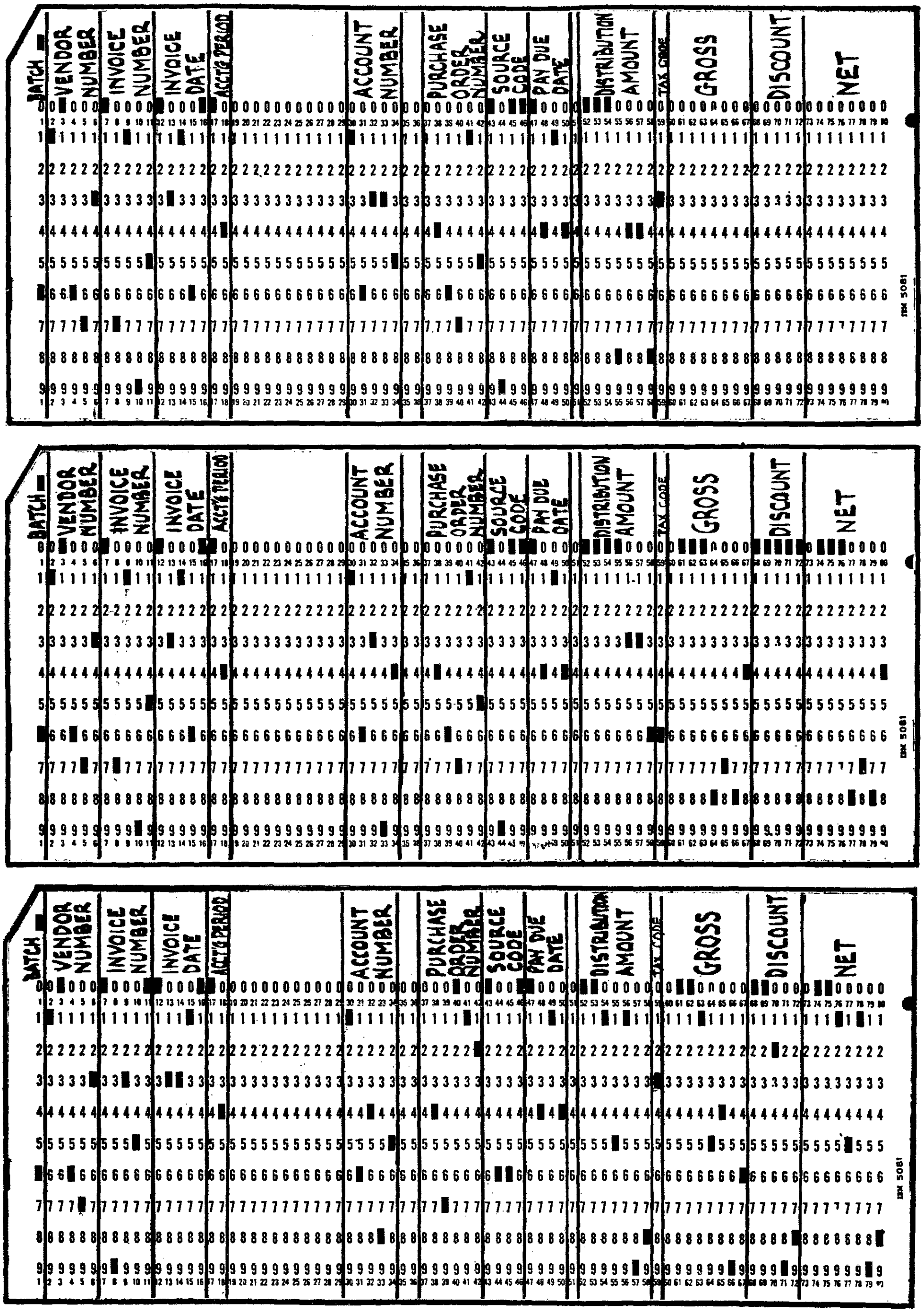


Figure 39a—Distribution Cards

verifier corresponding to the data recorded in each field. If a number or letter has been incorrectly recorded by the key punch operator, the verifier stops and the operator depresses the key again at which time a notch is placed over the column in error. If the card has been punched correctly, the verifier notches the right end of the card. Note the three cards in Figure 39a have notches at the right end indicating that they have been verified and are correct.

The audit blocks for the checks that are manually prepared are sent to data processing in a separate batch. The punching and verifying are the same as for a normal audit block with the following exceptions:

1. Pay due date normally punched in columns 47-50 is omitted and an X-47 is punched. See Figure 40. X-47 is the control punch for all manually paid cards; therefore, a card punched from a manually paid audit block can be recognized at any point in the processing by the X punch in column 47.
2. Each check prepared manually has a check number assigned. This check number is punched in column 37-42 rather than purchase order number.
3. The distribution card is not punched with gross, discount and net. A separate card is punched to be used in preparing the check register. This card is identified by an X punch in column 37. X-37 is used to identify check cards in this procedure (cards from which checks have been or will be prepared). See Figure 40 for the two cards that would be punched from the audit block in Figure 38.

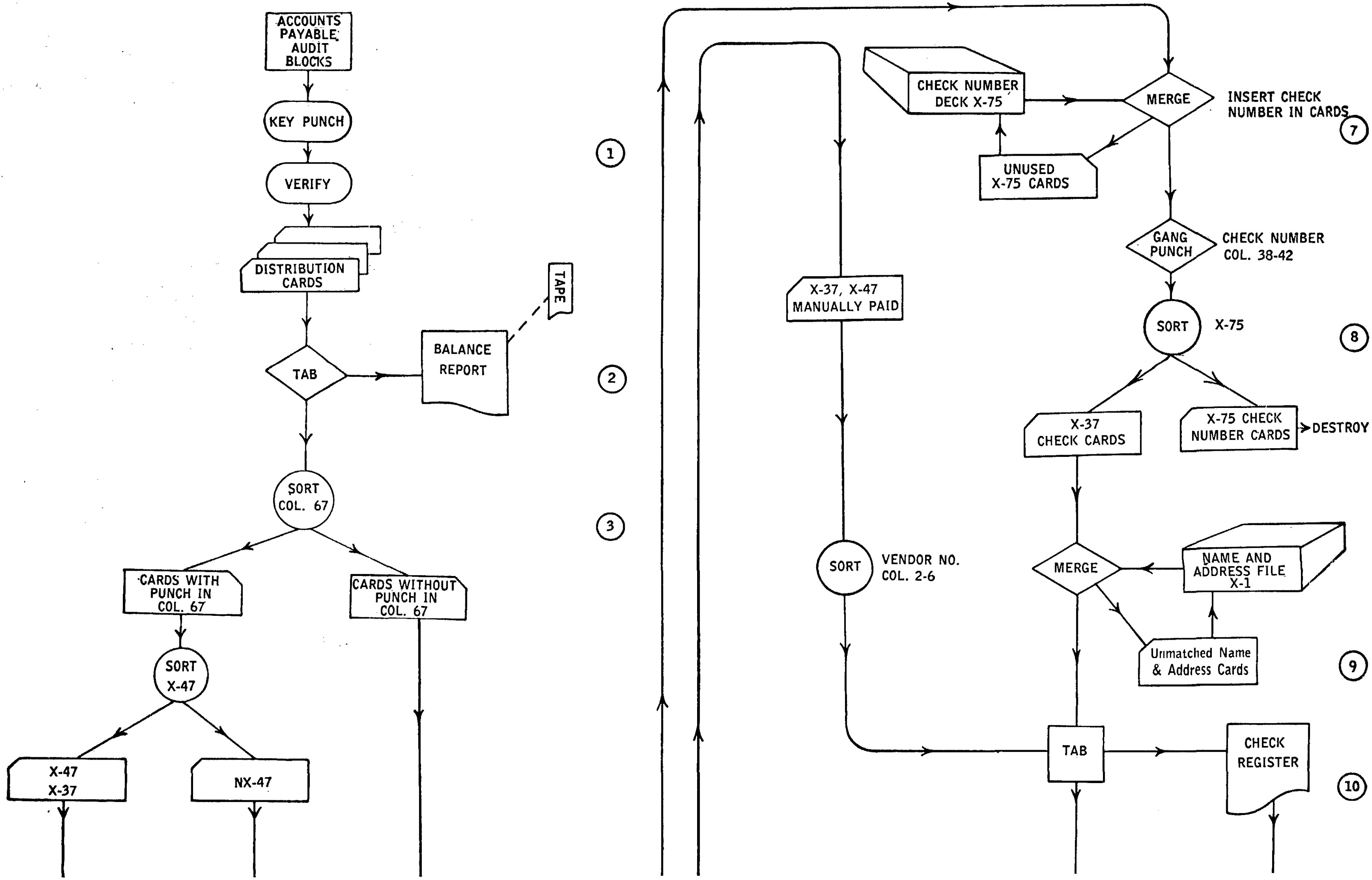
2. The next step is a balancing operation which is inserted because of the extreme importance of accuracy in this application. Each batch of distribution cards is passed through the tabulator, and a total of each of the four amount fields is printed. These are distribution amount, gross amount, discount and net amount. The totals are balanced to the tapes attached to the batch by the accounts payable clerk.

After all batches are balanced, the total of the distribution amounts is entered on the accounts payable control sheet in the column titled "Batch Totals." The total of the manually paid distribution amounts is entered on the accounts payable control sheet in the column titled "Manual Paid Checks." See Figure 41.

3. At this point we have only distribution cards and check cards for checks manually paid, but some of these cards have the information punched in them which is necessary for the preparation of checks and remittance statements (those punched from the last line for an invoice). We wish to pull these cards out and make a separate set of cards from them to use in writing checks.

In order to accomplish this, the first step is to sort on column 67 which separates the cards with punches from those without punches. The cards without a punch in column 67 do *not* have a gross amount and will not be used for check preparation. Consequently, they can be routed directly to the distribution processing. They will fall in the reject pocket on the sorter; the cards with punches will fall into pockets according to the numbers punched.

The cards with a punch in column 67 are recorded with gross amount and contain data needed in the preparation of checks and remittance statements,



ACCOUNTS PAYABLE AUDIT BLOCKS
KEY PUNCH
VERIFY
DISTRIBUTION CARDS
TAB
BALANCE REPORT
TAPE
SORT COL. 67
CARDS WITH PUNCH IN COL. 67
CARDS WITHOUT PUNCH IN COL. 67
SORT X-47
X-47 X-37
NX-47
1
2
3
X-37, X-47 MANUALLY PAID
SORT
VENDOR NO. COL. 2-6
CHECK NUMBER DECK X-75
UNUSED X-75 CARDS
MERGE
INSERT CHECK NUMBER IN CARDS
7
GANG PUNCH
CHECK NUMBER COL. 38-42
SORT
X-75
8
X-37 CHECK CARDS
X-75 CHECK NUMBER CARDS
DESTROY
MERGE
NAME AND ADDRESS FILE X-1
Unmatched Name & Address Cards
9
TAB
CHECK REGISTER
10

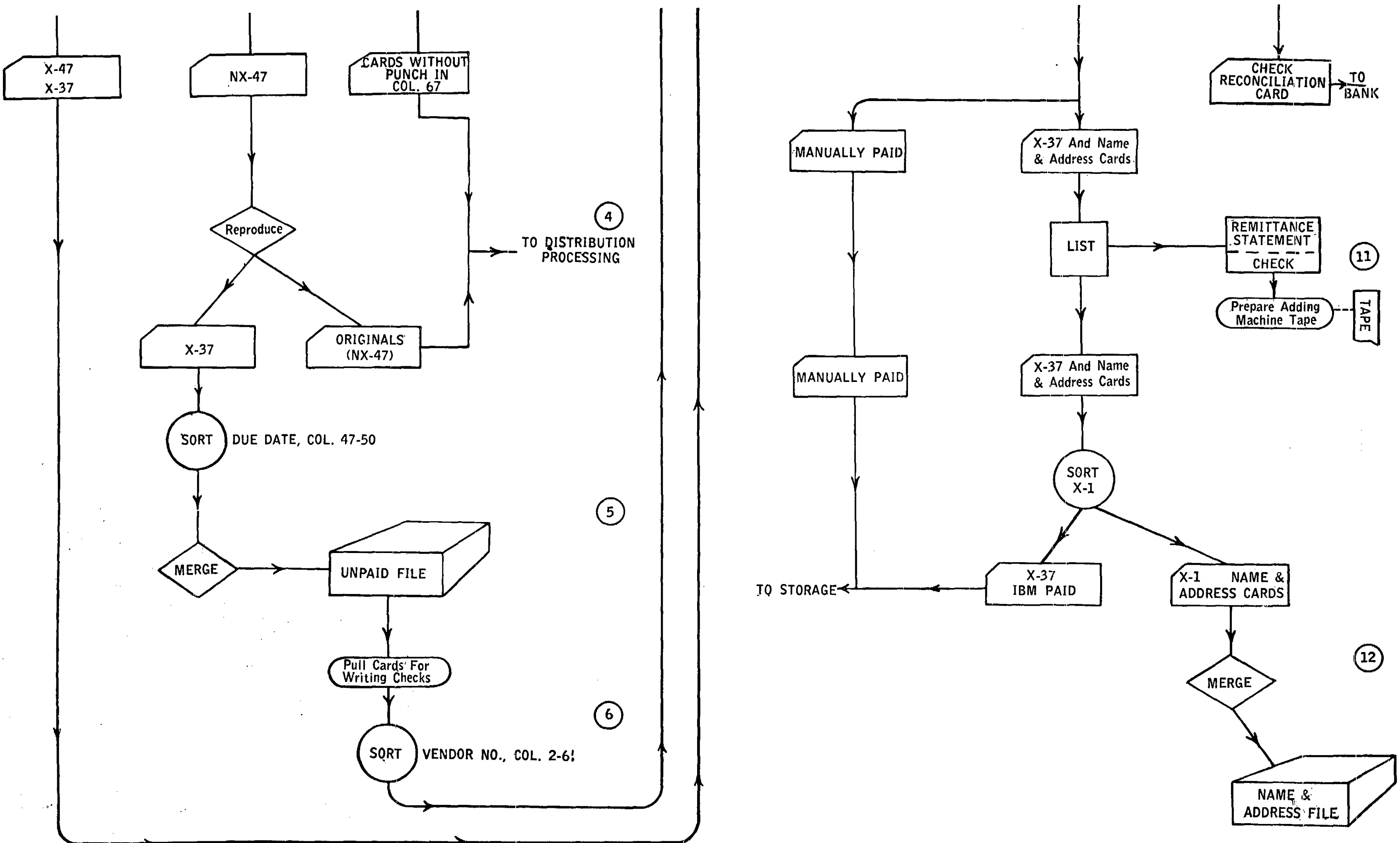
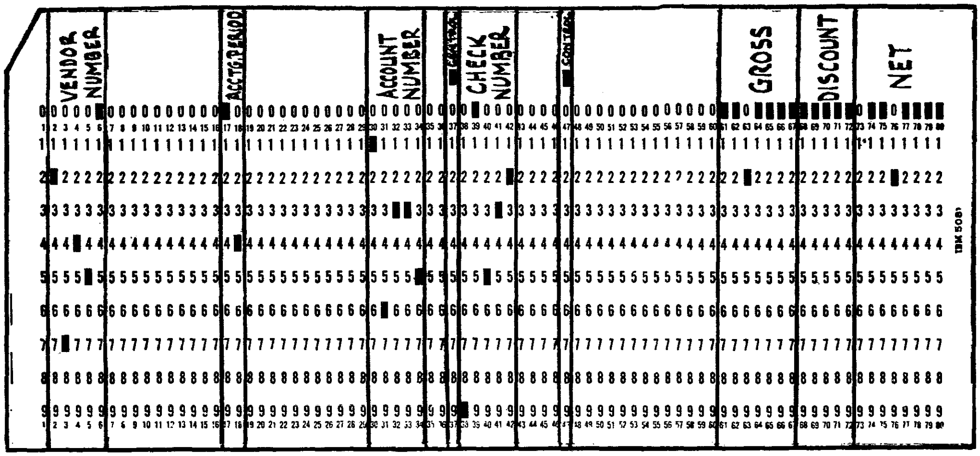
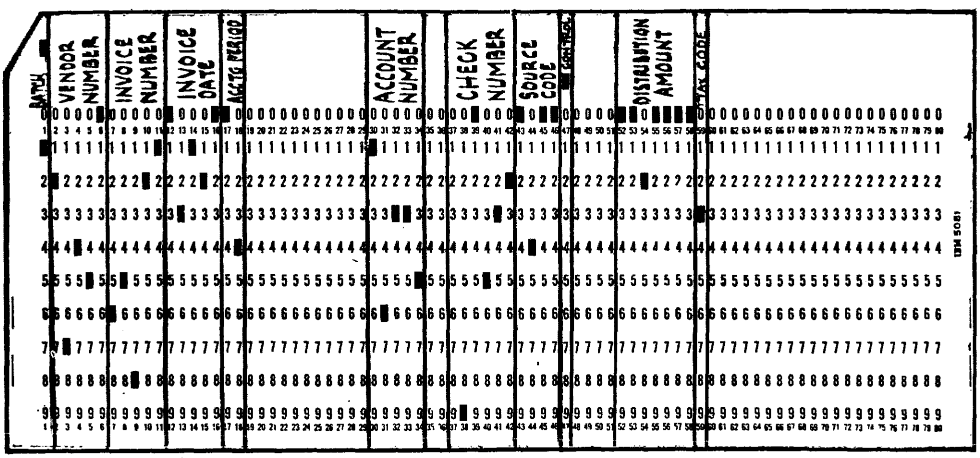


Fig. 39 — Flow Chart Showing Routing of Source Documents Through Data Processing Department



Manually paid check card (X-37, X-47), used for check register—not for distribution.

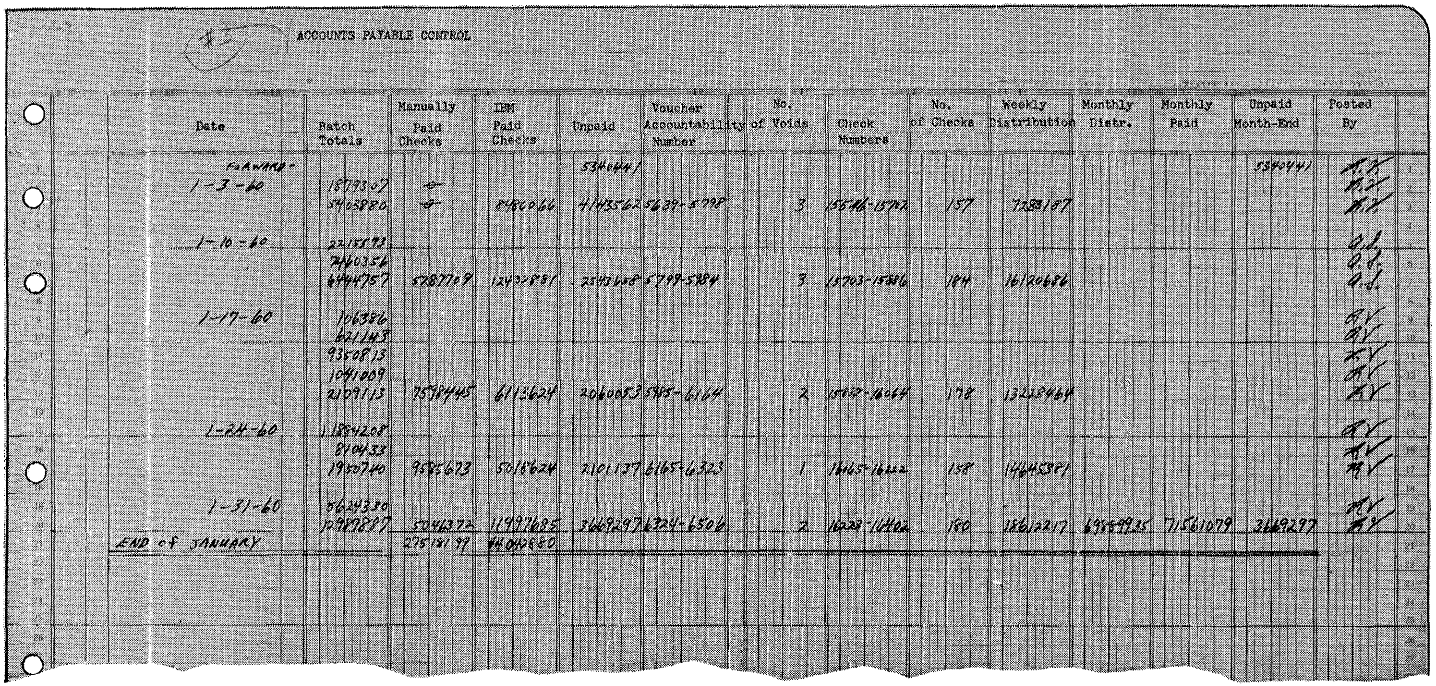


Manually paid distribution card (X-47), used for distribution only.

Figure 40—Check Cards

but some of these represent manually written checks which must be separated. This is accomplished by sorting out the cards with an "X" punch in column 47. The X-47 cards should also have an X-37. The manually paid distribution cards were pulled in step 3 along with other distribution cards that were not punched with gross amount.

The manually paid cards that remain are those that were key punched to use for writing checks and contain an X-37 and X-47 (this method of indicating control X punching is always used: the X followed by a dash and the number of the column in which the control punch is located). The X-37 identifies the cards as check cards and the X-47 identifies them as manually paid checks. Consequently, X-37 and X-47 means that they are manually paid check cards. See the top card in Figure 40. The bottom card also has an X in column



ACCOUNTS PAYABLE CONTROL

Date	Batch Totals	Manually Paid Checks	IBM Paid Checks	Unpaid	Voucher Accountability Number	No. of Voids	Check Numbers	No. of Checks	Weekly Distribution	Monthly Distr.	Monthly Paid	Unpaid Month-End	Posted By
FORWARD –				5340441								5340441	[illegible]
1-3-60	1879307	–											[illegible]
	5403880	–	8460066	4143562	5639-5798	3	15546-15702	157	7283187				[illegible]
1-10-60	2215593												[illegible]
	7460356												[illegible]
	6444757	5287709	12432881	2543658	5799-5984	3	15703-15886	184	16120686				[illegible]
1-17-60	106386												[illegible]
	621143												[illegible]
	9350813												[illegible]
	1041009												[illegible]
	2109113	7598445	6113624	2060053	5985-6164	2	15887-16064	178	13238464				[illegible]
1-24-60	11884208												[illegible]
	810433												[illegible]
	1930740	9585673	5018624	2101137	6165-6323	1	16065-16222	158	14645381				[illegible]
1-31-60	5624330												[illegible]
	10987887	5046372	11997685	3669297	6324-6506	2	16223-16402	180	18612217	69859935	71561079	3669297	[illegible]
END of JANUARY		27518197	44042880										

Figure 41—Accounts Payable Control

47 which identifies it as manually paid; but it does not have an X in column 37 (NX-37), which means that it is *not* a check card.

4. At this step the cards used for writing checks and remittance statements are created by reproducing the NX-47 distribution cards. (X-47 distribution cards are not included because these are the manually paid cards on which checks have already been manually prepared.)

The NX-47 distribution cards are placed in the read feed of the reproducer and blank cards are placed in the punch feed. The panel is wired to reproduce all columns straight across (80-80) with the following exceptions: omit column 1, omit columns 37-42, emit an "X" in column 37.

Column 1 is omitted because it is not needed and it contains zone punching (upper punch of alphabetic batch letter) which happens to coincide with the control punch used in the name and address file (X-1). See Figure 37.

Columns 37-42 are omitted because purchase order number is not needed in check writing. This space will be used later to punch check number.

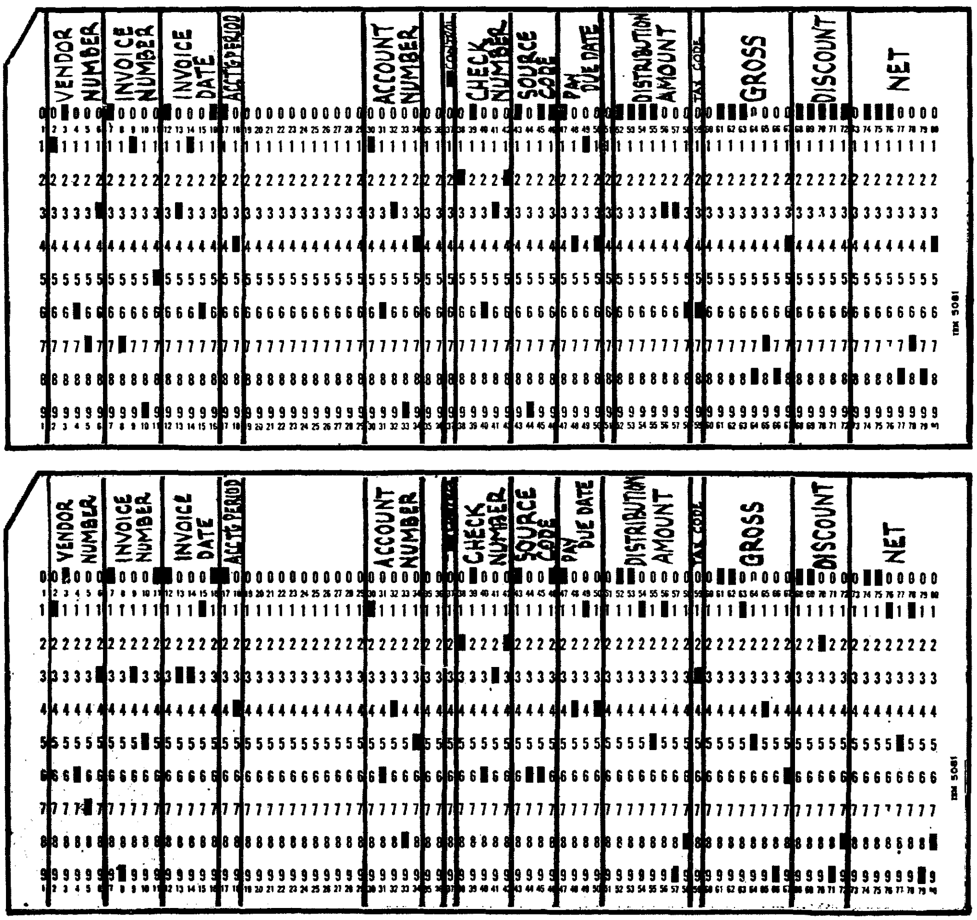


Figure 42—Check Cards

A control punch is placed in the new deck to identify it as an accounts payable check deck (X-37).

The check cards that would be reproduced from the distribution cards in Figure 40 are shown in Figure 42. There are only two cards because there are two invoices involved, as can be seen on the audit block in Figure 40. Invoice number 9350 has only one distribution and will also have one check card. The cards shown in Figure 42 already have a check number punched in columns 38-42. This is inserted at a later step; otherwise, the cards are the same as if they had just been reproduced from the distribution cards. Note that column 1 is blank and that in column 37 there is a control "X" punched.

The original cards, which are NX-47 (not manually paid check cards), are combined with the balance of the distribution cards, which are those that had no gross amount punched in them (see step 3), and routed to the distribution report, which will be covered later.

5. The check cards (X-37) are now sorted to due date. This separates them into groups according to the dates on which the checks are to be written. Other check cards from previous batches are already in the unpaid file awaiting the date for checks to be written from them. The next step is to merge the current batch of X-37 cards into the unpaid file on due date, columns 47-50. This is done on the collator. The unpaid file now contains a card for each check that is to be written on this date, and future dates on which audit blocks have been received in the data processing department. This represents the accounts payable for the company.

6. The check cards which are punched in columns 47-50 with due dates through the current day's date are lifted from the front of the unpaid file. These cards represent the checks that must be written by the data processing department on this date and are sorted to vendor number, columns 2-6.

7. These operations are performed to assign check numbers to the X-37 cards selected in the last step for writing checks. Check numbers are assigned from a "check number" deck that has been prepared in advance. This deck serves as a control over the assignment of numbers and precludes the possibility of assigning duplicate check numbers. The deck is very simple as can be seen by Figure 43. It is simply a deck of cards consecutively numbered in columns 38-42 and an X-75 for control.

The collator control panel is wired to insert one X-75 card in front of each vendor group of X-37 cards. This is done because one check is needed for each vendor regardless of the number of invoices involved. After one check number card has been selected for each vendor group, the remaining X-75 cards are returned to the file. Note how the control "X" punched in column 75 is used to instruct a machine to react in a predetermined manner. At this time, a check number control is posted by recording the numbers punched in the first and last check number cards selected on the accounts payable control sheet in the columns headed "Check Numbers."

The check numbers are punched into the X-37 check cards from the X-75 check number cards on the reproducer by an operation called "interspersed gang punching." The check number is read from the X-75 card and punched into the vendor group of X-37 cards that follow. The control panel is wired

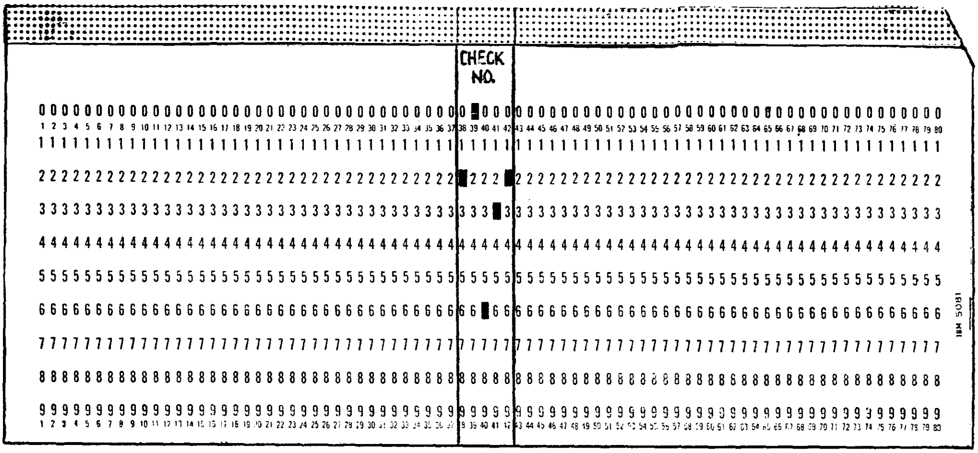


Figure 43 – Check Numbering Card

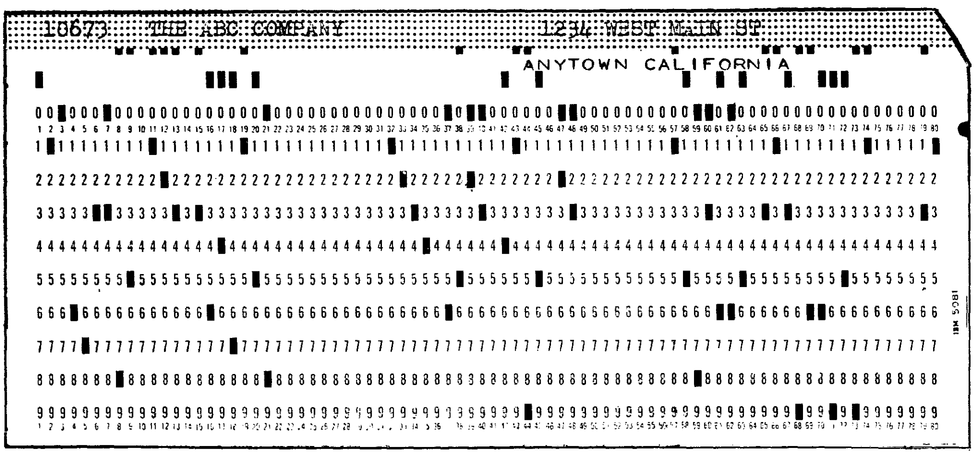


Figure 44—Name and Address File Card

so that the next X-75 card stops the gang punching of the previous number and reads the new number that is to be punched into the following group. Note that here again the control "X" punched in a card is used to instruct a machine.

8. The cards are sorted on X-75 to separate the check number cards from the check cards. The selection of cards with a control "X" punch is very common, and the sorter can be set up to perform this operation in a second or two.

The X-75 cards have served their only purpose (assignment of check numbers) and they are immediately destroyed. This prevents the same numbers from being assigned again.

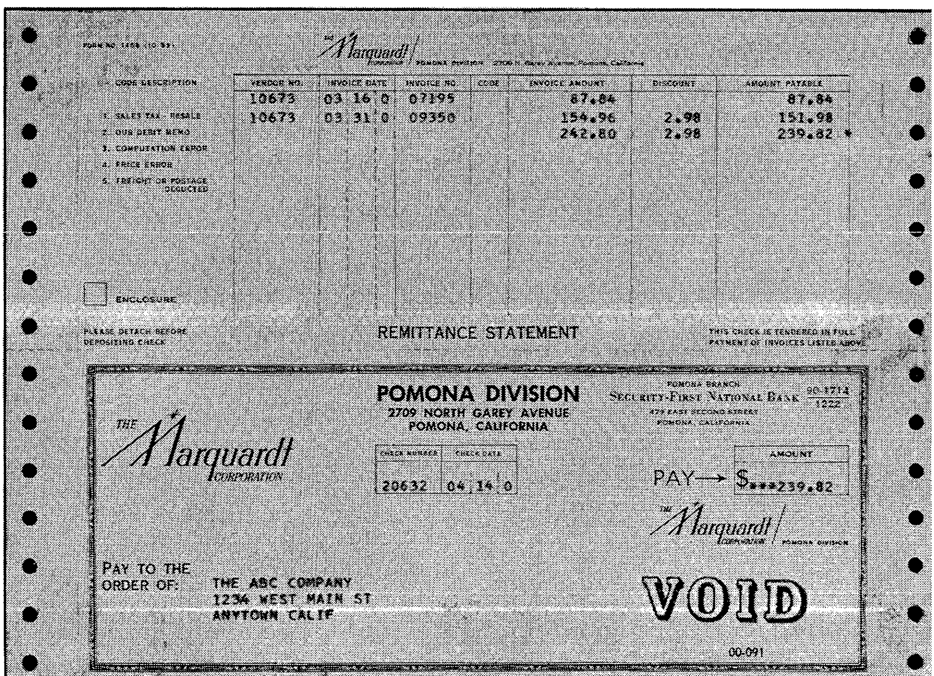
9. The check cards now have the check number punched in them that will print in the check number block on the check. The name and address of the vendor remains to be obtained in some manner, because it is needed to

print on the check and the name must print on the check register. In order to accomplish this, a separate file is maintained for all vendors. In this file, there is one card for each vendor number assigned containing the name and address of that vendor. See Figure 44. If the complete name and address will not fit in one card, a second card is punched. This deck is the same as the deck in the accounts payable section which is used to assign vendor numbers to the audit blocks.

This file is merged *behind* the check cards on vendor number, columns 2-6. The name and address cards are merged behind because the name and address prints last on the check form. See Figure 45. The collator control panel is wired to select unmatched check cards, if any. That is, the collator will automatically select any check card for which there is no name and address card. A name and address card must be prepared for these before proceeding. Unmatched name and address file cards are also selected and returned to the name and address file. This is permissible because checks will not be written for every vendor every week. In fact, only a small part of the file will be selected out for check writing in any one week.

The manually paid X-37, X-47 cards are sorted to vendor number, columns 2-6 in preparation for the check register.

10. The check register is printed on the tabulator. The check register is the record of each check written. Figure 46 shows a sample check register prepared for the one audit block shown in Figure 36. A separate register is



CODE DESCRIPTION
1. SALES TAX - RESALE
2. OUR DEBIT MEMO
3. COMPUTATION ERROR
4. PRICE ERROR
5. FREIGHT OR POSTAGE DEDUCTED

VENDOR NO.	INVOICE DATE	INVOICE NO.	CODE	INVOICE AMOUNT	DISCOUNT	AMOUNT PAYABLE
10673	03 16 0	07195		87.84		87.84
10673	03 31 0	09350		154.96	2.98	151.98
				242.80	2.98	239.82 *

ENCLOSURE

PLEASE DETACH BEFORE DEPOSITING CHECK

REMITTANCE STATEMENT

THIS CHECK IS TENDERED IN FULL PAYMENT OF INVOICES LISTED ABOVE

POMONA DIVISION
2709 NORTH GAREY AVENUE
POMONA, CALIFORNIA

The Marquardt Corporation

POMONA BRANCH
SECURITY-FIRST NATIONAL BANK 90-1714/1222

CHECK NUMBER	CHECK DATE
20632	04 14 0

AMOUNT
PAY→ $***239.82

PAY TO THE ORDER OF: THE ABC COMPANY
1234 WEST MAIN ST
ANYTOWN CALIF

VOID

00-091

Figure 45—Accounts Payable Check with "Piggy Back" Remittance Statement

REPORT 0112 ACCOUNTS PAYABLE CHECK REGISTER

VENDOR NAME	VENDOR #	CHECK #	DATE	GROSS	DISCOUNT	NET	
THE ABC COMPANY	10673	20632	04 14 0	242.80	2.98	239.82	
				242.80	2.98	239.82 *	
				34078.20	250.20	33828.00 *	UNPAID FILE TOTAL

Figure 46—Accounts Payable Check Register

prepared for the manually paid checks, and this is balanced to the accounts payable control sheet, manually paid checks column. The total of the register prepared from the X-37 check cards is entered on the accounts payable control sheet, IBM paid checks column.

The unpaid file from step 6 is tabbed for a total at the end of the register. This total is entered on the accounts payable control sheet, unpaid column. The register is now balanced as follows: unpaid from prior week + batch totals — manually paid checks — IBM paid checks = unpaid. In Figure 41, balancing for the week of 1-3-60 is as follows: $53,404.41 + $18,793.07 + $54,038.80 — $84,800.66 = $41,435.62. Balancing for the week of 1-10-60 is as follows: $41,435.62 + $22,155.73 + $74,603.56 + $64,447.57 — $52,877.09 — $124,328.81 = $25,436.58.

At the time that the check register is prepared, a check reconciliation card is summarized. You will recall that summarizing is an operation in which the tabulator and the reproducer are connected by a cable, and each time that a total is printed by the tabulator, a card is punched with the same information in the reproducer. See Figure 47. These cards are punched with the customer account number, check number, the net amount of each check written, and the vendor number.

The check reconciliation cards are tabbed for a total, which must equal the net amount of the manually paid and the IBM paid checks on the check register. The check reconciliation cards are sent to the bank each month for reconciliation with the cashed checks. The customer account number punched in columns 1-3 is used by the bank to identify each customer for whom reconciliations are being processed.

11. The deck, which still has the name and address cards merged behind the X-37 cards, is used to list the remittance statement and checks that are combined on one form. See Figure 45. A machine total of the net amounts printed on the checks is obtained after all checks are listed. This total must

equal the total of the IBM paid posted on the accounts payable control sheet. The first check number printed and the last check number printed must correspond to the check numbers posted in the check numbers column of the accounts payable control sheet.

It is important that checks be accounted for; consequently, an "accountability" number is consecutively preprinted on the backs of the check forms when they are purchased. The accountability numbers printed on the backs of the first and last checks are posted on the accounts payable control sheet, voucher accountability number column. The number of checks that are spoiled and have to be rewritten are entered in the "Number of Voids" column. (These represent spoiled vouchers, not voided checks.)

The number of checks written is now computed from both the voucher accountability column and the check numbers column. The number must be the same. In Figure 41, the number of checks written as determined from the voucher accountability column would be as follows for the date of 1-3-60: 5798 — 5639 + 1 — 3 = 157. The last voucher number is 5798 and 5639 is the first voucher number. Always add 1, because both the first and last number are used. Subtract the voids.

The number of checks written as determined by the check numbers column would be as follows: 15702 — 15546 + 1 = 157. The last check number assigned is 15702; 15546 is the first check number assigned. Always add 1 because both the first and last numbers are used.

Because of the extreme importance that the checks be accurate, the extra precautionary measure is taken of running an adding machine tape of the net amounts printed on the checks. This total must balance to the machine total of the checks, which in turn balances to the IBM paid checks total.

The audit blocks, check register and the remittance statements and checks are delivered to the accounts payable section for further processing.

12. The cards used to prepare the IBM checks are separated by sorting out the "X's" in column 1 (X-1). The cards that are *not* X-1 (NX-1) are

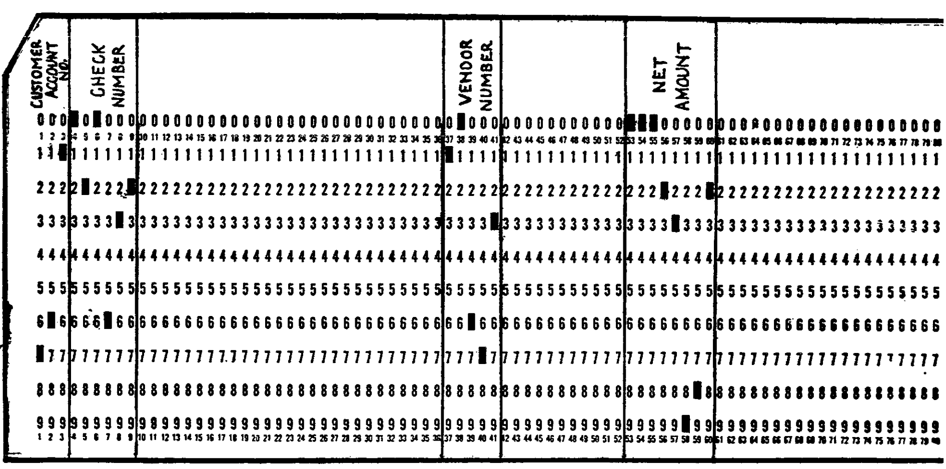


Figure 47—Check Reconciliation Card

X-37. The X-37 cards (IBM paid) and the X-37, X-47 (manually paid) are filed away in storage, as they will not be needed again.

The name and address file is restored by merging on columns 2-6 (vendor number).

This concludes the detailed explanation of the check writing procedure. Do not be discouraged if you did not thoroughly grasp every step along the way the first time through. By this time you have probably realized the significance of the statement made earlier in this book that the concepts of mechanized processing are much different than manual concepts. Note that in each operation, the content of the data has little or no significance except in total; the operator is more concerned with what to do with the data. Also note the emphasis placed upon balancing and controls within the data processing department. This is absolutely essential, as will be pointed out in the chapter on the responsibilities of the data processing department.

In step 4 of the check writing procedure, the distribution cards were routed to distribution processing. The procedure for this phase of the accounts payable application is as follows:

1. The distribution cards are sorted on X-30 to separate the direct from the indirect distribution charges (direct charges are indicated by an "X" punch in column 30).

The direct charges are then sorted as follows:

Department number	columns 43-44	Minor
*Task numbers	columns 31-34	
*Element code	columns 35-36	
*Cost element	column 25	
*JOA number	columns 26-29	Major

*These numbers are peculiar to the cost collection system on direct work only.

Note that the minor control is listed first. This is the least important order

REPORT 0102 ACCOUNTS PAYABLE DISTRIBUTION

04-14-60

DEPT NO	ACCOUNT NUMBER	PO #	MO	TAX	VENDOR NO	INV. NO	INV. DATE	DUE DATE	DISTRIBUTION AMOUNT
0400	16335	90532	04	3	27450	65821	03120		200.00 200.00 *
0900	16335	46715	04	3	10673	7195	03160	0414	84.48 84.48 * 284.48 **
0900	16394	46715	04	6	10673	7195	03160	0414	3.36 3.36 * 3.36 **
									287.84 ***
0660	16485	47012	04	3	10673	9350	03310	0414	151.98 151.98 * 151.98 **
									151.98 ***
									439.82 439.82

Figure 48—Accounts Payable Distribution

of magnitude and is sorted first, followed by task numbers, element code, cost element, and finally the most important (or major) control.

The indirect charges are sorted as follows:

Department number	columns 43-45	Minor
Account number	columns 30-34	Major

2. The direct and indirect distribution reports are prepared separately. As can be seen by the sorting sequence, there is considerable difference between the two; consequently, two different machine set-ups are required. See Figure 48 for an indirect report of the charges shown on the audit block in Figure 36 and Figure 38.

At the time the reports are prepared, summary cards are punched in the reproducer. The direct summary cards are balanced back to the report and routed to the *work in process ledger* procedure. The indirect summary cards are balanced back to the indirect report and routed to the *operating expense ledger* procedure.

The original distribution cards are reproduced to a slightly different card format for the *commitment* application. The original cards are filed away in storage. The reproduced deck is routed to the *commitment* procedure where, along with cards from other sources, it is processed through a series of operations to produce an "open commitment report."

This concludes the weekly accounts payable operations performed by the Marquardt Corporation-Pomona Division. Of course, there are also monthly distribution reports prepared from the source cards and other by-products, such as an approved vendors list which is prepared from the name and address file. However, the routine processing illustrated here has shown an example of most operations, which is the intent of this chapter, rather than the presentation of complete system.

End of Chapter Questions

1. What are the three requirements that are expected from an accounts payable application?
2. What is the original source document? Why are these documents unacceptable for key punching?
3. Why is a vendor name and address file needed? Why is a vendor number assigned to each vendor?
4. How does the accounts payable clerk determine the pay due date to insert on the audit block?
5. When is more than one line entry made in the body of the audit block?
6. Why does the accounts payable clerk prepare adding machine tapes of the four amount blocks? Why is accuracy extremely important?
7. Why are some checks written manually?
8. Why is batch letter punched in the cards?
9. Why isn't pay due date punched in manually paid cards?
10. Explain the purpose of a control "X."
11. Why are NX-47 distribution cards reproduced into cards with an X-37?
12. Why is only one X-37 card reproduced for each invoice number?
13. Why are check cards sorted to due date? What is the unpaid file?

14. How are check numbers assigned?
15. Are unmatched name and address cards permissible? Why?
16. Explain the purpose of *summarizing* at the time the check register is prepared.
17. Explain the controls that protect against loss or theft of blank checks.
18. Explain the controls that assure that the proper number of checks have been written.
19. Why is an adding machine tape of the amounts shown on the checks prepared?
20. Why are distribution reports needed?
21. Why are summary cards punched at the time the distribution reports are prepared?

CHAPTER 7

Controls

Controls have been mentioned throughout this book. The control over the accounts payable application was explained in great detail in Chapter VI. You will recall that a control sheet was illustrated and postings were made to this sheet as soon as control data was available. Subsequent operations were then balanced back to the posted data.

Controls are extremely important because they govern the degree of accuracy with which a data processing department operates. If adequate controls are maintained and all reports issued are properly balanced to these controls, a maximum degree of accuracy will be maintained. There is no legitimate excuse for issuing reports that do not balance. Just what do we mean by "balancing?" It often happens that source data received in the data processing department is incorrect. Consequently, the reports issued are just as incorrect. This is unavoidable within the data processing department and is not what we refer to as being out of balance. It is the responsibility of the data processing department to issue reports as accurately as the source data that was received. If tapes or predetermined totals of some kind were furnished with the source data, these totals must be posted and all subsequent reports must balance back to them. If adding machine tapes or predetermined totals are not available, then the cards that are punched from source documents should be tabbed at the earliest possible operation for a total to establish a control. This total is posted and supplies a control to which all reports prepared from these cards must balance.

It is a well-recognized fact that people working in the data processing department are just as human as anyone else and are just as prone to error. Practically any error is excusable except one: the issuance of a report that is out of balance. Everyone working in the data processing department should be thoroughly impressed with the importance of carefully balancing each report as it is prepared. In doing this, any error that might have been made during the processing cycle will be revealed. As you have seen, most applications require many different operations, and operators handle and process cards at several different machines. The operator's only assurance that he performed all of the operations as called out by the procedure and did not misplace any cards is to balance each report and to scan visually each report for any obvious defects.

An adequate system of controls should be established at the time the job is introduced into the data processing department. The person who converts the application from a manual to punched card system should be responsible for setting up adequate controls and check points, because he is the one most familiar with the application. The procedure for balancing should be incorporated in the operation procedure at each point where balancing is required. This is usually a sub-step in a tabulator operation, because reports are prepared on the tabulator and should be immediately balanced.

The following is an excerpt from a labor distribution procedure:

407-3.2 List the direct labor by department, Report Number 1205
 3.2.1 Use 407 panel number 10
 3.2.2 Use form paper number 133-2
 3.2.3 Balance totals to the Direct Labor Control Sheet.

You will observe that step 3.2 tells what is to be done (list the direct labor by department, Report Number 1205) and is preceded by the number of the machine on which the operation is to be performed (407). The first sub-step, 3.2.1, tells which panel to use (407 panel number 10). The second sub-step, 3.2.2, tells which paper to use (form paper number 133-2). Finally, sub-step 3.2.3 tells how to balance the report after it is finished (balance totals to the direct labor control sheet).

When procedures are written in this manner, standardization further reduces the possibility of error. The first sub-step of a tabulator operation tells which control panel to use, the second sub-step tells which paper to use, and the last step tells how to balance the reports. Other instructions can be inserted as required between the second and last sub-steps.

Generally speaking, the accounting and financial type applications are the easiest to control, because they deal with dollars and cents, are usually historical in nature, and are clearly defined. Some types of applications present more of a problem, especially those which delve into the future or the unknown. Some examples of difficult applications to control are operations research, forecasting, production control, parts requirements, and certain engineering and research type applications.

Visualize the problems in balancing an application which forecasts the load of a machine shop by month over the next six months based upon a master schedule, standard hours for each part to be fabricated and a realization factor for each machine group. The answer is unknown at the time the application is started. In fact, there is no one answer, there are dozens of answers because the final report will print out the number of hours that must be expended in each machine group in each month for the next six months. If there are 20 machine groups, there will be 120 individual answers (6 months $\times$ 20 groups). How can the data processing department be sure that an error has not been made in processing? There is no predetermined total to which the report can be balanced; therefore, additional precautions must be taken at each step. Controls must be set up over the number of cards being processed to assure that no cards are lost or misplaced. Extra steps must be inserted throughout the procedure to check other steps. For instance much of this work must be done on the calculator or on a computer. At the time this operation is set up, extreme care must be taken that every action by the machine is checked even if it requires passing the cards through the machine again using another control panel wired to check the first computation.

"Hash totals" should also be utilized wherever possible. Hash totals are totals of the data punched in a particular field which has no significance other than for control purposes. They may even be totals of apples and oranges. For instance, a hash total could be used in controling a bill of material file by adding all of the quantities together even though some of these quantities may be expressed in pieces while others are in feet, inches, gallons, barrels, etc. An example is as follows:

Part A (screws)	20	pieces
Part B (wire)	100	feet
Part C (paint)	50	gallons
Hash total	170	

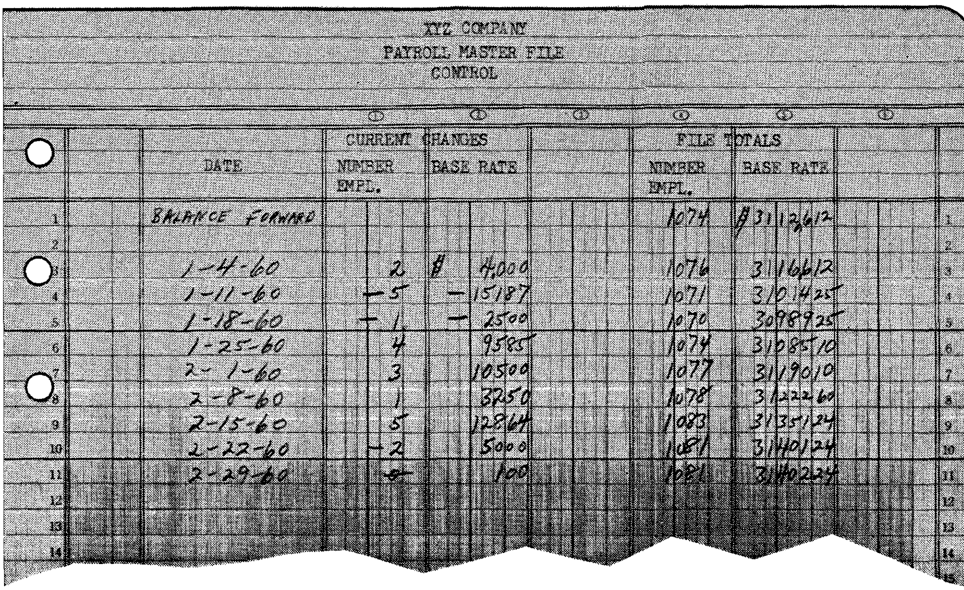
In this example, Parts A, B and C are samples of some of the things needed to build a product, but they are completely different in nature. They would all be intermingled in a bill of material deck along with many other types of parts. To control this bill of material file and to be sure that the quantity field is correct, a hash total control can be established on the quantity field. In the example, the total, 170, has no significance mathematically because screws, wire and paint in three different units of measure have been added together, a violation of one of the elementary rules of mathematics. This hash total can be extremely useful, however, for control purposes.

The controls used in a few different applications will now be illustrated to give you a picture of some of the methods that can be used to assure accuracy.

The first application selected is relatively simple. It is the maintainance of a payroll master file. This is a punched card file which contains a card for each employe in the company. It contains all of the necessary data to be used in conjunction with payroll, labor distribution, personnel accounting and other applications that require data about employes.

It is extremely important that this file be kept up-to-date each week with all personnel changes and that all changes be accurately recorded, because the employes are going to be paid according to the rates recorded in these cards.

Figure 50 shows a typical control sheet used for this application. There are two different sets of figures. One set represents the current changes and the other represents the file totals after these changes have been processed. The source documents are processed to the data processing department from the payroll department. These documents include start notices for new employes, termination notices for the terminating employes, and change of status notices on any employes that have a change in their base rate, department number, number of dependents, etc. These documents are sent to the data processing department by Thursday noon of each week and are effective on



XYZ COMPANY
PAYROLL MASTER FILE
CONTROL

	DATE	CURRENT CHANGES NUMBER EMPL.	CURRENT CHANGES BASE RATE	FILE TOTALS NUMBER EMPL.	FILE TOTALS BASE RATE
1	BALANCE FORWARD			1074	$3112612
2					
3	1-4-60	2	$4000	1076	3116612
4	1-11-60	-5	-15187	1071	3101425
5	1-18-60	-1	-2500	1070	3098925
6	1-25-60	4	9585	1074	3108510
7	2-1-60	3	10500	1077	3119010
8	2-8-60	1	3250	1078	3122260
9	2-15-60	5	12864	1083	3135124
10	2-22-60	-2	5000	1081	3140124
11	2-29-60	-0-	100	1081	3140224
12					
13					
14					

Figure 50—Payroll Master File

the following Monday. An adding machine tape is attached for the number of employes. Each new employe is added and each termination is subtracted. The total is the net difference for that week. In Figure 50, for the week of 1-4-60, the net difference in the number of employes is two. This could represent any combination, such as two new hires with no terminations, or 10 new hires and eight terminations. The important thing here is the net difference, because this is the amount to which the payroll master file control must be adjusted.

The payroll department also prepares a tape on the base hourly rates. The rate for all new employes is added, the rates of terminated employes are subtracted, and the amount of any base rate increases or decreases as shown on the change of status notices are added or subtracted. In Figure 50, the net difference in the base rates on 1-4-60 is $4.000 (the rate is expressed in three decimal places). Again, this difference could represent any combination, such as two new employes hired at $2.000 per hour each, or one at $2.500 and the other at $1.500. It could also be 10 new employes and eight terminations whose rates net out to a difference of $4.000. The important thing here again is the net difference, because this is the amount to which the payroll master file control must be adjusted.

The data processing department key punches cards from the source documents and lists the cards to balance to the tapes. When they are balanced the current changes totals are entered in the payroll master file control and the file totals are calculated. On the week of 1-4-60, the current change of two additional employes is added to the previous total number of employes (1074) as carried forward from the prior year's controls. This gives a total of 1076 employes on the payroll of 1-4-60. The base rate current change of $4,000 is also added to the file total of the base rates as carried forward from the prior year ($3112.612) for a new total of $3116.612. The file is tabbed after all changes have been processed and the totals should equal the control totals calculated for that week.

In the following week, 1-11-60, the employment figure dropped by 5 people as shown by the minus sign in front of the 5. Consequently, the current-changes figure must be subtracted from the previous week's totals. Thus, the new file total for number of employes is determined as follows: 1076 — 5 = 1071. The base rate file total control is computed as follows: $3116.612 — $15.187 = $3101.425.

Note that on the last week recorded, 2-29-60, there was no change in the number of employes but the base rate increased by $.100. This could be caused by an employe receiving an increase in pay or by a combination of new hires and terminations that balanced out but the difference in their rates was $.100. For instance, if one employe was hired at $3.500 per hour and one employe was terminated at $3.400 per hour the result would be as shown in the current changes for 2-29-60.

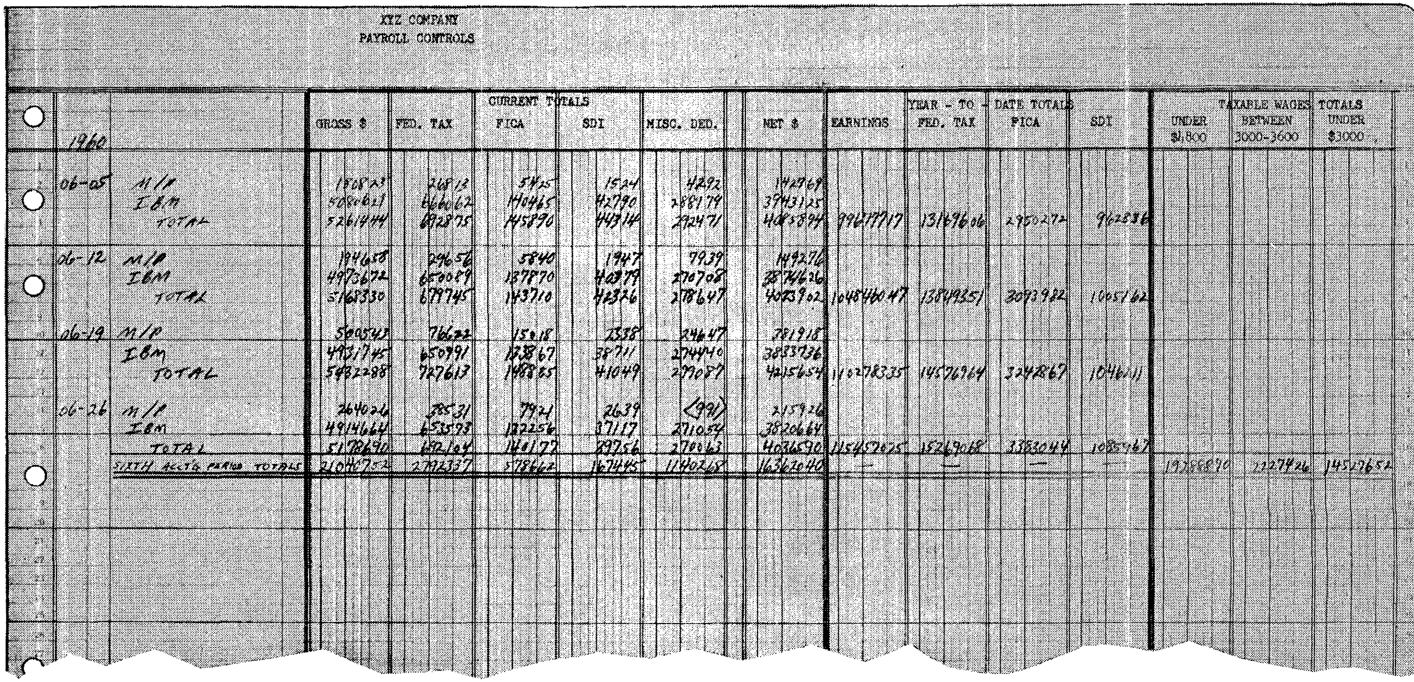
Because of the extreme importance of accuracy in this file, a manual checking operation is also inserted. The payroll department takes the list of changes prepared on the tabulator and visually checks each change made in the data processing department to the source documents. This operation catches any compensating errors that might not have been caught in the data processing department balancing operations.

The next example selected is somewhat more complex but is widely used. It is an example of one of the basic control sheets required for processing a payroll on punched cards. Here again accuracy is of extreme importance and adequate controls are absolutely essential.

This is an application in which many of the totals are calculated in the data processing department. The source documents are the clock cards on which employes clock in and out. These cards are sent to the data processing department each week from the timekeeping department along with an adding machine tape of the hours recorded. A separate tape is prepared for straight time hours, overtime hours, and double time hours. It is extremely important that the timekeeping department accurately compute the time worked for each employe and split out the overtime and double time, because the employes are paid according to the time recorded.

The data processing department punches cards from these clock cards and tabs them to balance to the hours on the tapes. The hours are then entered on a control sheet. The cards are merged with the payroll master file, which contains the base rates, and passed through the calculator to develop gross payroll dollars for each employe. There is no predetermined figure to which the gross payroll dollars can be balanced. Consequently, the cards are again passed through the calculator using a different control panel, which will check all of the calculations performed on the first pass.

The cards are then tabbed for a total and the hours are balanced to the hours control. The dollars are posted in the current totals section of the payroll



XYZ COMPANY
PAYROLL CONTROLS

1960		CURRENT TOTALS GROSS $	FED. TAX	FICA	SDI	MISC. DED.	NET $	YEAR - TO - DATE TOTALS EARNINGS	FED. TAX	FICA	SDI	TAXABLE WAGES TOTALS UNDER $4,800	BETWEEN 3000-3600	UNDER $3000
06-05	M/P	180823	26813	5425	1524	4292	142769							
	IBM	5080621	666062	140465	42790	288179	3943125							
	TOTAL	5261444	692875	145890	44314	292471	4085894	99217717	13169606	2950272	962836			
06-12	M/P	194658	29656	5840	1947	7939	149276							
	IBM	4973672	650089	137870	40379	270708	3874626							
	TOTAL	5168330	679745	143710	42326	278647	4023902	104846047	13849351	3093982	1005162			
06-19	M/P	500543	76622	15018	2338	24647	381918							
	IBM	4931745	650991	133867	38711	274440	3833736							
	TOTAL	5432288	727613	148885	41049	299087	4215654	110278335	14576964	3242867	1046211			
06-26	M/P	264026	38531	7921	2639	<991>	215926							
	IBM	4914664	653593	132256	37117	271054	3820664							
	TOTAL	5178690	692104	140177	39756	270063	4036590	115457025	15269068	3383044	1085967			
	SIXTH ACCT'G PERIOD TOTALS	21040752	2792337	578662	167445	1140268	16362040	—	—	—	—	19788890	2227426	14527652

Figure 51—Payroll Controls

control sheet shown in Figure 51, gross dollar column, on the horizontal line labeled "IBM." This means that this line has been calculated by machine in the data processing department. Note that there is a horizontal line above the IBM line labeled "M/P," which means manually paid. You will recall that in the accounts payable application illustrated in Chapter VI there were manually written checks to handle the exceptions. This is also true of payroll checks. There are invariably checks that must be written manually for some terminations and exceptions such as last minute vacations.

Since these manually paid amounts have already been calculated in the payroll department, they should be sent to the data processing department with adding machine tapes on the following fields: gross dollars, federal tax, FICA, SDI, miscellaneous deductions and net dollars. It is very important that departments preparing adding machine tapes to accompany source documents do an accurate job. The biggest problem encountered by data processing departments in balancing to predetermined totals is the inaccuracy of the predetermined totals. The people preparing the tapes should assure themselves that the tapes are correct. In the example just given of tapes on the manually paid documents, the accuracy of tapes can be checked by cross-footing the resulting totals as follows: gross dollars — federal income tax — FICA (social security) — SDI (state disability insurance) — miscellaneous deductions = net dollars.

The data processing department punches cards from copies of the manually written checks. These cards are tabbed for totals and balanced to the tapes. The gross dollars, federal tax, FICA, SDI, miscellaneous deductions, and net dollars are entered in the payroll controls in the appropriate columns on the horizontal line marked "M/P." The total hours, overtime hours, and double time hours are entered on a payroll and labor distribution hours control sheet.

At this point in a week's processing we have posted all of the current totals on the payroll control sheet for the manually paid and the gross dollars for the calculated cards (IBM paid). We are now ready to calculate taxes on the IBM paid. The year-to-date earnings cards for each employe, which contain his year-to-date earnings, federal income tax, FICA and SDI, are merged with the current earnings cards. Taxes for the current period are calculated. This calculation has already been explained in detail in Chapter V under the calculating function. The cards are passed through the calculator a second time using another control panel which checks the first calculation.

The miscellaneous deduction file must have current changes processed into it before the paychecks can be prepared. The control over this file is a simple total of the amount field for all miscellaneous deductions for which employes have signed payroll deduction authorizations. This file contains deductions such as group insurance, credit union, U.S. Bonds, etc. It does not include payroll tax deductions such as federal income tax, FICA and SDI. After the changes have been processed into the miscellaneous deduction file and it has been tabbed for a total which must balance to the deduction control sheet (Figure 52), the deduction file is merged with the current earnings cards on which IBM checks are to be written. Unmatched deduction cards are selected on the collator during this operation. These selected cards are for employes who will receive no check this week. They are listed off for the payroll department to check. The total of these unused deductions is entered in the deduction control sheet in the unused columns. See Figure 52.

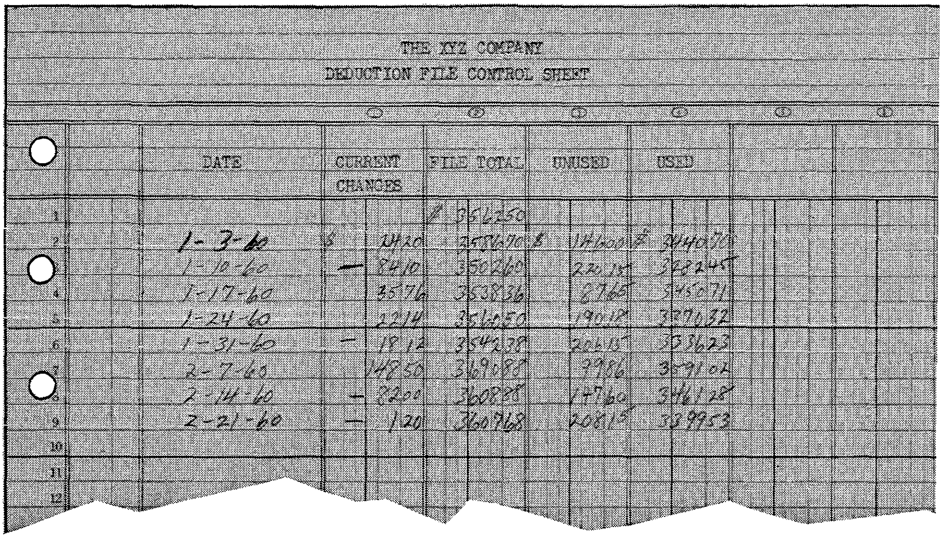
The check register is now prepared from the merged deck of IBM cards and a new year-to-date card is summarized. Totals are obtained at the end of both the manually paid register and the IBM register. The totals of the manually paid gross dollars, federal tax, FICA, SDI, miscellaneous deductions, and net dollars are balanced to the control sheet. The totals on the IBM register of gross dollars are balanced to the payroll control sheet; federal tax, FICA, SDI, and miscellaneous deductions; net dollars are entered in the control book. The miscellaneous deductions are balanced to the deduction control sheet by adding the miscellaneous deduction total on the IBM register to the total of the unused deductions and balancing this total to the file total shown in the deduction controls. A further audit is made by crossfooting the IBM register as follows: gross dollars less federal tax less FICA less SDI less miscellaneous deductions equal net dollars.

The new year-to-date cards for the manually paid are combined with those for the IBM paid and tabbed for totals. The year-to-date cards for employes who are not receiving checks this week are also tabbed (unused year-to-date cards). The totals of these three groups are added together and posted in the year-to-date section of the payroll controls. They are balanced as follows: the current total section is totaled to get IBM paid plus manually paid for the week in each vertical column; the previous year-to-date total for each item is added to the weekly total for that item and should equal the new year-to-date total. For example, in Figure 51, for the week of 06-12-60, balancing of year-to-date earnings would be as follows: \$996,777.17 + 51,683.30 = \$1,048,460.47. Balancing of federal tax would be 131,696.06 + 6,797.45 = 138,493.51. FICA and SDI are balanced in the same manner.

A total of the net pay is obtained at the end of the paychecks. It is balanced to the IBM paid column of net dollars. An adding machine tape is prepared of the net pay printed on the face of the paychecks to double-check the printing and totaling accuracy.

At the end of the month, the weekly totals in each column are added for a monthly total. Taxable wage reports are prepared from the payroll cards, which show the data for each employe as follows: year-to-date earnings, current month's earnings, current month's earnings under \$4800, current month's earnings under \$3000, current month's earnings between \$3000 and \$3600, FICA withheld, and SDI withheld. The total of the year-to-date earnings should balance to the year-to-date earnings total on the last week of the month (\$1,154,570.25 in Figure 51). The monthly earnings must balance to the gross dollars column total for the month (\$210,407.52). The FICA withheld must balance to the FICA column total for the month (\$5,768.62) and the SDI withheld must balance to the SDI column total for the month (\$1,674.45).

The computations of FICA taxes made during the month can now be checked by multiplying the "current month's earnings under \$4800" by 3%. The answer should be within a few cents of the FICA withheld for the month



THE XYZ COMPANY

DEDUCTION FILE CONTROL SHEET

DATE	CURRENT CHANGES	FILE TOTAL	UNUSED	USED
		$ 3562.50		
1-3-60	$ 24.20	3586.70	$ 146.00	$ 3440.70
1-10-60	— 84.10	3502.60	220.15	3282.45
1-17-60	35.76	3538.36	87.65	3450.71
1-24-60	22.14	3560.50	190.18	3370.32
1-31-60	— 18.12	3542.38	206.15	3336.23
2-7-60	148.50	3690.88	99.86	3591.02
2-14-60	— 82.00	3608.88	147.60	3461.28
2-21-60	— 1.20	3607.68	208.15	3399.53

Figure 52—Deduction File Control Sheet

(variances are caused by breakage). The SDI tax computation for the month can be checked in a similar manner by adding the current earnings under $3000 to the current earnings between $3000 and $3600 and multiplying the sum (earnings under $3600) by 1%. The result should be within a few cents of the SDI withheld for the month.

The taxable wages reports can be used to prepare the payroll journal voucher for the month and to develop the accruals for employer's FICA, employer's SUI (state unemployment insurance) and employer's FUI (federal unemployment insurance). These are the taxes that the employer must pay on the payroll in addition to the taxes withheld from the employes. The employer's FICA is at the same rate as the employe's FICA. Consequently, the current earnings under $4800 are multiplied by 3% to obtain this figure. The rates vary for the SUI and FUI. However, they are based on current month's earnings under $3000. It is simply a matter of multiplying this figure by the proper rate to obtain the employer's contribution for each.

Quarterly payroll reports are balanced back to quarterly totals developed on the payroll control sheets, and W-2 forms issued to employes at the end of the year must tie to the year-to-date figures for the last payroll written in the calendar year.

Another example of a control that can be used to check internal machine operations as well as verify the accuracy of the operator's processing is found in an inventory control application. This is an application in which a balance card is maintained for each part in inventory. Whenever activity occurs against this part, the balance card must be updated to reflect the new balance after the transaction has taken place. In the particular application being demonstrated, four balance fields are maintained in each card. These represent the accumulated requirements, quantity on hand, quantity on order, and the

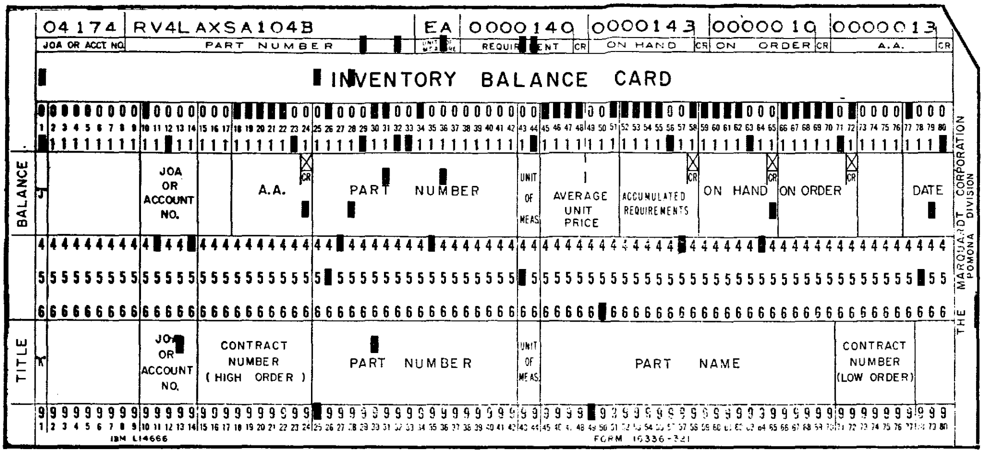


Figure 53—Inventory Balance Card

quantity available. The card shown in Figure 53 is an example of the card form used. The card is punched according to the "balance" format as shown on the face of the card. This same card form is used to punch a title card on new parts. This format is shown on the face of the card in the layout labeled "title." The abbreviation "A.A." is for assembly allowance, the terminology used by this company to designate the quantity available.

As transactions occur they cause various reactions in these balance fields. The fields always crossfoot as follows: on hand + on order — requirements = A.A. Thus we see that each transaction must either add or subtract to two of these balance fields in order to maintain the crossfoot balance.

Transactions must react upon the fields as follows:

Requirement will add to the Accumulated Requirements and subtract from the A.A.

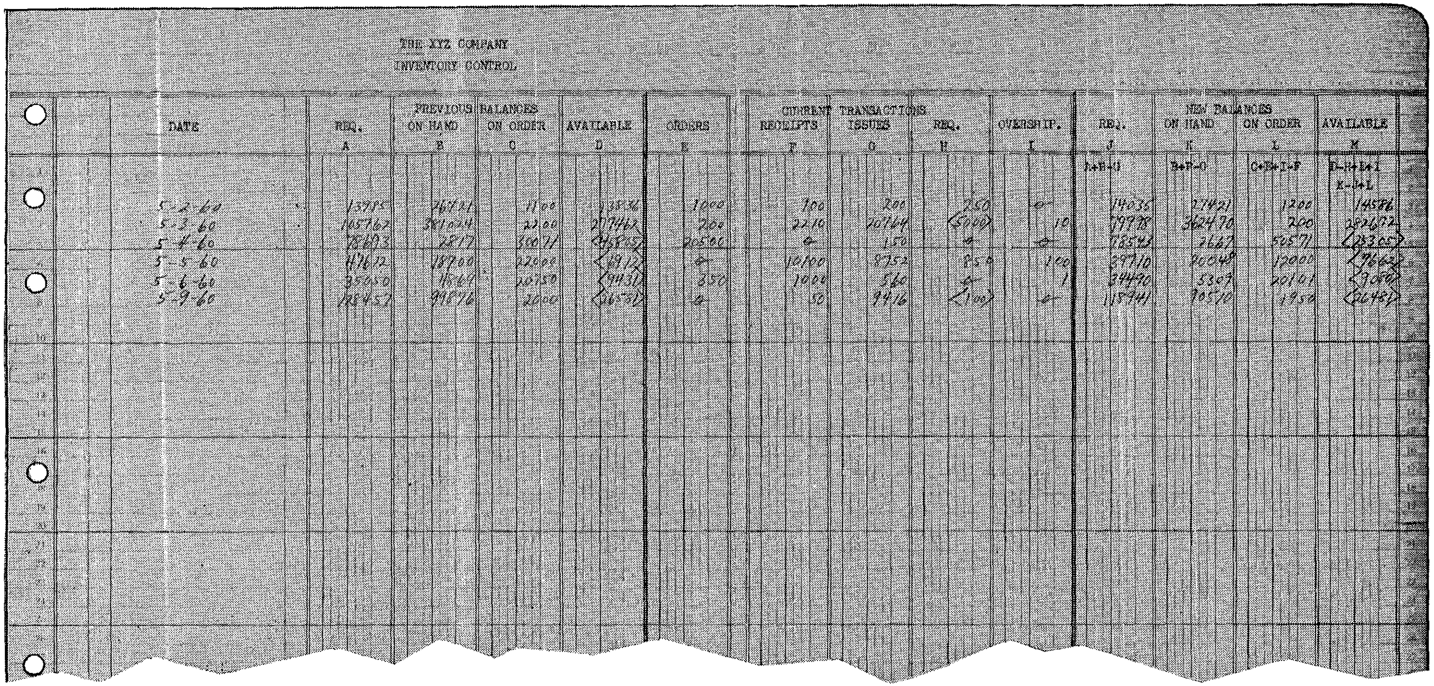
Orders will add to the On Order and add to the A.A.

Receipts will subtract from the On Order and add to the On Hand.

Issues will subtract from the On Hand and subtract from the Accumulated Requirements.

These calculations take place within the IBM Type 407 tabulator as the inventory register is being prepared and new balance cards are being summarized. The tabulator reacts according to a transaction code that is punched in the transaction cards. This code tells the machine whether the transaction is a requirement, order, receipt or issue. The machine then performs the proper calculation according to instructions given it by the control panel. Since there is no way to check this internal machine operation mechanically, it is necessary to set up controls so that each batch can be balanced in total. Figure 54 shows a sample control sheet for checking on operations like this.

Note that the control sheet is divided into three different sections: (1) previous balances, (2) current transactions, and (3) new balances. After the current day's transactions have been merged with the corresponding balance cards and the inventory register prepared, totals are obtained of the current



THE XYZ COMPANY
INVENTORY CONTROL

DATE	PREVIOUS BALANCES REQ. A	ON HAND B	ON ORDER C	AVAILABLE D	ORDERS E	CURRENT TRANSACTIONS RECEIPTS F	ISSUES G	REQ. H	OVERSHIP. I	NEW BALANCES REQ. J	ON HAND K	ON ORDER L	AVAILABLE M
										A+E-G	B+F-G	C+E+I-F	D-H+E+I K-J+L
5-2-60	13785	26721	1100	13836	1000	100	200	250	–	14035	27421	1200	14586
5-3-60	105767	381024	2200	277462	200	2210	20764	<5000>	10	79978	362470	200	282672
5-4-60	78693	2817	30071	<45805>	20500	–	150	–	–	78543	2667	50571	<25305>
5-5-60	47612	18700	22000	<4912>	–	10100	8752	850	100	38710	20048	12000	<9662>
5-6-60	35050	14864	20750	<9431>	350	1000	560	–	1	34490	5309	20101	<9080>
5-9-60	128457	99876	2000	<26581>	–	50	9416	<100>	–	118941	90510	1950	<26481>

Figure 54—Inventory Control

transactions and entered in the appropriate columns under the current transactions. The old balance cards are separated from the current transactions and tabbed for totals of the four balance fields. These totals are entered in the appropriate columns in the previous balance section. The new balance cards which have just been summarized while the inventory register was being printed are tabbed for totals. These totals are entered in the appropriate columns under the new balance section. The totals entered in this control are all "hash totals." They represent the sums of parts in the form of pieces, wire measured in feet, steel measured in square inches, etc. The mathematical formulae should still apply in total just as they applied to each part and each transaction individually.

The new balances can now be checked by substituting the proper quantities in each of the formulae shown in the columns in the new balance section.

Note that the formula for checking the requirements column is A + H — G. The "=J" is not shown but is understood because the formula is in the J column. To check the computation for 5-2-60 work the formula as follows:

$$A + H - G = J$$
$$13985 + 250 - 200 = J$$
$$14035 = J$$

We have proven the machine computation was correct by doing mathematically the same thing that the machine did electrically. The control panel is wired to add all new requirements (H) to the accumulated requirements (A) in the previous balance card. It is also wired to subtract all issues (G). After adding all new requirements and subtracting all issues the result is the new accumulated requirement (J).

The other computations in the balance card for 5-2-60 can be checked as follows:

On Hand

$$B + F - G = K$$
$$26721 + 900 - 200 = K$$
$$27421 = K$$

On Order

$$C + E + I - F = L$$
$$1100 + 1000 + 0 - 900 = L$$
$$1200 = L$$

Available

$$D - H + E + I = M$$
$$13836 - 250 + 1000 + 0 = M$$
$$14586 = M$$

Note that the Available has another formula which further proves the accuracy of all operations and proves the crossfooting correct.

Crossfooting Formula

$$K - J + L = M$$
$$27421 - 14035 + 1200 = M$$
$$14586 = M$$

After checking all New Balances by means of these five formulae, the data processing department can be satisfied that the computations have been performed correctly and the report can be released. This particular report is called the inventory register and is prepared on a special type of paper, because the inventory control department uses it to transfer post the activity for each part to stock ledger cards.

This application like almost all applications has an exception. When an order is placed for 100 parts, the vendor might ship 101 parts for one reason or another. This creates a problem because it reduces the on order column to a negative condition. Here is what happens:

1. When a requirement is processed for 100 pieces it adds to the Accumulated Requirements field and subtracts from the Available field.
2. When the order is processed for 100 pieces it adds to the On Order field and adds to the Available Field.
3. When the parts are received the 101 pieces are added to the On Hand field and subtracted from the On Order field.

This is illustrated one step at a time as follows:

	Accum. Req.	*On Hand*	*On Order*	*Avail.*
1. 100 required	100	0	0	–100
2. 100 ordered	100	0	100	0
3. 101 received	100	101	–1	0

Note that the crossfooting formula works at each step – the balance is always maintained. The problem is that we have obtained an erroneous answer in the On Order column. It is impossible to have "minus one" pieces on order. What we really want to show is that we no longer have any pieces on order but we have ended up with one extra piece. In order to accomplish this the control panel must be wired to check for a negative answer in this column, and if it is negative, add that amount to the Available column.

The steps can now be illustrated as follows:

	Accum. Req.	*On Hand*	*On Order*	*Avail.*
1. 100 required	100	0	0	–100
2. 100 ordered	100	0	100	0
3. 101 received	100	101	–1	0
4. Machine step of transferring negative On Order into available field.	100	101	0	1

Note that the crossfooting formula still works: 101 — 100 = 1. Needless to say this creates havoc with the other formulae. Therefore, another column is set up in the controls to enable us to take into account this exception. This column is "Overshipment," and the tabulator is wired to accumulate a total of pieces transferred from a negative On Order to the Available field and to print this total with the other current transactions.

Now let us work the formulae for the next date, 5-3-60 to illustrate how the Overship columns work:

Requirements

$$A + H - G = J$$

$$105762 + (-5000) - 20764 = J$$

$$79998 = J$$

The requirements were reduced on this date. This can be caused by loss of a contract, engineering changes, cancellation of sales, etc.

On Hand

B + F — G = K

381024 + 2210 — 20764 = K

362470 = K

On Order

C + E + I — F = L

2200 + 200 + 10 — 2210 = L

200 = L

Only 2200 pieces were ordered, but 2210 pieces were received. Consequently, the 10 pieces are added back into this field to cause it to come to zero.

Available

D — H + E + I = M

277462 — (—5000) + 200 + 10 = M

282672 = M

When the "minus 5000" requirements are subtracted, the law of algebra applies and the quantities are added.

The 10 pieces overshipped are added to the Available field because they are extra pieces and because the 10 pieces added to the On Order field must be counterbalanced so that the crossfooting formula will still apply.

Crossfoot

K — J + L = M

362470 — 79998 + 200 = M

282672 = M

Generally speaking, it is better to overcontrol than to undercontrol, especially when an application is first put on machines. Controls take very little time if properly installed. Even the inventory control application just explained requires only a few minutes each day, although it is rather complex and involves several formulae. Balancing, like all other operations, becomes much faster as the operator becomes familiar with it. The explanation is rather complex and requires quite a bit of time, but the day-to-day routine requires very little time. The job could be performed faster if this control were eliminated and probably the results would still be correct most of the time. Unfortunately, most of the times is not good enough; the results must be correct *all* of the time. The data processing department should take *extreme* measures to check the accuracy of all of its work, even the work that takes place inside a machine. Remember, accuracy is one of the principal advantages of mechanization. Speed is also an advantage, and if too much time is devoted to accuracy, speed will be sacrificed. The proper points at which controls should be inserted are one of the challenges placed upon the judgment of the data processing people. It is difficult to state firm rules in connection with controls because the number and type of controls required vary from one type of business to another and from one application to another.

The important thing to remember is that it is the responsibility of the data processing department to issue reports as accurately as the source data that it receives. The least that the data processing department can do is to establish a total of source data and balance subsequent reports back to that total. The number of extra controls that are required depends upon what is needed to assure accuracy. It is impossible to absolutely guarantee 100% accuracy at all times. People are involved and they make mistakes. Machines are also involved and they also make some mistakes, though fewer in number than the humans make. The most that can be expected of the data processing department is that a high degree of accuracy be maintained.

Rerunning of reports should require very little time. Some departments actually operate extra shifts just to rerun reports that were incorrectly prepared on the basic shift. This, obviously, is very poor management and demonstrates a lack of adequate controls. The supervisors of such departments usually look upon controls as "red tape," and they just do not have time to set up and maintain the proper controls. The fallacy of this philosophy is obvious. The time spent in maintaining proper controls and in exercising good management techniques will be offset several times over by the savings generated by increased efficiency to say nothing of the prestige gained by the department.

End of Chapter Questions

1. Why are controls important?
2. What is meant by "balancing?"
3. When should an adequate system of controls be established?
4. What precautions should be taken when predetermined totals are not available for balancing?
5. What are "hash totals?"
6. What is the biggest problem encountered by data processing departments in balancing to predetermined totals?
7. Why is it better to overcontrol than to undercontrol?
8. How accurate must reports be that are issued by the data processing department?
9. What will offset the time spent on controls?

CHAPTER 8

Coding Systems*

The development of civilization can be measured by the growth of man's ability to make use of signs and symbols in communicating ideas to his fellow men.

With the increase in volume and the complexity of ideas and events to be recorded and communicated, these signs and symbols passed through successive stages of picture writing, and on to symbols to represent the picture. Symbols later developed into descriptive letters and words, quantities expressed in numbers, and, finally, the use of numbers to depict description. Such numbers-use constitutes the foundation of coding which contributes so much to economy and convenience, and expedites the recording and handling of facts in modern business.

Coding, in turn, established the possibility of, and the necessity for, logical classification to amplify and augment basic meanings. Thus, classification presented a simple means of discovering order through generalizations, and logically there are as many "best" classifications as there are purposes to be served.

Events or transactions which affect a given business must be classified in many ways so that the full significance of an item may be known in as many phases of management as possible. Therefore, the use of numbers in the construction of codes must go hand-in-hand with a consideration of the purpose such codes will serve.

The selection of the proper code for a specific accounting problem involves not only coding for identification, but also coding which will aid in machine operations which precede and include the preparation of a desired report. Through the ability of the IBM accounting machine to distinguish between successive code numbers, such functions as addition, subtraction, printing, totaling, identification, spacing, etc., are initiated.

Code construction is a complicated task whose development requires a full awareness of all factors present in a particular problem. It should be preceded by a complete appraisal of the job to be done and a consideration of all pos-

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sible methods of accomplishment. Often, a given job will entail the combination of different specific codes in the preparation of a final, workable code.

Proper coding is vital to the successful operation of an accounting machine application, therefore it is important to develop the right code for the right situation. The construction of an adequate code should include exhaustive consideration to the following characteristics:

(1) Flexibility – the code should provide room for additional entries in sequence.

(2) Scope – the code should be designed to allow expansion to include additional categories.

(3) Operation – the code should be adequate for all required accounting machine segregations.

(4) Convenience – the code should be easy to assign.

(5) Construction – the code should include the least possible number of digits consistent with the problem, to reduce punching and sorting effort to a minimum.

(6) Identification – the code should, if possible, facilitate visual identification.

It is the purpose of this book to discuss some specific methods of coding and to indicate how various codes may be prepared and applied.

Automatic Application of Codes

The application of coded designations is often mistakenly considered to be a necessarily burdensome sequence of reference, manual transfer from reference to source data, manual recording in IBM cards, and the subsequent verification of that recording. Still left indeterminate, however, is the accuracy of the original transfer from reference to source document.

MASTER CODE CARDS – Data transfer by duplication:

Prepunched master code cards, filed in the basic sequence of reference, provide a ready means of meeting a difficult coding situation. Such code cards can carry a multiplicity of items of data not all of which are necessarily applicable to a single part of a process, but all of which are subject to use in various operations. As a very active example, a master employe file for use in payroll accounting may record such a variety of data as employe name, location, occupation, rate of pay, social security number, dependency status, etc.

In this instance the basic sequence of reference would be the individual's clock or working number recorded in the card, which is usually applied in alphabetical order. This provides for ready location of a card by name, or number, and is also the medium for restoring the file to its permanent basis of reference or employe name.

Cards manually removed from the file and associated with corresponding source time returns, payroll deduction authorities, insurance applications, address changes, etc., are used to automatically transfer the essential coded data to the corresponding IBM detail cards being prepared. After use, the master card is returned to file for re-use.

The advantages of the use of master code cards are:

1. Elimination of manual transcription from code record to source document.
2. Verification of such transcription is avoided.
3. Eliminates manual punching of coded data into detail cards.
4. The automatic accuracy of the duplicating punch mechanism makes verification superfluous.

PREPUNCHED CODE CARDS – Non-Recurrent Use:

Similar to the preceding method in the preparation of the code cards and file, this plan requires that the cards be created in the required quantities to provide a prepunched supply or reservoir file. Individual cards are extracted from the file and associated with the corresponding source documents. Detail data to complete the record of the transaction is punched into the code card itself. In the instance of multiple transactions of the same code group, the code card is utilized as a duplicating medium to record the coded material in succeeding detail cards.

Each of these methods has its own advantages, the choice being wholly dependent upon the circumstances under which it is to be applied; however, the factors of accuracy and time saving are equally beneficial under either plan.

AUTOMATIC DECODING – Alphabetical Designations:

Master code cards serve the distinctive and highly valuable function of automatic decoding of facts which during processing acquired numerical designations. This feature is particularly of value when constructing final or managerial reports.

The master code cards and the detail cards with which they are to be associated are designed with a common numerical control or reference field. Thus, the masters may be automatically merged by sorting or collating into the file of detail cards.

In the subsequent processing on the IBM alphabetic accounting machine, the alphabetic designation or descriptive matter is listed from the master card while the detail cards that follow are summarized under the corresponding classification, thus effecting automatic decoding of the report or exhibit under preparation.

THE LINE SELECTION DEVICE – Automatic Decoding:

The line selection device for IBM 402 and 403 accounting machines provides another, and perhaps the simplest, method of decoding yet known. It is based on the use of printed forms bearing printed alphabetic descriptions and a two-digit code number corresponding to each line or item of the report. These line numbers are punched into the carriage control tape which automatically causes the carriage to associate itself with each given line number embodied in the code punched into the cards. The carriage, therefore, is controlled to advance to the next active line printing position as indicated by the agreement of the codes in the tape and card. This assures the registration of quantitative or other numerical data opposite the proper and corresponding alphabetic description on the report.

The use of alphabetic decoding cards is eliminated along with machine operations otherwise necessary to place and remove code cards in the base file.

Self Checking Number System

Applicable to all usual kinds of codes, the IBM self checking number feature of the 24 and 26 card punches can be used to verify the accuracy of the application and punching of code numbers.

The system is based on the addition to the original number of an extra or terminal digit. Known as a "check digit," this figure is determined by a special computation of the digits in the original number, and sets up an almost airtight protection against erroneous designations. The check number must always be keyed to follow the last possible digit in the original number. As an example, in verifying so-called decimal codes that terminate in a varying number of digits beyond the decimal point, sufficient spaces or zeros must be punched following the code number in order to assure the placement of the check number in a predetermined card column.

Briefly, the check digit is established by considering the units digit, and each alternate digit to the left, to be a whole number. This number is multiplied by two and the digits in the product and the intervening digits which were not inflated are cross added. The sum is subtracted from the next highest number ending in zero. The difference is the check number.

Both numerical and alphabetical codes can be checked in this way as the device adds the lower zone character of an alphabetic symbol in the same manner in which it handles a number. The possibility of an error in only the upper zone is practically non-existent. Thus, all of the various types of codes mentioned in this book are subject to verification by means of the checking device.

	Code	*Check Digit*
NUMERIC	12345	5
	13245	6
	28792	0
ALPH-NUM	BA123	5
	AB123	6
	Z4321	7

Sequence Codes

The simplest method of coding that can be utilized is the sequence method. It consists of the simple assignment of numbers, starting with one, to a list of items arranged in any order. An example follows:

No.	*Salesman*
1	George Adams
2	John Beldon
3	Arthur Brown
4	John Calahan
5	Thomas Dalton
6	William Elkton
7	Earnest Eton
8	Charles Franklyn
9	Louis Gordon
	etc.

The sequence method does not provide for any classifying of groups and cannot be used where such requirements exist. It provides the best and only practical plan for coding lists of not more than 20 or 30 items, or for numbering longer lists where there is absolute assurance that no classification will ever be needed.

A sequence code always requires memorization or decoding, therefore the original list to be numbered should be arranged in some logical order to aid in this process. The code illustrated has been arranged in alphabetical order of last name.

New names or items are assigned to the next highest number; therefore, the order of the original list will not be maintained indefinitely unless the list is fixed in character. If it is desired to maintain a definite arrangement, the original list may be assigned to every second, third or fourth number, and new items inserted in their proper place in the arrangement. Generally speaking, a sequence code should not be employed where arrangement is a vital factor.

The sequence method of coding, due to its simplicity and unlimited expansion, has been mistakenly applied again and again to long lists of items or names, with the result that there can be no quick grouping by any classification, and reference must be made to group lists. When such a condition is encountered, a new scientifically constructed code should be designed along the lines set forth in the various sections of this manual.

The sequence plan of coding has a vital function in connection with most of the more comprehensive methods of coding, inasmuch as subdivisions of larger groups are usually coded in sequence. This principle can be employed to advantage where a combination of article numbers, descriptive codes and dimensions are used for identifying individual items. In these cases the use of ordinary coding principles results in a great many digits.

For example:

1839 (Mirror)–32	(Walnut)	14″ x 18″ – 11	(Bevel Edge)
1839 (Mirror)–32	(Walnut)	14″ x 20″ – 12	(Square Edge)
1839 (Mirror)–35	(Mahogany)	14″ x 18″ – 11	(Bevel Edge)
1839 (Mirror)–35	(Mahogany)	14″ x 20″ – 12	(Square Edge)

Twelve digits are required here because finishes and edges are coded according to a standard code for all articles, and because sizes have been used directly. Decoding requires reference to two code lists, one for finish and one for edge.

The same conditions can be met by the following sequence coding of subdivisions:

1839 Mirror – Item 1
1839 Mirror – Item 2
1839 Mirror – Item 3
1839 Mirror – Item 4

Thus one digit replaces eight, and decoding can be done at one operation instead of two.

In this manner sequence coding may be used to avoid the disadvantages of an over-coding situation, and in some cases will provide a quicker identification than a complicated, though scientifically constructed code.

Block Codes

This term is applied to codes which utilize groups or blocks of numbers in sequence to represent classifications. These blocks are not arranged according to tens, hundreds, or thousands, but according to any desired number of units. An example follows:

1	Razor blades—packed 10	
2	Razor blades—packed 12	
3	Razor blades—packed 50	1—5 Blades
4		
5		
6	Hoe Type Razor—Gold	
7	Hoe Type Razor—Silver	
8	Hoe Type Razor—Nickel	
9	Hoe Type Razor—Style H	6—12 Hoe Type
10	Hoe Type Razor—Style K	
11		
12		
13	Straight Razor—Black	
14	Straight Razor—Ivory	13—16 Straight
15		
16		
	etc.	

Block coding provides a method of coding by classes where the number of digits must be limited, as it provides more groups with less digits than any other class coding plan. Expansion is also provided in a limited way by the reserving of vacant numbers in each group.

The above principle can be brought out by a simple analysis of the illustrated code. Three groups with their individual items have been covered in the first 16 numbers, therefore 18 similar groups could be handled in the first two digits, or 99 numbers. In an ordinary group coding of the same items, it would be necessary to allow two digits to indicate the groups, and a third digit would be required for the individual items under the groups. Thus the block code has taken one digit less than the corresponding group code.

Block coding as a principle also has a function in combination with other codes for the designating of subdivisions and the signalling of special information. For example, in the following code of operating accounts, the numbers of the subdivisions of each account have been assigned according to the block principle.

10 Receiving Labor		
	1 Supervision	
	2 Cleaning and Janitor	1—3 Indirect
	3 Other Labor	

4 Trucking	
5 Receiving	
6 Stacking	4–9 Direct
7 Sorting	
8 Viners	
11 Preparation Labor	
1 Supervision	
2 Cleaning and Janitor	1–3 Indirect
3 Other Labor	
4 Serving Cutters	
5 Cutting and Sorting	
6 Lye Peeler and Blancher	
7 Sorting Belt Work	4–9 Direct
8 Grading	
9 Slicing	

Group Classification Codes

Group classification codes are those codes in which major and minor classifications are represented by the succeeding digits of the numbers, and are the most efficient for ordinary coding problems. An example follows:

1000 Materials
  1100 Production Materials
    1110 Brass
      1111 Strips
      1112 Sheets
      1113 Bars
      1114 Castings
    1120 Steel
      1121 Plates
      1122 Strips
      1123 Wire
      1124 Bars
      etc.

In the above code all digits except the last represent a definite classification in such a way that a sort on the peculiar digit representing any desired classification will accomplish a complete separation.

When constructing a group code, it is well to start each subdivision with the numeral "1" rather than "0," leaving the latter open to indicate the groups. In the sample code, for example, the first detail item is No. 1111 and no use is made of the numbers 1000 to 1110 other than to indicate the groups. If this wasting of 110 numbers in each major group is not desirable from a capacity standpoint, they may be assigned completely or partially as follows:

1000 – Materials – Production – Brass
  1001 Strips
  1002 Sheets
  1003 Bars
  1004 Castings

1010 – Materials – Production – Steel
1011 Plates
1012 Strips
1013 Wire
1014 Bars
etc.

This arrangement does not affect the efficiency of the code. It only tends to consolidate the names and numerical designations of the groups.

In many cases it will be found that there will be more than nine or 10 individual items to a group, thus breaking the ideal arrangement of the code. When this occurs two sets of numbers may be consolidated into one group as follows:

10 – Roadside and Grade
11 – Earth Work and Embankments
12 – Earth Shoulders
13 – Metal Shoulders
20 & 30 – Drainage Structures
21 – Bridges 100′ span or more
22 – Bridges under 100′ span
23 – Culverts
24 – Curb and Gutter
25 – Catch Basins
26 – Ditches
27 – Spillways
28 – Tile Lines
29 – Baffle Walls and Weirs
30 – Stream Channels
31 – Intakes
40 – Grade Separations
41 – Viaducts over Railroads
42 – Viaducts over Highways
43 – Subways under Railroads
44 – Subways under Highways

Group classification codes are so easily constructed and so popular, that they are often applied where there is no use for them. Where automatic summarization and recognition of definite groups is not a vital factor, a sequence code or block code will sometimes accomplish the purpose with fewer digits.

Significant Digit Codes

This term has been applied to codes wherein all or some of the digits represent weight, dimension, distance, capacity, or any other factor which has been transferred bodily into the code. In one sense this is not actual coding, as these factors determine the numbers without coding.

The primary object of significant digit codes is to eliminate or reduce the work of decoding by providing a code number that is directly readable. A secondary object is the provision of a means of expansion according to the schedule predetermined by the factor included in the code. An example follows:

Code Number	*R. R. Station Name*	
010	Leeds	Mo.
013	Edgecomb	Mo.
015	Swope Park	Mo.
017	Dodson	Mo.
019	Holmes	Mo.
058	Abbott	Okla.
116	Cleveland	Mo.
275	West Line	Mo.
375	Acorn	Ark.

The number representing the name of the station in this case is determined by its distance in miles from a starting point.

The following five-digit code explains how this principle of coding may be applied to various articles. In the examples, the first two columns are for group classification only. The other columns are devoted to unit classification in which the significant digit code is illustrated.

In this first example the code numbers are expressed in inches, and correspond to the length of the files.

10000 Files
- 10004 – 4″ Files
- 10005 – 5″ Files
- 10006 – 6″ Files
- 10012 – 12″ Files
- 10015 – 15″ Files
- 10018 – 18″ Files

In the following instance the code numbers correspond to the size of the bulbs expressed in watts.

13000 Bulbs, Electric Light
- 13020 – 20 Watt Bulbs
- 13025 – 25 Watt Bulbs
- 13040 – 40 Watt Bulbs
- 13060 – 60 Watt Bulbs
- 13100 – 100 Watt Bulbs
- 13200 – 200 Watt Bulbs

In the following code, the hundreds column is used in indicating the width of the chisels in inches. The tens and units columns indicate less than one inch expressed in sixty-fourths of an inch, which is the common denominator of the fractions.

11000 Wood Chisels
- 11008 – ⅛″ Chisel
- 11016 – ¼″ Chisel
- 11024 – ⅜″ Chisel
- 11032 – ½″ Chisel
- 11140 – 1⅝″ Chisel
- 11148 – 1¾″ Chisel
- 11200 – 2″ Chisel
- 11256 – 2⅞″ Chisel

In the code below, the numbers for the diameter are placed in the hundreds column expressed in thirty-seconds of an inch, the tens column gives the length of the pins in inches and the unit column shows the fractional lengths in eighth inches.

12000	Pins, Cotter
	12310 – 3/32″ diameter by 1″ Length pins
	12314 – 3/32″ diameter by 1½″ Length pins
	12410 – 1/8″ diameter by 1″ Length pins
	12412 – 1/8″ diameter by 1¼″ Length pins
	12414 – 1/8″ diameter by 1½″ Length pins

The following code gives directly the weight of the contents each kind of sack is designed to hold.

14000	Sacks, Cotton
	14025 – 25 lb. sacks
	14028 – 28 lb. sacks
	14035 – 35 lb. sacks
	14050 – 50 lb. sacks
	14056 – 56 lb. sacks
	14070 – 70 lb. sacks
	14100 – 100 lb. sacks
	14140 – 140 lb. sacks

In the next case, the containers are reduced and expressed in gills as the common denominator.

15000	Containers
	15001 – ¼ pint container
	15002 – ½ pint container
	15004 – 1 pint container
	15005 – 1¼ pint container
	15006 – 1½ pint container
	15007 – 1¾ pint container
	15008 – 1 quart container
	15016 – ½ gal. container
	15032 – 1 gal. container

Prunes and other fruits are often classified according to the count or number to the pound. Anyone of the following codes may therefore be selected.

38000 – Prunes		3800 – Prunes		38000 – Prunes
38020 – 20-30 Count		3823		38203
38030 – 30-40 Count		3834		38304
38040 – 40-50 Count		3845		38405
38050 – 50-60 Count	(or)	3856	(or)	38406
38060 – 60-70 Count		3867		38607
38070 – 70-80 Count		3878		38708

Codes similar to the examples given might be continued indefinitely. The principle can be applied to any products and items which are identified by units, measures or numbers, provided these factors are not too lengthy to convert into practical codes. Although most of the examples given in this section are five-digit codes, it is not essential that five digits be used in a significant digit code. Such a code may be applied to any number of digits. This of course depends entirely on the particular requirements of the problem.

The significant digits need not always be determined by units, measures or factors of like character, but may be in themselves code numbers. Thus in designing a new code to replace one already in existience, it may be found advantageous to have the new code numbers arranged so that they reproduce or partially indicate the old, thus –

4000 – Pumps
- 4017 – #17 Pump
- 4024 – #24 Pump
- 4077 – #77 Pump
- 4812 – #812 Pump
- 4997 – #13997 Pump

The old code numbers or identification numbers often have been well memorized, and therefore should be preserved for their significant value. This applies also to the conversion of mnemonic symbols into straight numerical codes, where as much of the original symbol should be retained in the new code as can be accomplished without increasing the number of digits.

In using the significant digit method of coding it will sometimes be found that actual dimensions may be used directly without a code, provided the number of digits is not too great for sorting. Thus tire sizes are often used directly without any code other than for indicating general groups.

Final Digit Codes

This term is applied to the use of ending or final numbers to designate certain information in regard to the items so coded. It is used only in connection with some other type of code and is not a complete code in itself.

The use of a final digit code is warranted only when the information to be brought out has no relation to the classifications of the main or primary code.

The simplest and most common application of the final digit principle is the assigning of numbers ending in "0" to indicate items of special importance. The telephone companies utilized this principle in assigning phone numbers ending in "0" or "00" to subscribers having large private switchboards, thus signalling their operators to try more than one line.

Another simple device under this method is to assign all of the items of one class to numbers ending in even numerals and all of a second class to those ending in odd numerals. This accommodates two kinds of items and presupposes that they will be about evenly divided. Where there are more classes and where they are unevenly divided, the following may be employed:

Final Digit		Final Digit	
1 – Manufactured Products		1, 2, 3, 4	– Manufactured Products
2 – Purchased Products	(or)	5, 6	– Purchased Products
3 – Assembled Products		7, 8, 9	– Assembled Products

The second arrangement makes more numbers available for each group. The first arrangement may be expanded to indicate ten classes by use of all of the ending numerals.

One of the most frequent uses of a final digit code of the first arrangement is the assignment of the ending numeral "9" to indicate "miscellaneous" at the end of a block of names, accounts or items.

400 Expense
401 Rent
402 Traveling
403 Automobile
404 Office
405 Research
406 Advertising
407
408
409 Miscellaneous

Where more capacity is desired, with only one numeral or column required for sorting, the second ending digit may be used as the significant numeral instead of the first, as follows:

10 – Class 1		10, 20, 30, 40 – Class 1
20 – Class 2	(or)	50, 60 – Class 2
30 – Class 3		70, 80, 90 – Class 3

The disadvantage of this method is that it may begin to interfere with the main code unless there are a large number of digits. It must be remembered that the use of tail digit designations always tends to reduce the capacity of the main code, because certain numbers must be reserved for their proper items and are not available for all new items. The second method shown in both cases above is based on the frequency of occurence of the classes, and therefore reduces the main code capacity to the least extent.

The use of fractions, letters or symbols at the end of a code number to designate special items must not be confused with final digit coding, as these devices are simply equivalent to the addition of another digit to the main code. A true final digit code adds one or more classifications to the main code without the addition of any digits. It simply governs the way the regular code numbers shall be assigned.

Decimal Codes

The decimal system of coding was developed primarily for the purpose of indexing in library work, and for classifying correspondence according to subject. One of these codes is reproduced in part below:

000 General
100 Philosophy
200 Religion
300 Sociology
400 Philology
500 Natural Science
    510 Mathematics
    520 Astronomy
    530 Physics
        531 Mechanics
            531.1 Machines

531.11 Lever and Balance
531.12 Wheel and Axle
531.13 Cord and Catenary
531.14 Pulley, simple
531.141 Pulley, compound
531.15
etc.

It will be noted that the coding to the left of the decimal point is the same as the regular group classification method. It is only in the finer subdivisions that the decimal principle comes into play. This type of coding is not as well adapted to the identifying of individual items or articles as it is to the designation of groups, accounts or subjects.

A decimal code is capable of unlimited expansion, since any number of new subdivisions can be inserted and designated by additional decimal places. This is accomplished, however, at the expense of a greater number of digits. In the illustration, "531.141 – Pulley, compound" has been inserted as a subdivision of "531.14 – Pulley."

The decimal system of designation has been used by many cities and municipalities for numbering lots on city maps. It is one of the best methods for this purpose, as it allows lots to be subdivided again and again, and a number is still available for each parcel of land.

In many other cases an attempt should be made to convert the decimal code to a fixed digit code which provides expansion by means of vacant numbers. The illustrated code converted to a regular group code would appear as follows:

531000 Mechanics
531100 Machines
531101 –
531102 –
531103 Lever and Balance
531104 –
531105 –
531106 Wheel and Axle
531107 –
531108 –
531109 Cord and Catenary
531110 –
531111 –
531112 Pulley, simple
531113 Pulley, compound
531114 –

In the above example the code has been definitely limited to six digits, with allowance for considerable expansion, whereas there is no assurance that the corresponding six-digit decimal code would not eventually be carried to seven or eight digits. In making such a conversion it is often found that one digit may be immediately dropped from the decimal code, particularly where there are only a few subdivisions utilizing the last decimal place.

Mnemonic Symbols

This term is used to designate codes which have, as an integral part of their construction, some aid to the memory expressed in letters, numbers or combinations. For example, the following is a common type of mnemonic symbol.

H 2 B W 1 2 ½

This describes a 2-lb. ball peen hammer with 12½″ wood handle, the initial letters and dimensions being used to determine the symbol.

It is obvious that this principle cannot be employed indefinitely, because of the conflict of names beginning with the same letter. Should it be desired to designate "hack saw," for instance, in the same code, it is likely that "S" would be used, or "HK."

In other cases it is customary to employ letters with similar sounds to accomplish the purpose, and there are no definite rules except that an effort is made to select a symbol which suggests in some manner the item it represents. The letters "I," "O" and "Q" must not be used, due to their similarity to the numerals "1" and "0."

Symbols which ordinarily do not accomplish this purpose may in some cases be considered mnemonic if the symbol itself has become familiar. Thus "R" may be used to designate supply items because the supply department has been known as department "R."

The sequence and position of the letters and figures constituting a symbol have a signficance, and in this respect resemble a decimal system of coding. This sequence should be arranged so that the letters of the alphabet are intermingled with the figures, as such a symbol is more easily remembered than one with all letters together and all numerals together, since the classifications are better accented.

An example of mnemonic coding may be found in the method of assigning automobile license numbers in certain states. Although these numbers are not code numbers in the strict sense, the mnemonic principle is used, inasmuch as the letters of the license are made to correspond to the initial of the county in which they are issued.

The disadvantage of a mnemonic symbol is that it is always growing in length. Whenever there is a split in classification, a new digit or numeral is added. It also has the disadvantage that the more items there are to be coded, the less mnemonic, or memory aiding, the symbols become.

This type of code is not efficient where machine processing is to be employed.

Numerical — Alphabetical Codes

Partial Sequence – Short Lists

This is the simplest type of numerical-alphabetical code, and appears as follows:

		01 – A			02 – B
01	01	Acme Engineers	02	01	Baker & Thomas
01	02	Adam Construction Co.	02	02	Balmat & Sons
01	03	Ahloin & Son	02	03	Bannon, Jas. L.
01	04	Ajax Construction Co.	02	04	Baptist, J. R.
01	05	etc.	02	05	etc.

		03 – C			26 – Z
03	01	Caldwell Engineering Co.	26	01	Zastrow & Lasher
03	02	Callahan, W. E.	26	02	Zimmerly Bridge Co.
03	03	Calument Const. Co.	26	03	Zimmerly, Frank
03	04	Cameron-Joyce & Co.	26	04	Zolpher & Sons
03	05	etc.	26	05	etc.

The first two digits represent initial letter, and the last two are assigned to individual names. The original list is coded in exact alphabetical sequence, but all new names are simply assigned the next open numbers under the proper initial letters, thus gradually destroying the original sequence and making this a partial sequence code.

This method should not be employed where the list of names is so long that some letter groups would have more names than can be readily scanned for reference or decoding, nor should the principle be expanded to include the second letter of the alphabet on the same basis, as four digits would be required to express only 26 times or 676 divisions. Four digits normally should give 9999 divisions. In most cases it is advisable to have 27 initial letters, "Mc" being regarded as a separate letter.

This type of coding does not require the use of a numbered coding register book, since new names are assigned the next open numbers, and a card file or ordinary code list may be used for determining these open numbers.

In using a code of this kind, study should be made to determine whether tail digit designations might prove beneficial, since significant information can be obtained by assigning these numbers according to the principles set forth in "Tail Digit Codes."

Partial Sequence – Long Lists

This type of code breaks down the alphabetical groups beyond initial letter without the use of extra digits, and appears as follows:

A	1 – 19	B	340 – 359
Ac	20 – 39	Bae	360 – 379
Ad	40 – 59	Bak	380 – 399
Ag	60 – 79	Bal	400 – 419
Al	80 – 99	Bam	420 – 439
Ale	100 – 119	Bar	440 – 459
All	120 – 139	Bari	460 – 479
Als	140 – 159	Barn	480 – 499
Am	160 – 179		
Ame	180 – 199	Wom	9840 – 9859
An	200 – 219	Wood	9860 – 9879
And	220 – 239	Wool	9880 – 9899
Ap	240 – 259	Wr	9900 – 9919
Ar	260 – 279	Wu	9920 – 9939
Arm	280 – 299	X-Y	9940 – 9959
At	300 – 319	Yo	9960 – 9979
Au	320 – 339	Z	9980 – 9999

Names are assigned to the next open numbers under their respective alphabetical groups. They will not, therefore, be in complete alphabetical order beyond the original groups, resulting in a partial sequence code.

The construction of such a code is as follows: The number of names to be coded is first ascertained, as well as the amount of expansion required. These determine the number of digits necessary in the final code. Although a four-digit code has been illustrated, the above calculation may indicate that a three-, four- or five-digit capacity may be required.

No more than 10, 20, or 30 numbers should be assigned to an alphabetical division. Therefore the total code capacity is next divided by one of these figures to determine the number of divisions. The smaller the number chosen, the finer will be the alphabetical break-down. The code illustrated is based on 20 numbers to a division.

The complete known alphabetical list of names is then counted and marked off into the number of equal parts which has been determined as above. This roughly fixes the alphabetical groups constituting the code, and slight adjustments, where dividing lines occur in the middle of groups, give the final code as illustrated previously.

In the event that a known list of names is not available or is, for some reason, considered not representative, city directory, phone book, correspondence file or other related lists may be used to build the code. It will be found more satisfactory in most cases to use an actual list, since the frequencies of certain names vary greatly with different enterprises and localities.

For the same reason it is better to design a seperate code for each application, following the principles set forth herein, than attempt to utilize one of the many published codes which have been designed for filing systems generally.

The coded names need not be registered in a numbered book, although it is advisable to have a code list or other medium for determining the next open numbers. Significant names may be designated by assigning them to numbers ending in zero.

It is also common practice to have a code of this kind start with 100, 1,000, 10,000 or 100,000 as the case may be, rather than with "1," so that all names are designated with a like number of digits. In this event the numbers with fewer digits may be assigned to auxiliary, miscellaneous, or special items, the smaller number of digits serving to identify them quickly and, in many cases, eliminating the need of a second code.

Complete Sequence – All Lists

This type of code is used where it is necessary to sort and list in complete alphabetical order down to the final letter. It is recorded on register sheets or a numbered book which appears as follows:

SHEET 39

00 Heland Co., Inc.	06
01	07
02	*08 Held Adams & Co.
03	09
04	10 Held Baking
05 Helbruin Polish Co.	11

44		56	
45	Helier's Drug Stores	57	
46		58	
47		59	
48		60	
49			
50	Hell Gate Packers	94	
51		95	Helpem Spec. Co.
*52	Hellman Co., Inc.	96	
53		97	
54		98	
55	Helmrath Bottle Co.	99	

The construction of this code is exceedingly simple when undertaken in the right way. The first step is the counting of the names on the list to be coded, and the estimation of proper allowance for expansion. This determines the number of digits and the total code capacity.

The code capacity is then divided by the number of known names on the list. This gives the exact factor of expansion, and should not be adjusted to round numbers except when a fraction results, in which case the next lower whole number must be taken. For example, should the above computation result in the figure 7.341, the factor used would be "7."

Numbered sheets are then prepared, 100 numbers to the sheet or page. As many sheets are prepared as are necessary for the total code capacity.

The names are then entered on the sheet, skipping as many spaces between each name as the factor of expansion indicates. The factor of expansion of the code illustrated was "5," therefore the names of the original list were entered opposite each fifth number. The first name on "Sheet 0" must not be entered opposite "01," as no space for expansion would be provided before this name. It is advisable to start with "03" or "04." Where IBM accounting machines are used, it is also desirable to change the starting point on each sheet so that the ending numerals will be evenly distributed for machine sorting.

Care must be taken in preparing the register to see that all computations have been made correctly, and that names are entered correctly, or the last page will be reached and more names may be left than available spaces. A check-up toward the end will show whether this condition exists, and if so, the factor of expansion may be reduced so that the remaining names will fit in.

New names as they occur are entered in the middle of the available vacant numbers so that expansion is still left on both sides for the other new names (see * on preceding example). This permits an exact alphabetical sequence and provides a complete sequence code.

It is necessary that obsolete and discontinued names be eliminated at regular intervals so that numbers may be later re-assigned and the complete alphabetical sequence thus be preserved indefinitely.

Complete Sequence – No List

This method of coding can be used where the complete list of names to be coded is not available, but where a master code is necessary as coding instruction or to insure uniformity.

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47	59
48	60
49	
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Complete Sequence – No List

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An example of this case might be the coding of customers by branch houses where each branch operates its own code, and numbers are not assigned at the home office. In a case of this kind, the same coding scheme would be in effect at all branches, the branch number being used to differentiate the customers.

If the correct basis is used, this code will keep the names in perpetual order by alphabetical arrangement to the last letter. It must, however, be kept in register form so that new numbers can be assigned intelligently.

The steps of construction are as follows:

(1) Select a list of names, such as a directory or trade list, which it is estimated will compare favorably in name frequencies with the list to be built.

(2) Divide this basic list into as many equal parts as is estimated will not cause more than thirty names to fall in one division.

(3) Adjust these divisions slightly so that they conform with the nearest alphabetical groups.

(4) Number the divisions from "1" up and record the master code as follows:

A	– 1	Af	– 9
Ab	– 2	Ah	– 10
Abe	– 3	Ai	– 11
Ac	– 4	Al	– 12
Ad	– 5	Ald	– 13
Adams A	– 6	Ald	– 14
Adams L	– 7	Alk	– 15
Add	– 8	All	– 16

(5) Prepare numbered register sheets, each sheet with 100 numbers, and record the alphabetical division and number at the top of each sheet.

As names occur, they are inserted on the sheets in the middle of the available vacant numbers. Thus, the first name in any group would be assigned to No. 50, the second to Nos. 25 or 75, etc. This allows a perpetual alphabetical sequence. The code number of any name consists of a combination of "Sheet No." and "Line No." unless complete numbers have been shown on each line.

Final digit designations may be used with this code to designate key names, although care must be taken that they do not interfere with the alphabetical sequence.

Consonant Codes

Consonant coding usually originates in the mind of the clerk or card punch operator coincidental to coding or punching and consists of ignoring all of the usual vowels beyond the first letter of surname or article. Under certain special instances, "W" and "Y" can be dropped where identification is not destroyed. The first letter in name is always retained to promote effective indexing. In some instances, the first two letters are recorded before starting the elimination of vowels. Precoding is not required.

This type of coding conserves sorting time and is especially helpful in saving space where an extraordinary amount of alphabetic description occurs, such as description of material items or place names. Reading proficiency or visual interpretation of such coded data is readily attained after comparatively little experience.

EXAMPLES –

SMITH	SMTH
JONES	JNS
SNOWLEY	SNWLY
SNODEL	SNDL
PUMP HANDLES	PMP HNDLS
TRACK MATERIAL	TRK MTRL

Phonetic Index Codes

Under certain circumstances, it is desirable to index by groups of names, locations or articles of similar sound. This provides for scanning a section of a file to locate a given item which may be subject to a variance in expression or spelling. As an example, the name of Johnson can be expressed in many ways. Index coding will group such variances as follows:

NAME	*INDEX CODE*
JOHNSON	J525
JOHNSEN	J525
JONSEN	J525
JOHNSTON	J523
JOHNSTONE	J523
JOHNSTOWN	J523
JONSTON	J523

Such a method of coding involves the establishment of a table of letter relationship in which the vowels "AEIOU," and the consonants "WHY," are ignored. Such a table is shown below:

1. BFPV
2. CGJKQSXZ
3. DT
4. L
5. MN
6. R

In application the initial letter of a name is retained and the next three successive consonants are given a numerical value. Thus, the name of JOHNSON becomes JNSN, or code number J525. In those names which have only one or two consonants, after eliminating the vowels, zeros are added to complete the three digits. This type of code is highly advantageous in that it reduces to a minimum the searching of a file for an item which may have been misspelled or where the name or fact is known only by its sound. The application is usually limited to files of extraordinary volume.

End of Chapter Questions

1. What is the purpose of coding?
2. What should precede the construction of a coding system?

3. What characteristics are to be considered in the construction of an adequate code?
4. Explain the use of master code cards. What are the advantages?
5. How can the descriptions of code numbers be printed on reports?
6. How can forms be preprinted to solve decoding problems?
7. What system can be applied to almost any type of coding to provide greater accuracy?
8. What coding system assigns the next higher unused number to a new item? What are the disadvantages? How is it usually used in conjunction with other coding systems?
9. What is the advantage of the block code system?
10. Why is the group classification code system the most popular for mechanical applications?
11. Why is the significant digit code method frequently incorporated in Parts Inventory applications?
12. What coding system is used in conjunction with other systems that utilizes the digit "9" for a "miscellaneous" classification?
13. Why was the decimal system of coding developed?
14. Is the mnemonic symbol system efficient for mechanical applications? Why?
15. The numerical-alphabetical coding structures are widely used on mechanical applications. What are the different types? How many applications can you think of that would use one of these types?
16. What are the steps to follow in constructing a complete sequence-no list system?
17. Explain the phonetic index coding system.

CHAPTER 9

Practices

The practices as set forth in this chapter rely somewhat upon the policies of machine manufacturers and upon new developments in the field. However, an effort has been made to screen out any practices which might be based upon transient or temporary policies. The practices as stated have been in existence a number of years and appear to be stabilized sufficiently to survive for some time in the future.

These practices are set forth to expose the reader to practical information intended to help him understand the character of a punched card data processing department. The revelation of these practicalities should assist in unveiling some of the mystery surrounding a mechanized system and expose it for what it is – a practical tool of management.

Points

The common unit of measure used to express the size of a punched card department is *points*. This term was used internally at IBM as a base for computation of rental fees and salesmen's commissions, but it has now expanded into general usage. Points, as generally used, are equal to the base monthly rental of all equipment in a punched card data processing department. Additional shift rental and federal excise tax are not included in fixing the number of points.

If the basic monthly rental of an installation is $2000, it is expressed as a 2000 point installation. Generally speaking, an installation below 2000 points is considered to be small. 2000-8000 points is considered medium sized and more than 8000 points is considered to be large.

Another common method of expressing the size of an installation is in terms of the number of tabulators in the installation. The tabulators are the backbone of installations, as these are the machines on which the final products – reports – are prepared. Other machines are used to prepare the data for the tabulator. As previously stated, machines vary in size and capacity. This has an effect upon the monthly rental charge (points). Tabulators demand a wide range of points depending upon their speed and capacity. A stripped down

IBM tabulator might rent for as little as $200 per month, while a loaded IBM Type 407 would be more than $900 per month.

Generally speaking, a department of one or two tabulators is considered small. However, an installation with two full-capacity IBM Type 407's has a great deal of capacity and would probably be considered by most to be a medium-sized installation.

Three to seven tabulators constitute a medium-sized installation, and eight or more tabulators are considered a large installation. This is a rough method of determining the magnitude of an installation and does not produce as accurate a picture as the point method. It is also strictly a matter of opinion and would vary from person to person depending upon their experience and background. There is a 10% federal tax on the rental of punched card equipment except for stored program computers. This is added to the bill from the manufacturer to the customer each month but is not considered when evaluating the points of a department. From the customer's point of view it is as much a part of the cost as the rent portion.

Shifts

Shift work is very common in the punched card data processing profession. There are two prominent reasons for this: schedules and economy.

It is quite common in this age of fierce competition for management to desire the reporting of facts as soon after an activity is performed as possible. This usually means a report at 8:00 a.m. of the day following the activity. An example of this would be performance reports on which the labor expended by workers in a factory is compared against the standard time allowed to perform the job. By accumulating all of the labor hours and all of the standard hours for the employes in a section, a percentage of efficiency can be determined for that section. In a controlled shop the percentage of efficiency of a given section should not fluctuate radically. By supplying management with a report of efficiency each morning representing the previous day's activities, a variation in the efficiency of a section can be spotted immediately. A drop in efficiency indicates that a problem has developed. Immediate analysis of the detail comprising the report will reveal the area or job on which the trouble has developed. A check with the people directly involved in the problem area can be made while it is still fresh in their minds. The problem can be analyzed by specialists and corrective action taken immediately.

The benefits of this quick reporting system are obvious. Trouble areas can be spotted when they start – before they grow into monsters. Quick corrective action can be taken before serious costs are incurred. This can have a direct effect upon the objective of the company – to make a profit. Problems on a job increase the costs; excessive costs cause the job to overrun the budget; overruns wipe out the profit and, if they occur on a sufficient number of jobs, will develop into a loss position for the company.

The second reason for shift work is economy. The rental for equipment used on an extra shift is based on the time the equipment is used on the additional shift. The rental charged for extra usage is one half the base rental multiplied by the *time the equipment is used.* Therefore, if a machine which rents for $4 per hour (monthly rate broken down to hourly rate) was used 8 hours per day on an additional shift the extra rental would be determined as follows: ½ x $4 (base rental) x 8 hours or $16 per day. The total rental would then be $4 x 8 (hours per day) = $32 for first shift plus $16 for the additional shift equals $48 per day. If this same equipment was also used on a third shift for eight hours the rental would be increased by ½ x $4 (hourly rate) x 8 (hours) = $16 which would bring the total rental to $64 per day for that particular piece of equipment. The net result is that we have achieved 24 hours machine time for $64, which averages $2.67 per hour for a piece of equipment that rents for $4.00 per hour basic cost.

If, in order to get sufficient time, additional equipment had been added on a one-shift basis the cost could continue at $4 per hour, so 24 hours machine would cost $96 rather than $64.

Another advantage of extra shifts is that a full eight hours of machine time does not have to be paid for unless it is needed. For instance, if the machine which rented for $4 per hour had been needed for only six hours on an additional shift the extra shift rental charge would have been ½ × $4 per hour × 6 hours = $12. If another machine of the same type were added the rental would be $4 × 8 hours = $32 and the machine wouldn't be fully utilized.

Other factors to be considered are space and machine availability.

Floor space costs money, and a machine used on 3 shifts doesn't take up a bit more floor space than if it is just used on one shift. But, each machine that is added requires more space, consequently the cost or unavailability of floor space might force extra shift usage in its own right without regard for schedules or machine rentals.

Machine availability from the manufacturer must always be considered when anticipating more equipment. Long lead times are common. Some machines have required as much as two or three years for delivery. The 1958 recession greatly improved this situation by reducing the manufacturer's backlog. However, in the event of a national emergency it is likely that lead times will lengthen again. At any rate, machines cannot be installed at will. Therefore, if additional machine time is needed it might be necessary to go to an extra shift, because additional equipment cannot be obtained soon enough.

Machines also require a cancellation period of at least 30 days and, in the case of a new installation, one year's notice is usually required. It is not wise, therefore, to add equipment without carefully considering whether the need is permanent. If the permanence of the condition is in question, it is much easier and less expensive to utilize existing equipment on another shift than to order and cancel equipment.

There are also disadvantages to adding extra shifts. Work is more difficult to control when spread out over two or three shifts because communications become more difficult. When a problem arises during the day, an answer can be determined by simply contacting the proper person. When a problem arises on the night shift, however, it is usually not possible to contact the people who know the answers. They are at home asleep or at a movie. Consequently, a certain amount of inefficiency results. There is also the problem of decisions being made on days without the night shift being "tuned" in.

Needless to say, much of this can be overcome by good management practices. This will be discussed in the chapter on Responsibilities of the Data Processing Department.

Shift work normally requires that a bonus be paid the workers. This may be 10 or 12 cents an hour or even more. The third shift often works only six and one half hours and gets paid for eight hours in addition to the shift bonus. This tends to reduce the savings generated by a decrease in machine rental.

Another disadvantage of shift work is the problem of getting qualified personnel who are willing to work at night. Most people prefer an 8 a.m. to 5 p.m. work day, as this coincides with the activities of their families and friends.

A common practice is to hire personnel on the night shift and transfer them to the day shift according to seniority as openings occur on the first shift. This complicates the hiring of new personnel and qualified personnel are often passed by because they will not or cannot work nights.

Another method sometimes used is to rotate shifts periodically so that personnel will be on days for a period and then on nights the next period. This makes for a more equitable distribution of the shift work among the personnel.

At best, personnel problems are certain to develop, and they are more rampant in a multiple-shift operation. Again, this is a problem that can be minimized by competent supervision.

In spite of the disadvantages, shift work is very common in punched card departments, which proves that most companies feel that the advantages of multiple shifts outweigh the disadvantages.

Machine Capacities

The purpose of this section is to discuss the meaning and importance of machine characteristics and their implications.

In the chapters on machine functions, some of the various types of punched cards machines were explained. These were presented as being the basic machines which might comprise a punched card data processing department. There are other machines which are very similar to each of these but which have different speeds and capacities. For instance the IBM Type 82 sorter was explained. There are other sorters made by IBM but the Type 82 is the one in most common use at this time. There is an IBM Type 75, which is much slower and has many characteristics that are different from those of the Type 82. Likewise, there is a Type 83, which has been introduced and is being widely accepted. This machine is much faster and has many improved engineering features. One of these features is called a *File Feed Device,* an optional feature that can be attached to the sorter. This device will accept a whole tray of cards and will automatically joggle them so that they will feed properly. It feeds at the rate of 1000 cards per minute.

The tabulators, their characteristics, speeds and capacities are more significant to personnel outside of the data processing department. If you will recall, one tabulator presented was the IBM Type 407. This machine is very popular, but equally popular is the lesser capacity IBM Type 402. Both tabulators print reports, but they operate under many different principles.

Counters are an important feature of tabulators, because the tabulation of totals requires counter wheels. These wheels rotate in response to the holes punched in cards as they pass through the machine. A Type 407 tabulator has a greater capacity than a Type 402 tabulator because it has more counter wheels. Each position of a total requires one counter wheel, and it is necessary to assign enough counter positions for the printing of each total as the highest possible number that will ever print in that total. Thus, if a total could conceivably reach $1,000,000.00 at least nine counter positions would have to be used. This doesn't sound like much, but when several different totals are printed across the report horizontally and several different "classes" of totals are printed one under the other, counter capacity can be expended quite rapidly. This is illustrated on the cumulative cost report format shown in Figure 55.

CUMULATIVE COST REPORT

	CURRENT WEEK'S COST	YEAR TO DATE COST	CONTRACT TO DATE COST
DEPT. TOTALS	XX,XXX.XX	XXX,XXX.XX	X,XXX,XXX.XX
JOB TOTALS	XX,XXX.XX	XXX,XXX.XX	X,XXX,XXX.XX
FINAL TOTALS	XXX,XXX.XX	X,XXX,XXX.XX	XX,XXX,XXX.XX

Figure 55—Cumulative Cost Report

The detail printing has been omitted and only the columnar heading of each total line and the different levels of totals are shown. Observe that the horizontal level of totals labeled department totals necessitates seven counters for Current Weeks Cost, eight counters for Year-to-Date Cost, and nine counters for Contract-to-Date Costs. The "X's" represent the maximum number of positions that will ever be printed in each total. We see that the Department total line requires at least 24 counters, and the Job total line requires an equal number, which uses up 48 counters. The final totals will be larger because they represent a total of all of the Job totals. The requirement on this line is for eight, nine, and ten positions for a sum of 27 positions, which when added to the 48 used for the other levels of totals gives a total of 75 counter positions. This illustrates how machine capacity can rapidly be used up.

The IBM Type 407 has many more counters than the IBM Type 402. Consequently, it will allow more totals to be printed on a report.

Machine capacities vary, not only from one type of machine to another but also within the same type. Just as an automobile can be ordered with many extras, so can punched card machines be ordered with various capacities. The monthly rental fluctuates according to the machine capacity. Consequently, each machine ordered should be of the most economical type which will serve the particular company installing it, and it should have only the capacity that is needed.

An IBM Type 407 tabulator, for instance, can be obtained with different numbers of counter positions.

Another important feature of the tabulator is its ability to print alphabetic and special characters. The IBM Type 407 can print 120 characters of alphabetic, numeric or special character data across a sheet. The IBM Type 402 has a serious limitation; it can print only 43 positions of alphabetic and numeric data at the left and 45 digits of numeric information only at the right. See Figure 56. Special characters are quite limited also. When designing a report to be printed on an IBM Type 402, one should keep in mind this limitation of not being able to print alphabetic characters on the right side of the sheets.

People employed by a company should investigate the equipment used by that company. The types of machines available and their capacities can indicate the capacity of the installation and how much to expect of it. The greater the machine capacities, the more elaborate can be the reports.

A good policy to follow is to lean heavily on the data processing management as far as machine capacity is concerned. It becomes quite technical, and outsiders should not get too involved with it except to be able to comprehend when machine capacity problems are discussed in relation to requests that are made for service. A good policy to follow is always to ask for the maximum that is needed, and then work with the data processing department in trying to get it. If machine capacity will not permit the maximum, you will be so informed and can compromise on the next best solution.

Another characteristic of machine capacities is their overlapping. That is, some features of the machine can be used for several different things. Consequently, if the capacity is used for one thing it cannot also be used for something else. Overlapping can create confusion and distrust, because people see a certain condition existing on one report, yet when they ask for the same thing on another report they are told that there is no machine capacity to accomplish it. The feature required to accomplish the particular effect they are requesting has already been used for some other effect on this report. This is more frequent on complex jobs which tax the capacity of the machine. Again the best rule is to consult and work with the data processing department and to be open-minded in discussing capacity problems.

Every company has a maximum that it can spend for punched card equip-

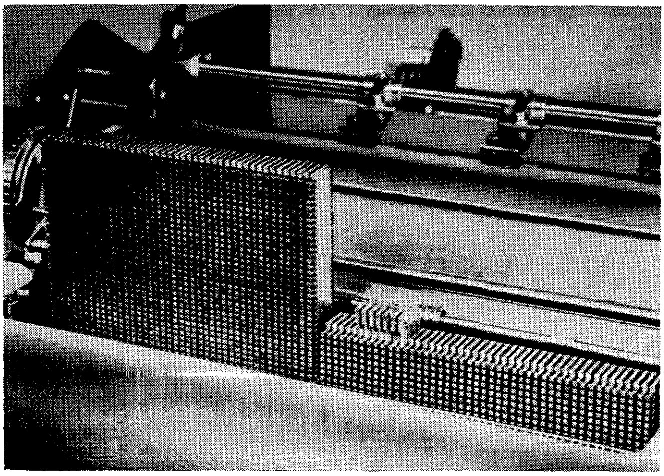


Figure 56—Print Unit IBM Type 402

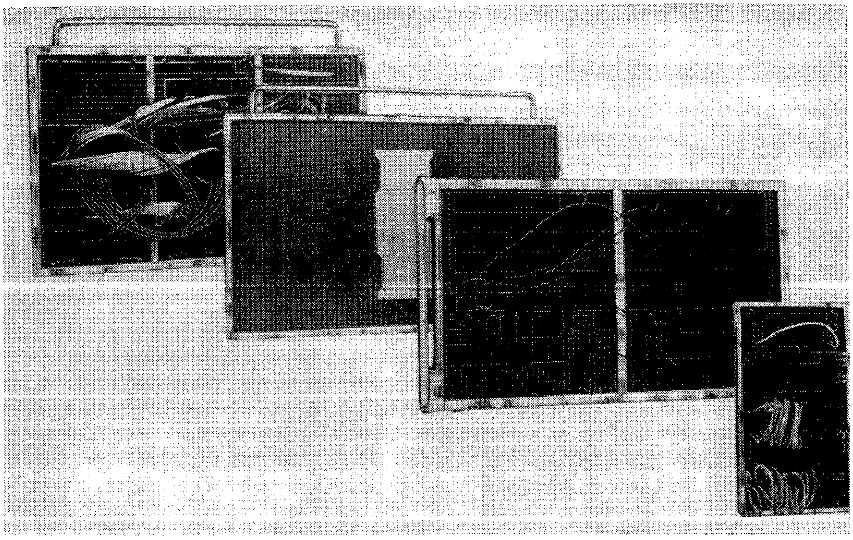


Figure 57—Control Panels *(Courtesy of International Business Machines Corporation)*

ment capacity. Obviously, the data processing department would like to have all of the latest equipment with all of the capacity available and have it loaded with all of the optional features. This would be ideal for providing fancy reports and furnishing the best service. However, the problem becomes one of economics. The cost of equipment must be held to the minimum point at which adequate service can be furnished. The data processing department must achieve a balance between cost and service. This balance can be very delicate and must be watched constantly because systems and schedule changes can shift the balance in one way or the other.

People working outside the data processing department can aid in retaining a proper balance by notifying the department as soon as possible of any changes in requirements, schedules, or work load. This gives the data processing department management more time to plan for the future and to get orders placed for more equipment or cancel machines and devices as the circumstances warrant.

Control Panels and Wires

Most of the IBM machines are given instructions by means of a control panel (Figure 57). The control panels are wired by the data processing personnel to cause the machines to react in the desired manner for each particular job. They greatly increase the flexibility of the equipment. Punched card data processing would be very restricted if each machine were internally wired to perform specific applications. This would require a different machine for each job, which would be impractical except where one high-volume application is processed in a company.

The control panel itself is a flat piece of material about ⅜″ thick with holes pierced through it in rows 1/16″ apart. The material is marked off with nomenclature identifying each individual hole or group of related holes. Paper templates are also available where the same size panel is used for two or more different machines. The IBM Type 602 calculator and the IBM Type 519 document originating machine both use the same size panel. If the data processing department has a panel available which is marked for wiring the 602 calculator, but it is needed for the 519 document originating machine, a paper template designed for the 519 document originating machine can be laid over the 602 calculator panel. By this method the data processing department can see the purpose of each hole as related to the 519 document originating machine and can proceed to wire the panel.

The wires used on the latest equipment are of the self-contacting type; the wires themselves make the contact with the prongs on the machine. The panel merely serves to position the wires so that they will make firm contact with the prongs on the machine.

Wires are of two types – fixed and temporary. The fixed wires lock into position and cannot be pulled out once they are inserted in a hole in the control panel, except by the use of a special instrument called a *wiring tool.* Fixed wires cannot be pulled out accidently when sliding the panel in and out of the cabinet, or they will not be pushed out from the back if the panel happens to be placed on an uneven surface. Panels which are wired and then used over and over again are usually wired with fixed wires. Panels which are wired for use only once, or which are subject to change or rewiring periodically, are wired with temporary wires, because they are so much easier to work with. They can be rapidly inserted or removed from a panel without the use of a wiring tool.

Wires also come in many different lengths for convenience in wiring. The shortest length which will reach between the two hubs being connected is selected. The two hubs might be adjacent, in which case a very short wire or a jackplug might be used. It is wise to use the shortest wire that will reach for two reasons. First is cost. The shorter the wire, the cheaper it is. Second is efficiency. A panel wired with wires that are too long becomes a mass of tangled wires. It is quite difficult to trace circuits in testing out the panel and in making changes at a later date. A compact panel is neater, lighter in weight, and easier to analyze.

Split wires are also available. These wires have more than two ends. They may have three, four, five, six or even more ends, all of which are common. They can be obtained as either fixed or temporary and come in various lengths also.

When a panel is being wired for repetitive use over a long period of time, it is wired with fixed wires and a cover is placed on the panel which completely covers the wires and protects them from damage.

Wires come in several different colors, but the color has no significant use other than to serve as an aid in keeping wires separate when wiring panels.

Wires serve the purpose of connecting one hub with another to complete an electrical circuit. The machine is internally wired so that some hubs will emit electrical impulses while other hubs will accept the impulses. When an output hub (emits electrical impulses) is connected to an input (accepts electrical impulses), the machine will react in a certain manner depending upon which input hub is connected to which output hub.

Let us take a simple example of an IBM 552 interpreter panel. You will recall that an interpreter prints information across the top of the card according to the holes that are punched in the card. The card can be punched with 80 columns of information but the interpreter will only print 60 characters across the top of the card on one line (two lines of printing are possible, but require two different control panels and two passes of the cards through the machine).

The wiring of a control panel gives complete flexibility. Data punched in any of the 80 columns can be printed from any of the 60 type positions. The data punched in column 1 can be printed from type bar 1 or type bar 60 or any other type bar. There are 80 holes in the control panel corresponding to the columns of the card and 60 holes in the control panel corresponding to the 60 type bars. The 80 holes corresponding to the columns of the card are output hubs. Each hub emits an impulse representing the hole punched in the card in that particular column. This is done by a set of 80 brushes under which the cards pass as they feed through the machine. The brushes sense the hole punched in the card, and this is relayed to the corresponding output prong. When the panel is inserted, the self-contacting wire makes contact with the prong and the impulse is carried to the input hub into which the other end of the wire is inserted. The input prong for the type bar accepts the impulse from the wire and transmits it by internal wiring to the corresponding type bar.

Thus, if the digit "4" is punched in column 1 of the card and column 1 is wired to type bar 49 on the control panel, the "4" impulse would be picked up by the brush under which column 1 would pass as the card feeds through the machine. The "4" impulse would be carried by internal machine wiring to the prong which is in contact with a wire inserted in the hole representing column 1. The "4" impulse enters the wire and passes to the other end, which is inserted in the hole labeled Type bar 49. This end of the wire is in contact with an input prong into which the "4" impulse passes and is carried by internal wiring to type bar 49 which receives the "4" impulse and prints the number 4 on the card in position number 49.

This is a very simple example of a card column being connected to a type bar. The same principle applies in wiring counters, selectors, heading control, but it becomes more complex. In fact, the wiring of control panels is such an exact science that it is easily forgotten unless one keeps in constant practice. It is so time-consuming and so exact that technical personnel are employed to do this type of work. These people are commonly known as analysts.

Other personnel in the data processing department wire panels also, but the complex panels are wired by analysts. Because of the great amount of time involved, it is usually not wise to let personnel in other classifications do much wiring because it interferes too much with their assigned tasks. Operators are responsible for preparing reports, consequently if schedules are properly met they usually do not have much time for wiring. It is advisable, however, to allow an operator who has shown wiring aptitude to do some wiring so that he can work up to an analyst position.

The supervisors may do some wiring occasionally; however, this should be very limited because they are not being paid to wire panels – they are being paid to manage their departments. This is a common failing of data processing supervisors; they want to continue to wire panels. This can be very dangerous because they are doing work in a lower classification and neglecting the work that they are being paid to do. Let the analysts wire the panels – that is their job.

People outside of punched card data processing often overlook the cost of control panels and wires. Even a small installation can easily have $2000 - $3000 invested in wires and panels. Another investment required is the cabinets to keep the panels in. Both control panels and wires can be purchased from several manufacturers. Consult Business Automation, the JOURNAL OF MACHINE ACCOUNTING and DATA PROCESSING published by the National Machine Accountants Association, or other data processing publications for advertisements of suppliers. The president of the local chapter of the National Machine Accountants Association may also be contacted for the names of suppliers and for sources of used wires and panels in a local area. The "used" market is becoming quite active, but is usually done by word of mouth among people in the field and by announcements at their organization meetings and in bulletins.

The time required to wire a panel and check it out is also a factor often overlooked by people outside of punched card data processing. Complex panels can require several days and even weeks. This is especially true of IBM Type 407 panels and calculator panels.

When a new report is being considered, the data processing personnel must determine whether the wiring can be incorporated into an existing panel or whether a new panel is required. It is usually possible to prepare several related reports by using the same panel and producing variations by means of switches on the machine or mounted on the panel cover. This will be of interest to people who are requesting the report, because it might be necessary to purchase more panels and wires, which will add to the cost and may require more justification to management.

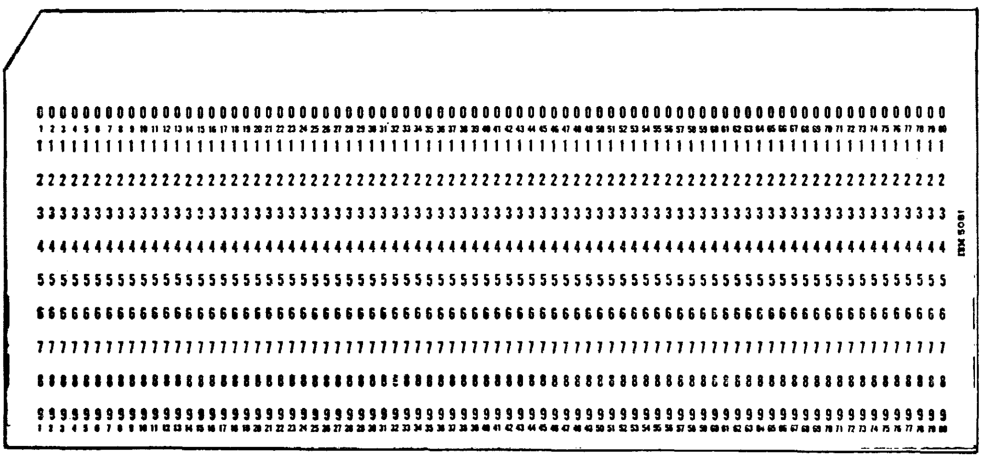
The answer must come from the data processing department. This is a technical area and it should be left strictly to the technical people. People not directly working in the department should *never* interfere with panels or wires. One wire in the wrong hub could cause reports to be issued incorrectly and take hours to locate.

Cards and Forms

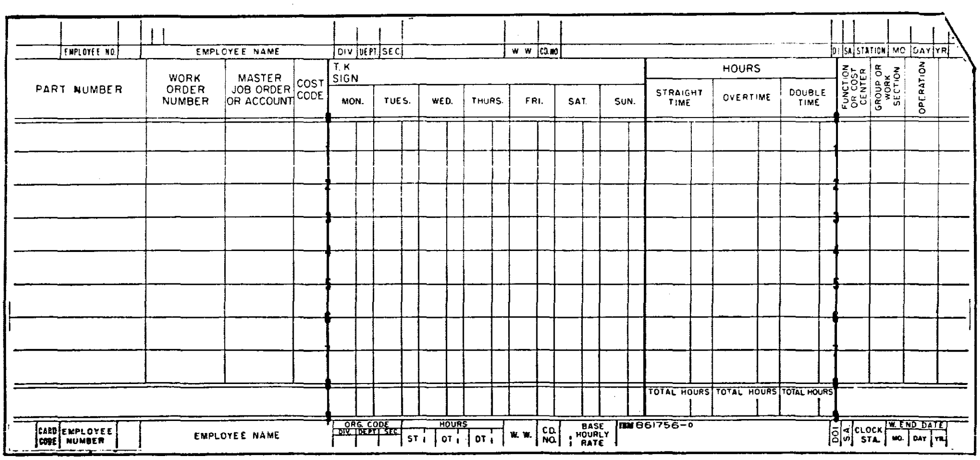
Cards and forms comprise the major cost of supplies in a data processing department. When one considers that the punched card is a unit record and that there is one card for each transaction processed through the department, it is easy to visualize a staggering volume of cards. For instance, labor distribution for 10,000 employes who average three different charges per day requires 30,000 cards per day. Cards are relatively cheap (about .1 of a cent each) but tremendous volumes do build up the cost.

There are now a number of companies engaged in the manufacture of cards. These cards must be of the best paper quality and must meet rigid specifications in thickness, width and length in order to feed through the machines properly. Prices are close but price breaks may vary; consequently, it pays to investigate the various sources of supply. If 500,000 cards are being ordered, one company may offer a more favorable price for that quantity than another company. Service is a very important consideration. Delivery schedules and freight cost will vary greatly in some localities because of physical proximity to the various manufacturer's plants.

The cards used within the department for working decks are often *stock* cards. These are blank cards with the columns numbered and a number in



Stock card form



Preprinted attendance card

Figure 58—Stock and Special Forms

each position which can be punched. These cards are easy to read by looking at the punches and are stocked in large quantities throughout the country so they can be obtained in just a day or two. See Figure 58.

Other cards are ordered so that they are especially printed for a particular application. There is a flat charge for setting up an electroplate according to a particular company's specifications (around $45). Thereafter, cards are ordered preprinted on this electroplate and they are much easier to translate and work with.

All cards used outside of the department must be preprinted (such as clock cards, job time cards, etc.), for they are handled by laymen. See Figure 58.

Many departments do not use stock cards because they are harder to read and cost the operator's time. Consequently, there is a preprinted card form for each card pattern used in the department. There is a great deal of merit to this and it is especially attractive in larger departments where many operators are involved and there is a turnover of personnel. There are disadvantages which must be considered. There is the initial cost of each electroplate and the obsolescence caused by changes in the system. Changes cause fields in the card to be changed; consequently, a preprinted form may actually be incorrect. Minor changes can be made to the electroplate for a small cost, but all cards in stock are incorrect. By the time the new shipment is received it may be obsolete because of another change.

In government installations and in companies that fully engage in work for the government it is possible to buy cards under the Government Printing Contract. This is a contract agreed upon between the federal government and certain card and paper manufacturing companies. Prices are usually 20 to 30% less than commercial prices, and at the present time there is no charge for new electroplates or for changes. This makes the use of preprinted card forms much more attractive in companies and government installations buying under the Government Printing Contract.

There is also an inventory problem. It is easier to stock and control 500,000 stock cards all alike than to maintain necessary balances of 10 different printed patterns. Besides adding nine more items of inventory, it will probably necessitate at least a 50% increase in cards in inventory in order to prevent running out of stock and to order in economical lot quantities.

Cards can also be ordered in numerous colors or with stripes across the top or center. These various colors allow an immediate identification of a card. For instance, clock cards could be reproduced on three different colors — manila for first shift, yellow for second shift and blue for third shift. In this way, a clock card can instantly be identified as to shift. One precaution in the use of solid colors (the whole card colored) is that they have a lower salvage value. Punched cards that are no longer needed can be sold for salvage. This is a very high grade of paper. Consequently, many data processing departments have containers placed around the room for salvage cards. These are accumulated until several tons are available and then they are sold. Prices fluctuate greatly, but even at $30 - $60 per ton, it is well worth the effort. Solid colors will greatly reduce the salvage value even though there may be only a few sprinkled in with plain cards. Stripes do not affect the price. When colored cards are used, it is advisable to have a separate container for the operators to dispose of them in. This presents an education problem in getting the operators to segregate the cards into the proper containers.

The ordering of cards is the responsibility of the data processing department. If ordering is done by a purchasing department, the data processing department should still be consulted because of the technical nature of the product. When a new electroplate is needed, the data processing department draws the specifications on a card layout sheet, which is an exploded card. See Figure 59. The enlarged drawing is easier to print on and work with. It is drawn in pencil exactly the way the card is to appear and sent to the manufacturer with the first order. The manufacturer will do the artist work and send back a proof. The data processing department will check the proof and return it, noting corrections, if any; the manufacturer will then proceed to prepare the electroplate and print the first order. This may require several weeks.

There are many variations of cards which can be ordered for specialized uses. These include card checks, mark sense cards, stub cards, creased cards, scored cards, etc. Utility bills on punched cards with a stub that can be torn off are quite common. The short card is returned with the check. Special attachments on the reproducer allow these short cards to be fed through the feed side where they are reproduced to an 80 column card in the punch feed, for processing through all equipment.

Card checks are becoming very common. The federal government uses these extensively for veterans benefits, income tax refunds, insurance payments, etc. They are more expensive than paper checks but faciliate bank reconciliations. Their preparation also requires special equipment. Several different methods may be used to prepare them. They can be prepared by the use of a bill feed device on the tabulator. This device permits the feeding and printing of each card individually on the tabulator. Continuous form card checks are now available which can be prepared on the tabulator the same as paper checks. See Figure 60 and 61. The new IBM Type 557 interpreter enables the checks to be prepared on that machine also. There is the problem with all of these methods that the cards must be printed and punched in two different operations, as neither the tabulator nor the interpreter is capable of punching. This necessitates constant unison between the punched cards and the check through both the punching and printing of the checks.*

New uses are being found for punched cards every day. Variations to the conventional cards have resulted in very unique and profitable applications. The data processing department should be aware of all of the possible variations and advise whenever their use is applicable. The layman cannot be expected to be aware of all of these. However, if he is searching for some way to handle a specific problem and suspects that a specially-designed card will solve his problem, he should discuss it with the supervisor of the data processing department. Books which illustrate the various possibilities and give the prices are available from the card manufacturers. It would be well for the layman to study one of these books in order that he may become aware of the possibilities and can recognize potential applications.

*IBM has developed a Type 408 tabulator which solves this problem by its ability to punch as well as print, but this new machine is not in common use at this writing.

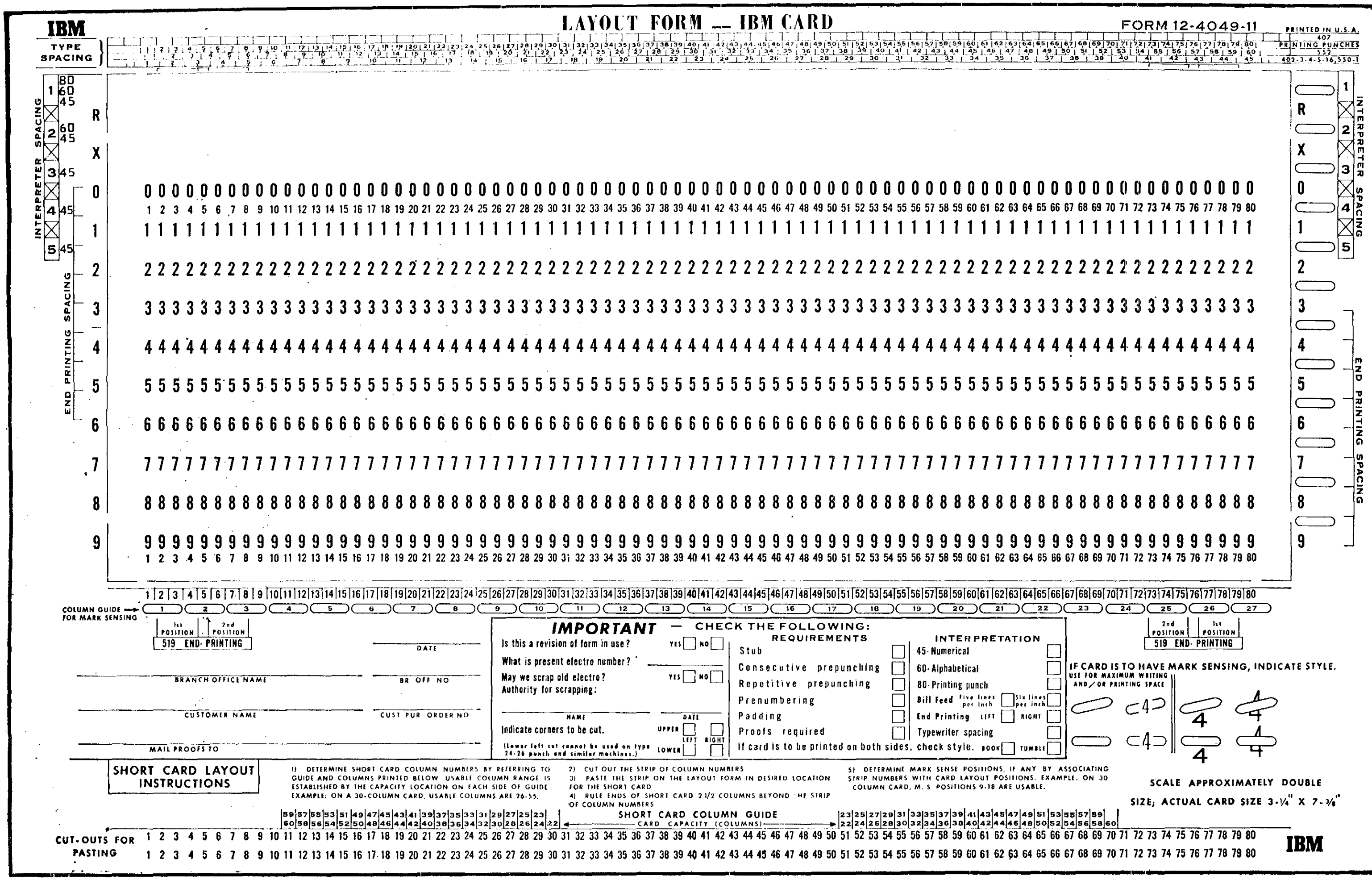


Figure 59—Layout Form

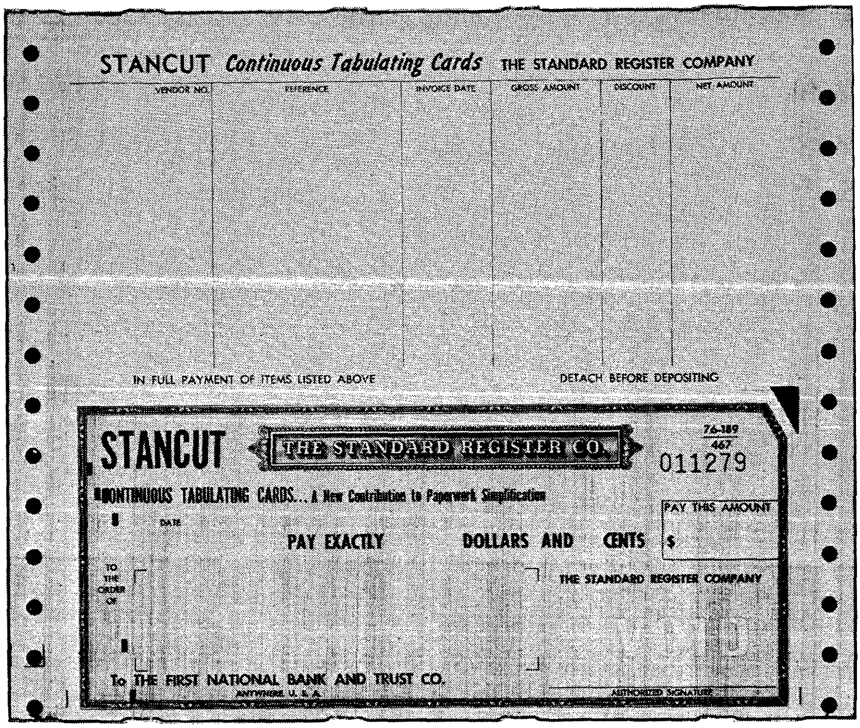
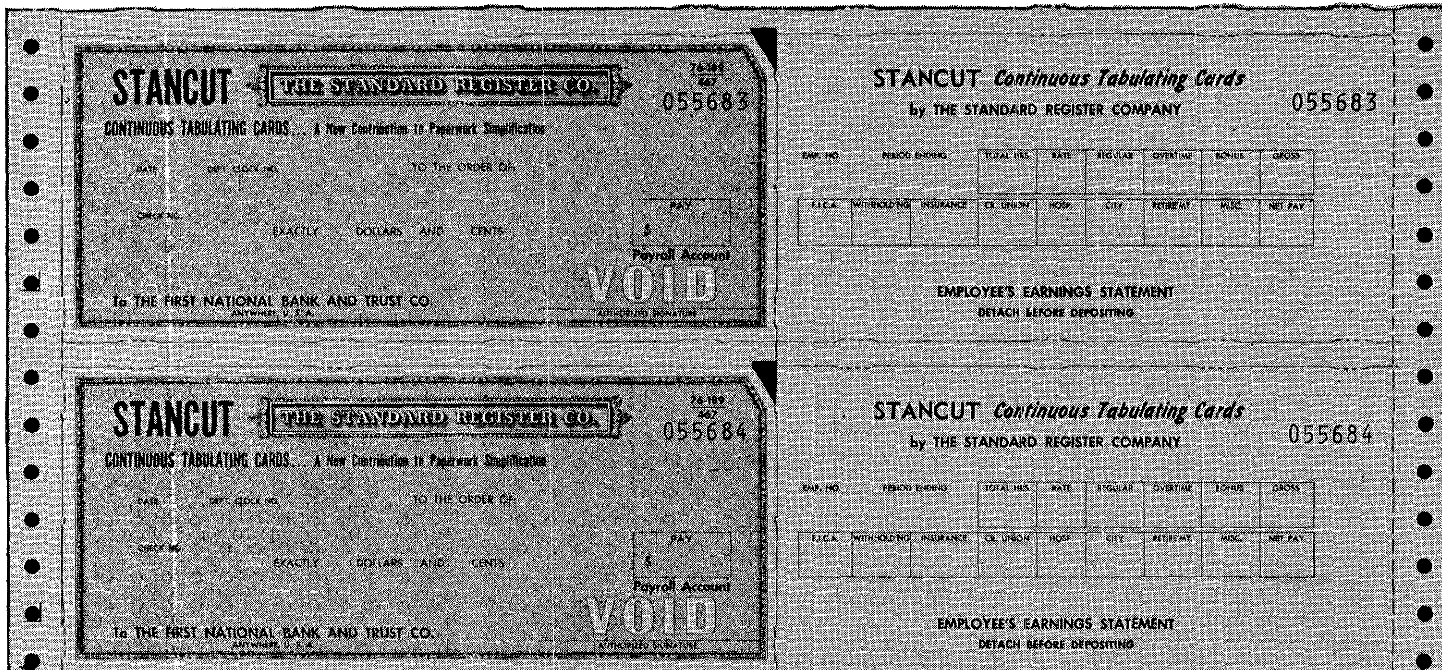


Figure 60—Continuous Form Card Check with "Piggy Back" Remittance Statement

Forms

Forms are very important because the final products of the data processing department, the reports, are prepared on them. Forms like cards can be stock or preprinted. See Figure 62. Unlike cards, forms can vary in size and number of copies. Multicopy forms are prepared by interleaving carbons between the continuous fanfold papers. This is done at the forms plant and these carbons are for one-time use only. They are removed from the reports and destroyed as soon as the reports are prepared. The number of copies that can be printed is dependent upon the weight of the paper and the carbon. It will also vary with the type of tabulator that is used for the printing. Generally speaking, five copies of stock form are considered the maximum for good clear copies. Specially-made forms can run as high as 14 copies by using extra thin paper and carbons and printing on an IBM Type 407 tabulator.

Forms can be cut in practically any size desired by the customer. Labels such as those used for addressing may be only 2 inches x 1 inch, while some forms may be as much as 18 inches long and 17 inches wide. The paper can be blank or it can be printed in practically any manner that is required. See Figure 62. A common stock form that is used for almost any kind of report is blank except for three horizontal lines per inch. These lines serve as guides so that the printing is easier to follow across the sheet without straying from one line to another.


STANCUT THE STANDARD REGISTER CO.
76-109
467
055683
CONTINUOUS TABULATING CARDS... A New Contribution to Paperwork Simplification
DATE DEPT. CLOCK NO. TO THE ORDER OF
CHECK NO. EXACTLY DOLLARS AND CENTS
PAY $
Payroll Account
VOID
To THE FIRST NATIONAL BANK AND TRUST CO.
ANYWHERE, U. S. A.
AUTHORIZED SIGNATURE

STANCUT *Continuous Tabulating Cards*
by THE STANDARD REGISTER COMPANY
055683

EMP. NO	PERIOD ENDING	TOTAL HRS.	RATE	REGULAR	OVERTIME	BONUS	GROSS
F.I.C.A.	WITHHOLD'NG	INSURANCE	CR. UNION	HOSP.	CITY	RETIREM'T.	MISC.

NET PAY

EMPLOYEE'S EARNINGS STATEMENT
DETACH BEFORE DEPOSITING

STANCUT THE STANDARD REGISTER CO.
76-109
467
055684
CONTINUOUS TABULATING CARDS... A New Contribution to Paperwork Simplification
DATE DEPT. CLOCK NO. TO THE ORDER OF
CHECK NO. EXACTLY DOLLARS AND CENTS
PAY $
Payroll Account
VOID
To THE FIRST NATIONAL BANK AND TRUST CO.
ANYWHERE, U. S. A.
AUTHORIZED SIGNATURE

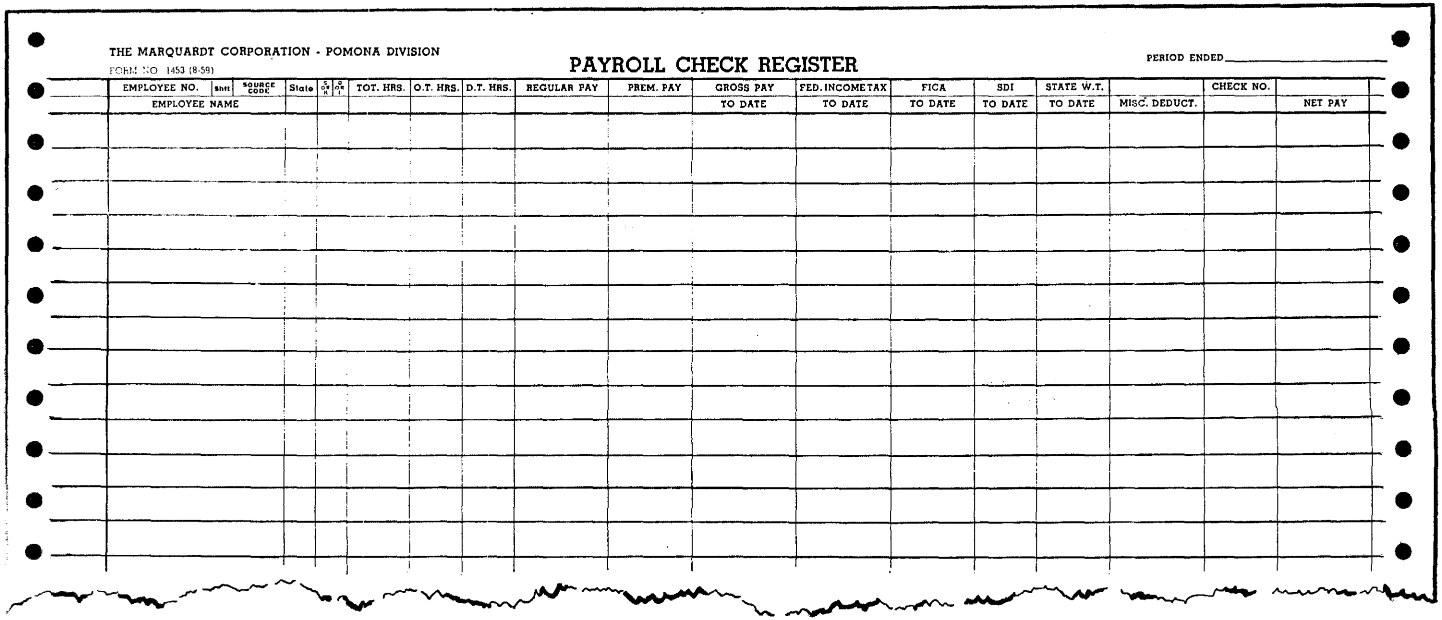
STANCUT *Continuous Tabulating Cards*
by THE STANDARD REGISTER COMPANY
055684

EMP. NO	PERIOD ENDING	TOTAL HRS.	RATE	REGULAR	OVERTIME	BONUS	GROSS
F.I.C.A.	WITHHOLD'NG	INSURANCE	CR. UNION	HOSP.	CITY	RETIREM'T.	MISC.

NET PAY

EMPLOYEE'S EARNINGS STATEMENT
DETACH BEFORE DEPOSITING

Figure 61—Continuous Form Payroll Card Check with Stub



THE MARQUARDT CORPORATION - POMONA DIVISION

FORM NO 1453 (8-59)

PAYROLL CHECK REGISTER

PERIOD ENDED ____________

EMPLOYEE NO.	Shft	SOURCE CODE	State			TOT. HRS.	O.T. HRS.	D.T. HRS.	REGULAR PAY	PREM. PAY	GROSS PAY	FED. INCOME TAX	FICA	SDI	STATE W.T.		CHECK NO.	
EMPLOYEE NAME											TO DATE	TO DATE	TO DATE	TO DATE	TO DATE	MISC. DEDUCT.		NET PAY

Figure 62—Preprinted Form

Many data processing departments have concluded that it is more economical to standardize the size of paper used than to order several different sizes to suit the needs of each job. By standardizing, larger orders can be placed and quantity discounts can be realized. The advent of the IBM Type 407 with all of its printing in a 12-inch width made this approach practical.

The 13¾ inch x 11 inch is a very popular size. It leaves space for a full 12 inches of printing and 1¾ inches for margins that can be used for binding the reports for storage.

Another advantage of standardizing is that there is less chance of an operator running a report on the wrong-size form. When several different sizes of stock forms are available, it is not unusual for operators accidentally to use the wrong form, which results in an awkward situation for the recipients of the reports. They suddenly find themselves with a folder of reports which are on different sizes of paper and difficult to work with. When only one size stock form is available, this mistake is avoided. It sometimes happens that only a small portion of the sheet is used for some reports, and it looks as though paper is being wasted. In most cases, however, it is more economical to do this than to stock another form.

Many devices are available for removing the carbons from reports and for bursting the continuous forms into single sheets. The machine that removes carbon is called a separator. See Figure 63 and 64. The machine used to burst the sheets apart is called the "burster." See Figures 65, 66 and 67. These machines can be purchased from the companies that prepare the fanfold forms. A common misconception is that these machines and the forms are purchased from the punched card equipment manufacturers. This is not true; the manufacturing of paper is a science in itself, and there are dozens of paper companies in the business.

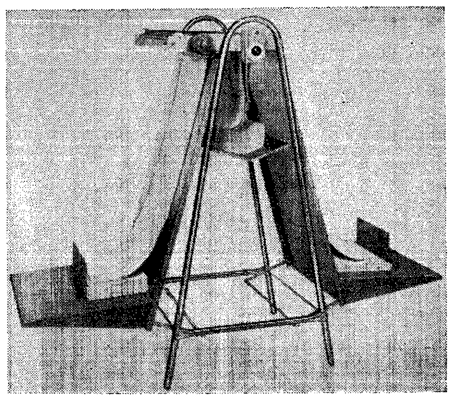
Another common misconception is that the data processing department retains a copy of each report that is prepared. This is usually not true. So many reports are prepared that it would require a library to stock them. The storage function is the responsibility of the recipients of the reports.

Every effort should be made to keep the number of copies of each report as low as possible without hampering the efficiency of the company. Each copy increases the cost. On a typical form, costs range as follows:

1 part paper – $4 per thousand sets
2 part paper – $12 per thousand sets
3 part paper – $19 per thousand sets

The cost can be much greater on tailor-made forms. These are forms preprinted to the customer's specifications. They require the preparation of plates that are used to print on the paper. The cost of distributing and storing the extra copies also adds to the expense as well as the labor cost involved by the people who are looking at and filing them without sufficient justification. It seems to inflate the ego of some people to be on the distribution of many reports. This creates a real problem to the data processing department in controlling costs. It is difficult for them to investigate thoroughly the need for every copy of every report that is issued. They must rely to a certain extent upon the recipients to act in the best interests of the company. They should not request

Figure 63—Gravity Carbon Separator with Power Rewind Spindles. The carbon separator is placed behind the tabulator and forms stack in the various sections. The carbons wrap around spindles which automatically wraps as the report is being prepared. When the report is finished the spindles are removed and the carbon is slipped off the end into a wastebasket. *(Reprinted by permission of The Standard Register Co.)*



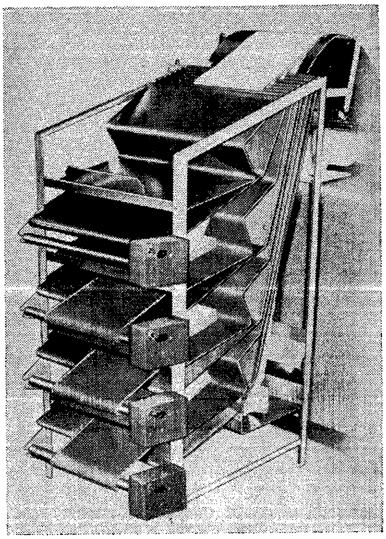
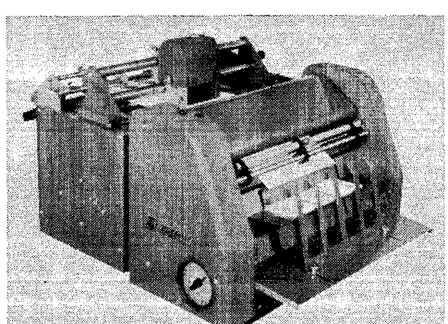


Figure 64—Power Feed Vertical Separator. Multicopy report is placed in center section. One carbon winds around a spindle and one copy folds in a side rack. The other copies fold in the opposite side rack. These copies are then placed in the center section and the process is repeated until all carbons have been removed. *(Reprinted by permission of The Standard Register Co.)*

Figure 65—Tab Card Burster. This burster will burst apart continuous form cards as well as regular paper forms. It can be quickly adjusted to accept any standard sized paper forms as well as cards. *(Reprinted by permission of The Standard Register Co.)*



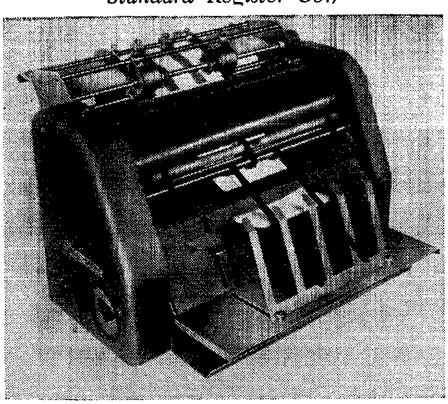


Figure 66—Burster-Imprinter. This burster will burst and print at the same time. The unit on top contains a printing mechanism which can be used to sign checks or print dates and other data that is required on each sheet of a report or check. *(Reprinted by permission of The Standard Register Co.)*

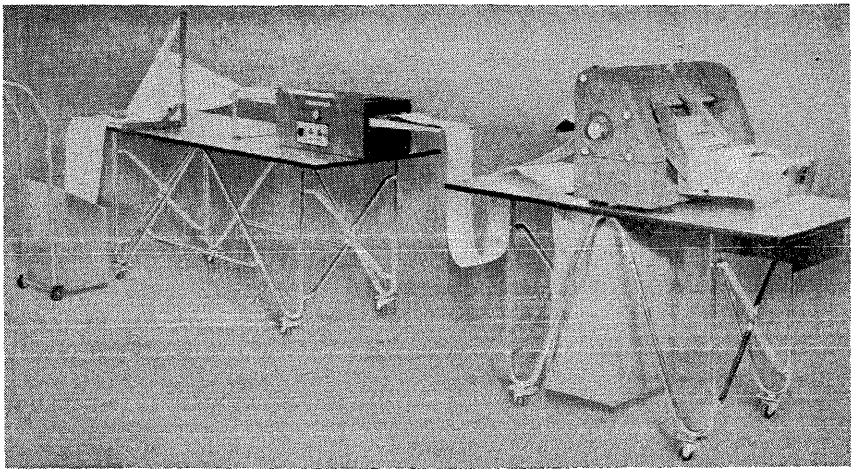


Figure 67—Thermobond and Burster. This equipment is used for billing operations such as postcard utility bills where both sides of the cards must be printed. The form is purchased in a wide sheet so that both sides of the postcard are on the same side of the sheet. The postcard is printed on the tabulator, both sides being prepared at once. The form is then placed in the cart shown on the left and is folded as it feeds into the thermobond unit. This unit heats and seals the two sides together into a postcard size bill. It then feeds into a burster for separating into individual bills. *(Reprinted by permission of The Standard Register Co.)*

reports that are not essential to their operations, and they should immediately notify the data processing department whenever conditions change so that the report is no longer required.

W. T. McLaughlin, manager of field operations for the Service Bureau Corp. states, "The science of management, in its simplest form, must be stated as the ability to get things done through people."

Devereux C. Josephs, president of New York Life Insurance Co. recognizes the importance of people in the machine age, as is shown by the following statement that he made in a talk delivered in 1952 at the 29th Annual Conference of the Life Office Management Association:

> We have been talking about machines and methods. They must be used by people; but they are not interchangeable with people. And in the last analysis, ultimate effectiveness of our business operations depends upon people. Unless the personnel who run the machines or use the systems are made to feel that they are participating in a common endeavor, are made to want to cooperate, the machines or techniques will be of no great value.*

In discussions of machines it is not difficult to overlook the human factor; yet, this is still by far the most important segment of any organization regardless of its degree of mechanization or automation. In fact, it seems that the more advanced the equipment becomes, the more important the people become who work with it. It also follows that a higher calibre of people are required to organize, systematize and operate this more complex equipment.

It is interesting to note the contrast that is evident among data processing

*Devereux C. Josephs, "Machinery, Systems and the Priceless Ingredient." Life Office Management Association, Sept., 1952.

departments. Two departments in similar type companies having similar equipment may function in opposite fashions. One may be highly efficient, with model systems and a good reputation, while the other may be in chaos, with constant reruns, inadequate systems and a poor reputation. The reason for this is usually found to be in the personnel who are running the data processing departments. Well-qualified people can make just about any system function properly. They will have adequate controls and practice good management policies and good working habits. Others just don't seem to have what it takes. This is one reason for the abnormally-wide range of salaries paid for similar positions from one company to another. Some companies feel that they cannot afford to pay the price to get top-quality people. Consequently, they must settle for mediocrity. The thing they overlook is that well-qualified people, especially in supervision, usually more than offset the difference in salary by an efficient operation.

So much of the company's systems hinge around the data processing department that it can be disastrous to tolerate inefficiency at this point. There was a time, in the days of tabulating, when the machines were so simple and the systems so limited that an inefficient tabulating department was a nuisance but did not have much effect on the organization as a whole. Today, the opposite is true; advanced equipment and highly integrated systems have so interwoven the systems of a company through the tentacles of automation that inefficiency at the core can be catastrophic to the point of wiping out a company's profits.

There are several different classifications of personnel in a data processing department, and they will vary from company to company. There are also many different titles used, and no attempt will be made to name all of the titles used for each classification. They will be grouped under one simple title which is in common use. The type of equipment used in the data processing department will also have some bearing upon the different classifications of personnel employed.

A data processing department that has the conventional punched card equipment but does not have a computer would normally have the following classifications:

1. Supervisors
2. Analysts
3. Clerks
4. Key Punch Operators
5. Equipment Operators

In smaller departments one person might fill two or more of these positions. For instance, a girl might spend part of her time key punching, part operating other equipment, and the balance of her time on clerical activities. In larger departments, these classifications can be expanded. One large department has the following different job classifications:

	Chief, Data Processing
Supervisors	Supervisor, Data Processing
	Assistant Supervisor, Data Processing
Analysts	Systems Analyst
	Analyst

Clerks	Secretary Control Clerk Accounting Clerk
Key Punch Operators	Key Punch and Verifier Operator, Leadgirl Key Punch and Verifier Operator, Senior Key Punch and Verifier Operator Key Punch and Verifier Operator, Junior
Equipment Operators	Equipment Operator, Leadman Equipment Operator, Senior Equipment Operator Equipment Operator, Junior

All of these classifications can be filled by either men or women. Key punch operators and clerks are almost always women. Most members of supervision are men. However, there is a large number of female supervisors, especially in the very small departments. Analysts are also predominently men, but there are many women successfully handling these jobs also. Equipment operators are usually men, but here again there are a lot of women working in this classification. Strangely enough, the theory that women aren't mechanically minded just doesn't seem to apply. Women grasp the techniques in this field just as quickly as they do in clerical work. Of course, there are individual cases of women who aren't adapted to this type of work, but this applies equally as well to men.

Women have proven to be so much more adept at key punching and verifying that they have monopolized this classification. They also seem to be better at certain types of equipment operation. Detailed applications, such as payroll, file maintenance, and other jobs that require more memory and concentration seem to appeal to women while men favor large-volume, fast-moving jobs.

Some states have restrictions on the amount of weight that women are allowed to lift. This can present a problem for female equipment operators in data processing departments using the IBM Type 407 tabulators. Some of the control panels used on these machines can be quite heavy. Therefore, it is advisable to check the state law and weigh the control panels before employing female equipment operators.

Another problem is the lifting of cases of cards and boxes of paper. It is usually possible to break these down into smaller boxes or smaller stacks of paper but this is sometimes an inconvenience. If these boxes exceed the weight restrictions for female employes, they must be so advised.

Storage of used cards can be quite a problem, as many of the cards used by the data processing department must be saved because they are source documents or because they might be needed again. It is necessary to periodically rearrange or dispose of these cases of cards. This is *not* a job for a female employe.

Because of the wide variety of work performed in a data processing department, it is usually better to employ both men and women than to employ one sex exclusively. In this way, the personnel can perform the work best suited to them.

One of the biggest personnel problems is the lack of experienced and capable people to fill all of the vacancies. Well-qualified supervisors are always in great demand. Likewise, analyst positions go unfilled for months in some areas. Many companies have training programs for key punch and equipment operators. The equipment manufacturers make a commendable contribution in the field of education. They conduct a constant series of classes in every big city across the country and in many small ones for all types of training. These classes are free of charge but usually require that students be employed by a company where they will be assigned to this type of work. There are also many private schools that offer classes to individuals for a fee. An impetus was given to the labor market by the tremendous number of people who were trained by the armed forces.

It is difficult to state a definite period of training time that is required to qualify as an experienced person in each of the various classifications. This depends very much upon the individual and his or her aptitude for the work. A rough rule of thumb is six months' experience for key punch and equipment operators. This means that an individual with average intelligence and with an average degree of aptitude for this type of work should be able to master the fundamentals sufficiently within six months to meet the minimum qualifications for an experienced operator. Much more time is usually required to become proficient.

When learning to play a musical instrument, a certain period of time is required to grasp the fundamentals of what to do, how to do it, and when to do it. Then a lot of practice is required in which these fundamentals are repeated over and over again until one becomes proficient and can play naturally and by habit without thinking of each thing that must be done. The same is true of key punching and operating the other equipment. The first six months are spent in grasping the fundamentals of what to do, how to do it, and when to do it. After that it is a matter of practice. An average key punch operator with two years' experience should be better than an operator with six months' experience because she has had more practice. Of course, after a period of tim, the increase in the degree of proficiency lessens as the learning levels off, so that there is a much greater difference between two key punch operators with six months and two years' experience respectively than between two girls with two years and four years' experience respectively.

In spite of the shortage of personnel in this field, it is frequently difficult for new people who desire this type of work to find employment. Most data processing departments prefer to hire experienced people if at all possible. If they cannot find experienced people to fill a vacancy, it often happens that there are employes in other departments who desire to learn this work, and they are transferred into the data processing department where they are given training. This route is probably the one by which most people break into the field. This is very logical when one considers the advantage of such a move. It is advantageous to the data processing department because the employe is known. He is already working for the company and will obviously not be considered unless his record is good. He also is familiar with the company's policies, documents and personnel so that less training is required. It is to the company's advantage because it represents promotion from within and brands the company as being broad-minded and liberal toward its employes. It is advantageous to the employe because it gives him a chance to break into a new field which will probably result in an ultimate increase in wages.

The classifications of analysts and supervisors require more training and experience. A natural path of promotion is from equipment operator to analyst to supervisor. However, there is nothing that dictates this course must be followed. In fact, the present tendency is to fill these two classifications with quite different types of individuals.

At one time it was essential for a supervisor to be an expert at control panel wiring. This was considered to be the primary qualification for this position, and even today it is not uncommon to see ads for supervisors stating that 604 and 407 wiring ability is required.

As the classifications become more refined, it is obvious that supervisors should possess administrative and managerial qualities. They should be objective and be able to visualize the over-all systems concept of the company. They should be experts in human relations and be able to direct employes and coordinate activities. They should also possess a sufficient degree of technical ability to understand the equipment and its potential.

Analysts, on the other hand, are technicians. They should be experts at control panel wiring and thoroughly understand the equipment with which they are working. They should be able to take a system and adapt it to a machine. They should be able to advise their supervisors on technical matters and to write procedures.

It would be a rare individual who possesses all of the qualifications for both of these classifications. There have been many excellent technicians who have been ruined by being pushed into the administrative area. The type of person who makes a good analyst usually does not make a good supervisor. These people will invariably try to involve themselves in technical problems at the expense of their administrative duties. Good supervisors will try to rid themselves of technical work as much as possible so that they can devote their energy to the tasks for which they are being paid. Those supervisors who deliberately relegate themselves to wiring, operating and other tasks which can be performed by less highly paid employes are courting disaster.

Because of the nature of this type of work, both supervisors and analysts should be systems men. Systems are so interwoven throughout all mechanical and automated data processing functions that a knowledge of systems is basic. There is a classification called systems analyst which is filled by more advanced technical personnel who are also highly skilled in the systems area.

These people are able to develop over-all systems and coordinate with many other people and departments in the development and installation of new systems.

The pay scale for supervision is higher than for analysts, but there is quite an overlap. It is not uncommon for experienced analysts in a large data processing department to be higher paid than the lower levels of supervision. A well-qualified systems analyst may be second only to the head of the department.

End of Chapter Questions

1. What are points as applied to a data processing department?
2. What are the various methods used to identify a data processing department's size?
3. Why is shift work quite common?
4. Why is speed in reporting essential in many applications?
5. What are the advantages of extra shifts? Disadvantages?
6. How does an IBM Type 407 tabulator compare in capacity with an IBM Type 402 tabulator?
7. What limitation does the IBM Type 402 tabulator have in printing alphabetic data?
8. What policy should be followed by people outside of the data processing department in regard to machine capacities?
9. How much should a company spend for equipment?
10. How are most IBM machines given instructions?
11. How can control panels manufactured for one IBM machine be used on another IBM machine?
12. What are the two types of wires? What purpose does each type serve?
13. What is the purpose of wires?
14. What is the most common classification used for people who spend a great deal of time wiring control panels?
15. Why shouldn't people in other classifications devote much time to wiring?
16. Where can sources of supply for new and used control panels be found?
17. Should people outside of the data processing department ever interfere with panels or wires?
18. What is the approximate cost of 10,000 cards?
19. What are important considerations in purchasing cards?
20. What is the difference between stock and preprinted cards? What are the disadvantages of each?
21. What is a government printing contract? Which companies can purchase under the provisions of this contract?
22. Why are different colored cards and striped cards used?
23. What are the advantages and disadvantages of card checks?
24. Why are forms important?
25. How are multicopy forms prepared?
26. What are the advantages of standardized, one-sized forms?
27. What is the name of the machine that removes carbons? The machine that tears the sheets apart? The device that prints on the forms?
28. Who is responsible for saving copies of reports?
29. What responsibilities do recipients of reports have?
30. What is the most important segment of any organization regardless of its degree of mechanization?

31. Why is there an abnormally wide range of salaries paid for similar data processing positions from one company to another?
32. Why should a company seek well-qualified personnel to run its data processing department?
33. What are the personnel classifications normally found in a data processing department that does not have a computer?
34. What are the advantages and disadvantages of women in this field?
35. How do new people break into this field?
36. What different characteristics should be possessed by supervisors and analysts?
37. Why is a systems knowledge so important to both the supervision and analyst classifications?

CHAPTER 10

Responsibilities of the Data Processing Department

The data processing department is a service organization designed to serve the company or organization of which it is a part. It accepts data in a raw form and processes it into reports suitable for analysis by management.

It is the responsibility of the data processing department to establish controls to assure that the reports issued will be as accurate as the data received. It is unreasonable to expect reports of better quality than raw data put into them. For this reason, source documents should always be checked to assure their accuracy before sending them to the data processing department for introduction into the mechanized system. *Reports cannot be any more accurate than the source documents.*

The data processing department issues reports which are used throughout the company. Many of the decisions made by the various levels of management are based upon the contents of these reports. Timeliness is important. If these reports are issued too late, they will be useless. No one is interested in old business facts. Reports must be received within a reasonable length of time to be of value to management. If management is to be expected to make wise decisions, it must have current facts upon which to base these decisions.

Facts must not only be current but they must be received on a dependable schedule if management is to utilize them properly. You can imagine the confusion that would result if reports were issued haphazardly. Important decisions might have to be delayed pending the receipt of the latest facts. In a competitive economy such as we have, this is dangerous because our competitors may be getting the facts on schedule which places us at a disadvantage. Of course, management has a responsibility here too – that is to supply the data processing department with adequate personnel and equipment to meet the desired schedules.

The organizational location of the data processing department in the company will depend somewhat on its scope of responsibilities. There is a marked tendency toward positioning this department at a high level, even reporting directly to the general manager or executive vice-president. It is felt that this is the position from which it can best serve the interests of the whole company rather than a certain department. Data processing is vitally connected with systems, and systems are interwoven throughout all of the functions of the company. High-level organization promotes a more objective viewpoint and subdues departmental loyalty and subjection.

There are many installations, however, which are a single purpose and exist solely for one application such as billing or inventory control. These types of operations normally report directly to the department for which they are performing a service. This is natural and normal because they can best serve the purpose for which they were intended in this position.

Naturally, a department reporting to top management has broader responsibilities than a department reporting to any function within the company such as accounting, production control, material control, etc. The relative advantages and disadvantages of the various locations of the data processing department will be discussed in the next chapter.

The data processing section which reports to the head of a department within the company is responsible for satisfying the needs of that department to the best of its ability, but at the same time it is responsible to act in the best interests of the company to the best of its ability within the limitations placed upon it. Naturally, the supervisor of the data processing section cannot violate the orders of his superior, or a department head, even though he may not agree that these orders are in the best interests of the company as a whole. It is certainly his responsibility to make his objections known and the reasons for them. If the department head does not concur, then the data processing supervisor has no further responsibility than to comply with the orders.

In the organization where the data processing department reports directly to the general manager, it is responsible to always act in the best interests of the company. This demands a thorough knowledge of the company's operations and systems. It demands a higher calibre of personnel who are capable of independent thinking and sound judgment. This type of organization will usually be more diversified, more complex and more difficult to supervise.

At one time most installations were of the one application type. The trend today is away from this type and the company-service type is most popular. Progress in the engineering of more flexible punched card equipment is greatly responsible for this. The earlier equipment was very limited and was not capable of processing several applications. Today's equipment, especially computers, are extremely flexible and are quite adaptable to many different applications and to the processing of integrated systems.

This trend toward greater complexity has increased the responsibility of the supervision of the data processing department. This is not to imply that more personnel are involved because frequently there are fewer personnel in the department but much more complex equipment and systems. The number of personnel supervised is a commonly misused factor in rating the value of supervisors by wage and salary departments. In a department consisting of people and equipment, this factor considered alone can be very misleading. The complexity of the equipment and of the systems can have a much more significant effect upon the responsibility of supervision. It is much easier to supervise 20 people engaged in the processing of millions of cards for one application than it is to supervise 10 people working on several diversified applications. Regardless of the position of this department in the organization of the company, its size, or the number of personnel involved, there are certain responsibilities which the supervision must assume.

System of Management

It is important that there be a system of management. It is rather astonishing that this profession which is so vitally concerned with systems work is often found lacking in setting up that most important system – a system of controlling the department.

This system of management should include:

1. Control over requests for services received from other departments.
2. A system for identifying reports.
3. A scheduling system.
4. A system of procedures and controls.
5. A system of time utilization and analysis.
6. Control over the distribution of reports.

It is the responsibility of the supervision of the data processing department to set up these controls. This does not guarantee an efficient, well-organized department because there are many other factors involved, but it will be impossible to have such a department without these controls.

Let us now analyze each portion of the system.

1. Control over requests for services received from other departments.

Most of the work performed in a Data Processing Department is for someone else. This work may come as a result of a request from another department. It may also more or less evolve from decisions made at conferences attended by data processing representatives or as a result of recommendations resulting from studies made by data processing personnel. In some organizations, a request can come from almost any employee in the company.

These requests are of two types. Regular requests are those requests made for reports which are to be issued on a *regular, repetitive* basis. Special requests are those requests for a "one-shot" report which will be issued once and probably never produced again.

It is important to the efficiency of the data processing department that these requests be controlled and flow in an organized pattern. Chaos will result if requests for both regular and special jobs are taken from anyone without setting up a system for handling them.

The request *for any work which is to be performed in the data processing department should always be in writing.* It is customary to have a preprinted form for this purpose. This form should supply all of the necessary information that the data processing supervisor needs to analyze to determine if the work should be performed by his department. This would include the data to be printed on the report, the purpose of the report, its sequence, totals required, distribution (who it is to go to), and the appropriate signatures.

The normal procedure that is followed is for a person who thinks he needs the services of the data processing department to contact the supervisor. A meeting is arranged at which time the problem is discussed. The data processing supervisor should try to determine exactly what is required at this meeting. This is sometimes very difficult because of communication problems and because people do not always know exactly what they want and are merely seeking information. If possible, however, the supervisor should try to determine if it is in the best interests of the company to perform this work in his department. If it is not, then he should so inform the person making the request and his reasons for arriving at this conclusion. If this is done diplomatically, it should be the end of this request.

If, however, the request appears logical and the data processing supervisor feels that it is appropriate for mechanization, then a request can be filled out jointly by the two parties involved and signed by the person making the request if he is a department supervisor. If he is not, he must get his supervisor's signature. This prevents a report from being mechanized without first being officially requested by a member of the company's management. It also prevents just any employe from making a request.

All requests, both regular and special, must be submitted on this form. This is what throws many departments into a state of confusion. The supervisor must know everything that is going on in his department or he cannot exercise proper control. Machine operators should not perform any work requested unless it has been approved by their supervisor. They have certain regular work to perform and they should not do anything except this work regardless of how small the task may appear unless directed by their supervisor.

A primary responsibility of the Data Processing Department is to get regular jobs out on schedule. Bootleg work or even approved special requests can do more to defeat the fulfillment of this responsibility than anything else. Once a request for a regular report has been received, approved and the report has been set up on a schedule, it is the responsibility of the data processing department to meet that schedule. This is why it is so important to get all requests in writing, properly signed and analyzed by data processing supervision before any work is performed. Supervision must consider the effect that each request will have on present schedules.

It is senseless to set up a new report that will cause present work to fall behind schedule. This must be taken into consideration by the data processing supervisor at the time he is analyzing the request. It should *not* be considered at the time he is trying to determine whether the report is applicable to mechanization. Too often, an overloaded department behind the supervisor is the dominating factor in his rejection of a request while in reality the request may be for an ideal mechanized application. This is a mistake! If the request is good, it should be so recognized. The fact that there is not time to do it must then be made known and several choices are available. More people or machines or another shift may be added in the data processing department. Perhaps an outside service bureau would be practical. It is the responsibility of the data processing department to recognize the request as sound and valid and to make management aware of this. A further responsibility is to recommend a method of fulfilling the request and an alternate method, if possible.

For instance: A request is received for an inventory control application. It is estimated that this will save approximately three people but the data processing department has no time to do it. The supervisor determines that by adding one key punch machine and operator he can absorb this job. He notifies management of this along with his recommendation. Since this represents an over-all cost reduction for the company, it is likely to be approved. The important thing is to have everything in writing, the problem thoroughly analyzed, and a solution ready before presenting it to a higher level of management.

If the personnel of the data processing department do all that is expected of them (analyzing requests for services and aggressively pursuing applications for mechanization and improvements in existing systems), it is obvious that they must possess above-average capabilities in several areas. They must be good systems personnel in order to distinguish the correct way of performing each operation. There are usually several different ways to accomplish a given result. It takes experience, good judgment and a keen mind to ferret out the right way to do a job.

They must think like the general manager. Punched card data processing is a tool of management; therefore, it must function the way management wants it to function. This can be extremely difficult, especially in view of the fact that too often there is little or no communication between the general manager's office and this department. An attitude of objectivity must be maintained and selfish interests are not to be tolerated. This department supplies a life-line of data to all other departments. It sprays a never-ending flow of information throughout the company that permeates into every function. This information and data must represent a reflection of management. The format and arrangement of data must be consistent with the philosophy of management.

An often-quoted example of a punched card data processing department that failed to act in the will of management is the department that utilized the latest techniques and equipment to speed up its payroll processing. After several months of systems work which cost tens of thousands of dollars, they were able to write paychecks Monday night for work performed through Sunday. Technically this was a very commendable feat. Managerially, however, it backfired when the worker's union found out that the company could prepare paychecks faster, they demanded that the employes be paid on Wednesday of each week rather than the normal payday of Friday. The net result was that the company had to release several hundred thousand dollars two days earlier each week which now costs the company several thousand dollars in interest each year.

It is common for personnel in this profession to become obsessed with their technical ability and perform seemingly impossible feats of reporting. All too often, this results in a complex system that will not work or in a result which is not practical, is not needed, or even is harmful (such as the payroll example).

Technical knowledge must be tempered with sound judgment and simple logic. Technical knowledge is useful only insofar as it assists one in developing a system which is best for the company. One must constantly strive to broaden his knowledge in company systems, management philosophy, and technical advancements that he may meld these in proper proportions to develop simple, logical, practical systems. A technical knowledge which exceeds other basic knowledge tends to produce complex systems. This is detrimental because a complex system is less workable than a simple system. Strive for simplicity! A system may be beautifully illustrated with operations that are technical marvels but the only real test is not the degree of mechanical and electronic complexities but rather, will it work? The best system is the simplest possible system that will work.

Once a request for services has been submitted, it must be analyzed by the supervisor of data processing to determine its feasibility and practicality. He may assign this responsibility to an assistant who will do the research and submit an opinion. Based on the qualifications previously cited, the request will be either approved or disapproved. Normally, special requests are approved only by the data processing supervisor unless they require extra expenditures or overtime. It is common practice to route regular requests to higher levels of management for approval. However, this is often intended more to keep them cognizant of current activities than to analyze the request for approval or disapproval.

After the requests are approved and the report is installed, the requests are filed for possible reference in the future. Thus, the request file contains a complete history of all regular and special reports ever issued.

Figure A illustrates a form used by one company for the requesting of services from their machine services department which is the name they have given to their data processing section.

The request form serves as a tool of the manager of data processing in these ways:

A. It supplies the manager with control over all work performed in his department, because no work can be performed unless it is requested on this form.
B. It supplies the manager with essential data required to determine the feasibility of satisfying the request in his department.
C. It forces the requesting department to thoroughly analyze its requirements before making a request.
D. It supplies basic criteria required by technicians to wire control panels and write procedures or programs.
E. It eliminates "nuisance" requests by forcing the individual making the request to sell his boss on the idea.
F. It supplies a historical record of every demand for services placed upon the department. This is invaluable in justifying expenditures.

2. A system for identifying reports.

Once a report has been implemented, we need to be able to identify it so that there is no danger of confusing it with any other report. Titles are dangerous. They are too similar and difficult to distinguish but numbers are evident and mutually exclusive.

The numbers may be assigned consecutively as requests are received or they may be blocked off for greater meaning. One system uses a four-digit number with the first two digits representing the type of application, the third digit

MARQUARDT AIRCRAFT COMPANY
Pomona Division

REQUEST FOR MACHINE SERVICES

Title of Requested Report:	
What is the Report to be used for?	
Information to be printed on the Report	
Sequence of the Report	Totals Requested
Number of copies and their distribution	Frequency __One Time __Weekly __Other (Explain) __Daily __Monthly
Schedule on which Report is to be issued	Date service is requested to begin
Source Documents______ Volume per week______ Number of cards to punch per document______	Estimated cost per week to do the job without Machine Services
REMARKS	
Person in Requesting Dept. who will coordinate with Machine Services Name______ Phone______	Requesting Department number______ By______ Signature Date

Estimated Man Hours	For Machine Services use only APPROVALS	
	______ Controller Date	Scheduled Start Date______
	______ Manager, Machine Services Date	Report Number______

Figure A—Request for Machine Services

distinguishing regular or special reports and the last assigned consecutively. Assume that the first two digits "06" had been assigned to the labor distribution application and that in the last two digits 01-49 were used for regular reports and 50-99 were reserved for special reports. The number 0610 would be a labor distribution regular report. 0655 would be a labor distribution special report.

Report numbers are also essential for the accumulation of time for time utilization control. It would be too time consuming to write down the title of the report being processed when recording time at the various machines.

An effective system is one in which all work performed in the department is backed by a written request for services to which a report number has been assigned. This provides justification for and identification to all work performed in the department.

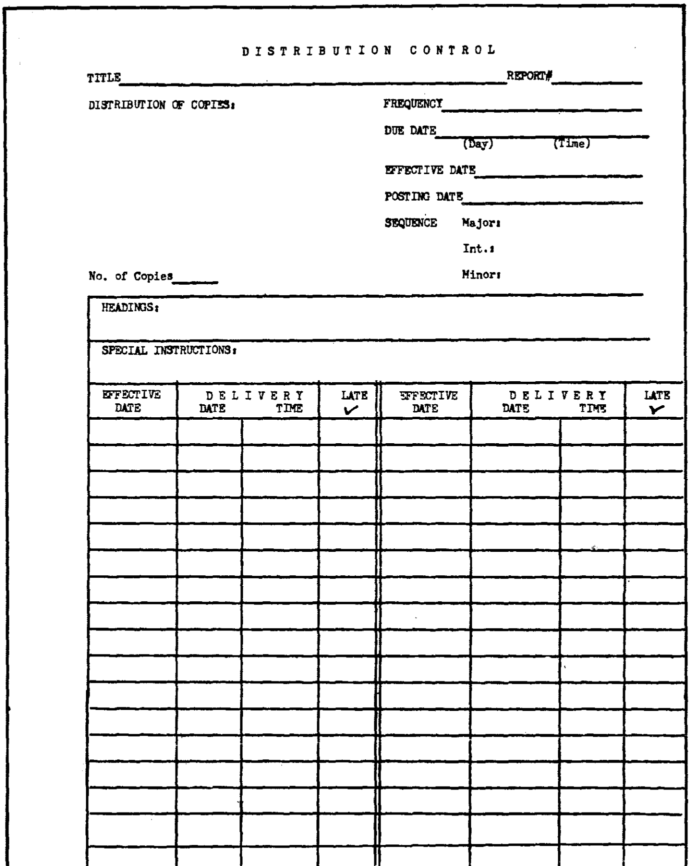
3. A scheduling system.

At the time the request for services form is being analyzed, a schedule should be set for issuing the report. It is the responsibility of the data processing department to set up a schedule which can be met most of the time. It is unreasonable to allow so much time that the schedule is certain to be met all of the time. There are many things which can cause schedules to be missed such as machine breakdowns, excessive absenteeism of personnel, reports being out of balance, etc. In an efficient department, these are held to a minimum and schedules are met most of the time even though it takes extra effort in case something goes wrong.

The schedule must be set to supply the report in time for it to be of value to the recipient. Reports, like newspapers, tend to lose their values if delayed. Facts, like news, get stale very quickly. It is often difficult to set a schedule which is tight enough to satisfy the recipients, yet is loose enough to be met most of the time. Experience and judgment are key factors in determining this. Many data processing departments have trapped themselves by setting schedules to please the recipients of the reports but which could not be met under normal working conditions. As a result, it often develops that the supervisor finds himself doing operator work late at night and on week-ends in order to keep the reports flowing on schedule. This may seem to be commendable that a man is willing to donate his time in this manner but actually it is foolish because he is not being paid to operate machines – he is being paid to manage. When he operates machines, he is actually trying to cover up a poor job of managing. Anyone who does a job other than the job which he is being paid to do is treading on very dangerous ground. His job is sure to suffer sooner or later and he will be held responsible for it regardless of how well he did the other job.

What can be done when a report is desired sooner than it can be issued? Extra shift operations are often the answer to scheduling problems as well as overload problems. A department working 16 hours a day can meet tighter schedules than a department working eight hours a day. Additional employes or machines are sometimes the solution too. It is the responsibility of the data processing supervisor to determine the solution which he feels is best and to report it to management. If they want the report and they want it on a tight schedule, then they must accept the responsibility of furnishing whatever is necessary to meet that schedule. Of course, when they see the cost they may decide that they don't need the report after all. The data processing supervisor must make management aware of the problem. The supervisor should not incapacitate himself because he is too timid to report a problem. A data processing department is not like a sponge that can absorb any amount of work. Management realizes this but cannot be expected to do much about it unless the problem is brought to their attention as it occurs.

Once a mutually agreed upon schedule has been established and any necessary action taken to supply the potential for meeting the schedule, it is the responsibility of the data processing department to have a system of scheduling reports on a day-to-day basis which will assure that the schedules are met. There are many kinds of schedule systems but they must all supply one thing — the day on which work must start on a report to get it out by the scheduled date.



D I S T R I B U T I O N   C O N T R O L

TITLE ____________________ REPORT# ________

DISTRIBUTION OF COPIES:

FREQUENCY ________

DUE DATE ________ (Day) (Time)

EFFECTIVE DATE ________

POSTING DATE ________

SEQUENCE Major:

Int.:

Minor:

No. of Copies ______

HEADINGS:

SPECIAL INSTRUCTIONS:

EFFECTIVE DATE	D E L I V E R Y DATE	TIME	LATE ✓	EFFECTIVE DATE	D E L I V E R Y DATE	TIME	LATE ✓

Figure B—Distribution Control

Figure B illustrates a form that is extremely helpful in a schedule system. It is called a distribution control sheet. One of these sheets is prepared for each regular report issued by the department and they are filed in report number sequence in a three ring binder. It follows the receipt of a request form and the assignment of a report number. It is not necessary to prepare one of the sheets for special reports because the required information is on the request form which should accompany the job to its completion.

The distribution control sheet is used as a link in the scheduling system as well as a control over the distribution of reports. It provides management with the following essentials:

A. It provides a readily accessible, compact record of all active reports.

B. It provides scheduling data as follows:

Frequency with which report is issued, i.e., daily, weekly, monthly, etc.

Due date – Date on which report must be issued to meet established schedule.

Effective date – Date of the report.

Posting date – Date on which work must be commenced so that report will be finished by Due Date.

C. It provides data for the distribution of reports.

D. It provides a control over late reports.

E. It provides a historical record of all reports issued including the date and hour of the day.

The controls furnished by this form over the distribution of reports will be discussed later as that topic is explored. For the present we are concerned primarily with its usefulness in the area of scheduling. It has been pointed out that certain data necessary to the preparation of reports on schedule is available on this form. However, it would be unwieldy for a supervisor to thumb through all of these sheets each day to determine which reports are due.

Most supervisors find it necessary to keep some kind of a record of what jobs must be worked on each day. A very successful method of doing this in many departments is known as "The Schedule Book System." The schedule book consists of one sheet for each work day in the month and it is prepared a month in advance. It is prepared by posting to the daily sheets in the schedule book from the distribution control sheets according to the posting dates which are the dates on which work must commence to get the reports out by the due dates.

Figure C is a sample schedule book sheet. Note that this sheet is for one day only, Wednesday, April 11. It contains the reports that are supposed to be processed on that date in order to maintain schedules. For instance, Report #0220, Labor Distribution by Department was posted from the distribution control sheet for that report. Assuming that it is a weekly report, it will appear on the sheet for each Wednesday in April. Its posting date on the distribution control sheet is indicated as Wednesday, its due date as Thursday and its effective date as the previous Sunday. From this information a clerk was able to post this report on each appropriate schedule book sheet and indicate the effective date and due date. The same is true for each report on the distribution control sheets. When each report has been posted on the schedule book sheets for the posting dates indicated, the schedule book is complete.

Each morning the supervisor analyzes the reports to be processed that day and copies, from the previous day, any reports that have not been completed. The name of the operator who is to work on each report is also written in. When the report is completed, the completion date is written in the last column on the line for that report.

The schedule book provides the following management controls:

SCHEDULE BOOK

Wednesday, April 11th

REPORT NUMBER	REPORT TITLE	EFFECT. DATE	DUE DATE	OPERATOR	COMP. DATE
0110	Accounts Payable Check Register	4-10	4-11	Bill	
0111	Accounts Payable Checks	4-10	4-11	Bill	
0215	Labor Distribution Detail List	4-8	4-11	John	
0220	" " By Dept.	4-8	4-12	John	
0221	" " By Section	4-8	4-12	John	
0401	Accounts Receivable Transaction List	4-10	4-11	Mary	
0402	" " Delinquent Report	4-11	4-11	Mary	
0408	" " Completed Sales	4-10	4-11	Mary	

Figure C—Schedule Book

A. It serves as a reminder of all work to be performed. This prevents any report from being overlooked or started too late to be completed on schedule.

B. It provides first line supervision with a formal means of analyzing and planning the day's work.

C. It provides a schedule of all work to be performed each day in the coming month. This enables management to fit special jobs into the slack periods and plan for peaks by advance requests for overtime, part time help or some other means.

D. It provides a complete historical record of every report issued, the date completed and the operator who worked on it.

E. It promotes teamwork and curtails "bossing" because each operator refers to the schedule book to see which jobs have been assigned to him for the current date. The load picture for the whole department can be seen and he may offer constructive suggestions and volunteer assistance in other areas. In other words, the operators have a tendency to share the supervisor's problems when they know about them.

The scheduling of special requests has already been mentioned but it bears repeating. Extreme care must be exercised in scheduling special jobs not to disrupt the regular work flow and cause regular reports to be issued behind schedule. Data processing people are service-minded by nature and want to help wherever they can. This is commendable so long as they remember that the first service they must render to their company is to get the regular reports out on schedule. Each request for services form on special reports should be thoroughly analyzed and an estimate made of the time required to do it. If this can be worked into the scheduled workweek, there is no problem. If it can't, then overtime should be requested. If management does not feel that the job is important enough to warrant paying overtime for it, then don't do it.

There will be some exceptions to this. Circumstances may arise where a report is urgently needed yet overtime cannot be worked for one reason or another. Regular reports may have to slip schedule to get the special report out. In this case the recipients of the regular reports should be notified that their reports will be late and the reason for the slippage. These should be held to a minimum.

A scheduling system should also have a method of feedback to supervision of any reports which were issued behind schedule. This will enable supervision to see where the system is failing and take steps to prevent reoccurrence. This feedback will normally come from the control over the distribution of reports which will be discussed later.

4. Procedures and Controls.

Now that we have a request for services for a report, have issued a number to it, and have a schedule set, we must prepare a set of instructions to tell the machine operators how to prepare it. This is very important because if the proper steps are not followed the resulting report will be inaccurate. Data processing departments that attempt to operate without written procedures are not unusual. Yet, there are very few supervisors that will deny the need for them.

There are several different ways of writing procedures but basically they can be categorized into two:

1. Outline
2. Detailed

The outline form is quite general and each entry is a reminder to the operator to perform a step. Much of the detail of what the operator has to do is omitted and the operator has memorized it after being instructed by another operator or the supervisor.

Flow charts may be classified under the outline form. Flow charts present a better pictorial impression than a written procedure. The over-all system is easier to grasp and every job that is set up is almost certain to be flow charted, in rough form at least, at the time the job is being planned. It is easier to plan out a flow chart leaving no loose ends. All decks are accounted for and disposition made of all cards. The flow chart used in the planning stages of a job evolves into the operator's procedure in some companies.

The outline form has the advantage of taking less time to prepare and less time for the operators to read. It has the disadvantages of taking longer to train new operators and of making it difficult to communicate procedural changes to the operators.

The detailed form, as the name implies, is a complete set of instructions for performing the job. It tells the operator everything he is to do (it is assumed that he knows how to operate the equipment and machine instructions are omitted). Any exception should be pointed out as this is a chance for him to make an error.

The detailed form has the disadvantage of taking longer to write and it also takes the operator longer to read. It has the advantage of simplifying the training of a new machine operator. If the procedure is properly written, it should be followed with very few questions. Since this type of procedure contains every detail, any change to the system will affect it. The revised procedure tells the operator exactly what the change is so that he will process in the new way with no difficulty. Verbal communications to the operators are virtually eliminated.

MACHINE ACCOUNTING PROCEDURE CONTROL SHEET

Date 4-30-62

The following procedure (1) is new ______ (2) is revised ✓ (3) is canceled ______

Report Number 1026

Report Name PARTS CATALOG

Brief explanation - (For more detailed explanation, see the revised procedure).

INCREASE NUMBER OF COPIES OF PARTS CATALOG FROM 4 TO 5. THE EXTRA COPY IS TO BE SENT TO J. SMITH IN MATERIAL CONTROL DEPT.

Authorization for change: R. DOE, MANAGER OF MATERIAL CONTROL

Check items affected:

Report Number List		
Procedure	✓ BILL	W.K. 4-18
Distribution Control	✓ BILL	W.K. 4-18
Schedule Book		
Other (Explain)		

ROUTING

BILL
RAY
TOM
PAT
FILE

W. Kyler
Originator

R. R. Jones
Manager, Machine Accounting

D-1188

Figure D—Machine Accounting Procedure Control Sheet

Larger companies may have both types of procedures. The outline form is usually retained by supervision for reference and the detailed form is used by the operators.

Probably the most preferable procedure is a combination of the two types. This combination consists of a flow chart indicating each step that is to be performed with short phrases written alongside to provide further explanation and to point out exceptions to the operator. This is the type that was used in the accounts payable application explanation in Chapter VI.

Regardless of the form of the procedure, each application should have a card form for each card used on a particular application. It should be the front sheet for that procedure. It is imperative that the operator performing the job be aware of, or be able to find out, what fact each field in the card is reserved for.

It is preferable that all procedures be typed but if this is not possible, they may be handwritten. Handwritten procedures are better than none at all. Some companies punch the procedures on tab cards and list off the procedure sheets on the tabulator. This is a very expensive method because it is using the tabulator as a typewriter, but it produces a clean procedure sheet.

A major problem with procedures, regardless of the type used, is to keep up with changes. Systems are so variable that changes often occur. These changes must be accurately made to the procedures at the proper time and all parties must be notified. It is not sufficient to just change the procedure. Most operators do not refer to the procedure after they have processed the job a few times. Consequently, some method is required to solve the communications problem.

Figure D illustrates a form used for this purpose. It is prepared for each new, revised or cancelled procedure. The report number and title of the report are written on the appropriate lines near the top of the sheet. Next, a brief explanation of what the change involves is indicated. The authorization is written in the "Authorization for Change" block. This is usually the name of the person who requested that the change be made. On new reports, it is the request for services number.

Actions that need to be taken are checked off in the next area and the name of person assigned to take care of each is written on the line immediately after the element checked. When the action is completed by the person, he places his initials and the date of completion on the second line.

The form shown in Figure D has been prepared to process a change to the number of copies of Report #1026, Parts Catalog from four to five copies. It was authorized by J. Doe, Manager of the Material Control Department. This would involve the procedure because the procedure tells the operator the number of part paper on which to prepare the report. It would also require a change on the distribution control sheet for Report #1026. This would require an addition of one line in the distribution block as follows: "1 – J. Smith." This indicates to the distribution clerk that one copy is to be sent to J. Smith.

The names of the people in the department who might be involved with this report are written in the routing block. This includes every operator who works on this job and any supervisors, analysts, programers or others who should know about the change. The manager determines the routing at the time he signs and approves the change. The document is then routed to all whose names appear on the routing portion and it finally ends up in a file for future reference, if necessary.

The procedure control sheet provides the following controls:

A. It notifies each of the systems changes to all pertinent personnel.
B. It serves as check off list of all steps required to implement the change.
C. It gives management control over all changes. A change should never be made without the authorization of this form.
D. It gives a record of who authorized the change.
E. It records what the change involved was and who implemented the changes to the various elements.
F. It records systems activity.

Controls are of paramount importance and a complete chapter has been devoted to this subject. (See Chapter VII.)

5. Time Utilization.

It is important for a manager to know if his machines are being utilized enough, or if they are being overworked. The same applies to the personnel. It is also important to know how much each application costs and the cost of services performed for each department. Service bureaus represent the extreme of this because they often bill customers based upon usage. The degree of control varies from company to company. In a very small company, it may be that none of these records are required because supervision is so close to the operation that the pulse can be accurately counted. In the medium and large-sized installations, this knowledge is a must. Machine utilization for the machine shop is a common application for punched cards in manufacturing companies. The reports produced supply machine shop management with the facts which they need to make intelligent decisions for scheduling, assignment of work, and ordering or cancelling machines. Accurate reports take much of the guesswork out of decision-making.

Just as the management of the machine shop needs labor distribution and machine load reports, so does the management of data processing need information. As previously stated, there is a marked similarity between a machine shop and a data processing department. By its nature the data processing department demands a more administrative approach, but many of the problems and responsibilities of the two bear a marked similarity.

The actual accumulation of machine times and personnel hours expended is of little value in itself. The real responsibility of the department's management rests in the analysis of this data and subsequent decision-making steps.

This analysis places an implied responsibility of being aware of all types of equipment and systems. It is not sufficient merely to be familiar with the machines and the systems of your company. Management, and for that matter, all personnel engaged in the data processing profession must constantly and continuously strive to keep abreast of all developments in the field. This task alone is staggering. Improvements are being made and new machines continually are being introduced by many different manufacturers. As new and better machines are introduced, systems undergo radical changes. How can one keep up with these advancements?

Probably the single, most significant contribution that one can make to himself and to his company in keeping abreast of the profession is to join, and take an active part in, an organization which exists for this very purpose. One of the organizations in this profession is the National Machine Accountants Association (NMAA). This association promotes the education and elevation of its members and of the profession as a whole. Educational meetings, conferences and seminars are also offered to help members keep up in this fast-moving field.

There are many different systems of time utilization. The simple systems seem to work the best. If the recording of time is made too complicated, it will involve too much of the operator's time and will probably not be as accurate.

A report numbering system is essential. The four-digit numbering system described previously is simple and is easy to record. Actually time utilization consists of two factors. One factor measures machine utilization and the other measures operator utilization. Since it is quite common for one operator to operate several machines at once, it is usually necessary to either maintain two different systems, or to allow operator time to accumulate for each machine that he operates. This tends to exaggerate operator hours. Keypunching and verifying time is easy to accumulate because there is one operator to one machine, in which case the machine time and the operator time are equal.

Some departments develop the actual dollar cost of each application by multiplying the hours that each machine is used by the hourly rental. The operators split their time among the applications on which they are working as equitably as possible so that their time recorded adds up to the time actually worked. This time is then extended by their rate of pay. Unused machine rental, supervisors' salaries, material and other costs are prorated over the jobs. This system spreads the cost of operating the department over reports produced for the period and provides a fairly accurate report cost.

Another system which is commonly used by organizations which charge for their services is to keep a record of machine time only. The machine time is then extended by a rate which includes the operator's rate, machine rental, overhead and profit. This system is much simpler and has more widespread use. It does not provide a true distribution of costs but does provide a more uniform standard against which to measure.

6. Control Over the Distribution of Reports.

The reports which are issued are the trademark of the data processing department. Their appearance and contents will establish the department's reputation. Some system must be set up to exercise a reasonable amount of control over the distribution of reports so that the final product (the report) reaches its recipient quickly and correctly.

A record should be maintained of each report issued, the date and time of issue. Recipients frequently misplace reports and then claim that they didn't receive them. A record of distribution is sufficient to dispel these accusations.

If this record is not available and there is a question whether the report was ever distributed the recipient will invariably demand a rerun.

The distribution control system should also include instructions for the preparation of reports before they are mailed. Headings may be required on the report or carbons may have to be removed and continuous forms burst apart. It is not uncommon to see a prepared report ruined by untidy headings being typed on the first page. The person typing the headings and distributing the reports is usually not the same person who prepares the report. The biggest problems of distribution arise in small departments which do not have sufficient volume to warrant a person full time on this job. In these small departments it is a great temptation and even a necessity sometimes to send reports out without titles or headings. There may not be anyone who has time to perform this clerical task and it is omitted in order to get the report out on time.

Obviously, preprinted forms are ideal because this eliminates the typing of headings over each column as they are already printed on the paper. Some tabulators are capable of printing headings according to instructions fed via control panel wiring. These methods are superior to typing and should be used wherever possible.

The date placed on the report should be correct, yet this is a common error. When hundreds of reports are being issued each month with many different effective dates it is easy to become confused and place the wrong date on a report. The system should include a method of selecting the proper effective date to be placed on each report.

The system should also include the date the report is due and a method of feedback to management on reports issued after the due date. This feedback enables management to take corrective action so that the report will be issued on schedule the next time. This feedback also gives management a measure of the effectiveness of the schedule system and of the efficiency of the department in general.

The distribution control sheet discussed earlier (Figure B) is designed to aid management in the distribution of reports. Note that it provides a space entitled "distribution of copies." The people who are to receive the report and the number of copies that each person is to receive are entered here. This tells the distribution clerk where to send each copy of the report. It also provides a space for headings where the caption that is to be typed over each column is indicated.

The operator producing the report should write the report number and the effective date of the report in the upper left corner of the first page and pass the report to the distribution clerk. She will turn to the distribution control sheet for that report number and verify that this is the proper report number and effective date. She will then proceed to type headings, if indicated, and perform any special action required that is indicated in the special instruction block. This could include certain audits or stampings, such as, stamping the first and last sheets with a confidential stamp. She then removes carbons if it is a multiple copy report and bursts the report, if that is required. As the various copies are mailed or delivered, she logs the report out in the lower section of the distribution control sheet by entering the effective date of the report and the current date and time under the delivery block. She checks due date and if report is being delivered late, she checks the late block. This indicates that report has been issued behind schedule. Each time a check is made in the late block, she records the report number, title and effective date on a sheet. At the end of each day, this sheet of late reports is submitted to the manager of the department. This provides him with a feedback of how well his scheduling system is functioning. There is nothing he can do about the reports that have already gone out late, but he can spot problem areas and take preventive action to avoid reoccurrences.

Some type of audit should be included in the distribution system. Supervision must be assured that each report is in balance, in sequence, accurately prepared and suitable for distribution. The department's reputation rides on each report that is issued. A reasonable amount of control must be exercised to assure quality. The amount of auditing necessary will vary from one department to another. The experience and capabilities of the operators preparing the reports will have a great deal to do with the amount of checking required.

In summary, it is the responsibility of the data processing department to have a system of management which will include:

1. Control over requests for services.
2. A system for identifying reports.
3. A scheduling system.
4. A system of procedures and controls.
5. A system of time utilization and analysis.
6. Control over the distribution of reports.

End of Chapter Questions

1. What is the responsibility of the data processing department in the area of controls?
2. Why must reports be issued on a timely basis?
3. Why is there a trend toward positioning the data processing department at a high level within the organization?
4. What are the responsibilities of the supervisor of data processing if he feels that his superior is not utilizing the data processing services to the best interests of the company as a whole?
5. The trend today is toward what type of data processing department? Why?
6. What should a system of management include?
7. What are the two types of requests received?
8. Why should all requests be in writing and be approved by the head of the data processing department?
9. What is the responsibility involved in processing regular work? How do special requests interfere?
10. What must the data processing supervisor consider in analyzing the request?
11. Why is technical knowledge sometimes dangerous? How is it useful?
12. What is the best system possible for an application?
13. Why are report numbers required?
14. Why are report schedules necessary?

15. What happens when schedules are too tight?
16. What must all schedule systems supply? What feedback should they have?
17. How should special requests be scheduled?
18. Why are procedures necessary?
19. What are the two methods of writing procedures? Discuss the advantages and disadvantages of each.
20. What are flow charts? What are their advantages?
21. Why are time utilization records necessary?
22. What are the implied responsibilities associated with the analysis of time utilization data? How can these be satisfied?
23. What is the purpose of the National Machine Accountants Association?
24. Why is control over the distribution of reports necessary?
25. What should the distribution control system include?
26. What is the connection between a data processing department's reputation and the reports that it issues?

CHAPTER 11

Responsibilities of Management to the Data Processing Department

Volumes of information have been written about the responsibilities and duties of management. It goes without saying the rules generally prescribed for sound management apply to the managing of a data processing department as well as to the other departments of a company. It is the purpose of this chapter to emphasize some of these management principles and discuss the relationships between the data processing department and management, especially the higher levels of management.

Management

Management is a very broad term used to identify the collective group of persons who are engaged in the control and direction of a business enterprise. Some of these persons are found within the data processing department; they are the managers and supervisors who are responsible for the operation of that department. The term "management" as used in this chapter is not meant to include these people. It refers to those individuals who are on a level or levels of management above the management representatives in the data processing department, especially the particular individual in management to whom the manager of the data processing department directly reports.

Thomas J. Watson, Jr., president of International Business Machines Corp., has stated, "One of the greatest struggles of our time is to try to simplify the tasks of people who have to make decisions."

In every profession, tools are used to lighten the load and increase efficiency. Management has a tool also; data processing is the tool of management. One of the primary purposes of a data processing department is the rearrangement and refinement of data into forms suitable for use by the management of a company.

In the complex business and industrial world of this era, the volume of data surpasses the ability of the people in positions of leadership to analyze and remember for reference at the time decisions are made. Management has gradually become more and more burdened with detail. The additional time spent in trudging through masses of detail reduces the productive time of an executive until he eventually becomes buried in masses of detail and loses his sense of objectivity. As the details magnify, the over-all picture becomes blurred, resulting in ineffective management and unwise decisions.

Management has long recognized the need for a tool capable of accepting large amounts of data, with the ability to summarize and screen this data into simple, concise forms. Data processing is the tool that is satisfying this requirement.

"Management by exception" has become a popular philosophy. This theory is to furnish management with only the other than routine problems for human analysis and decisions. The great mass of data which follows the routine pattern is absorbed and processed through the data processing systems unassisted and untouched by management. This frees management from the drudgery and calls upon management only when an exception arises which requires an executive decision.

Each level of management requires a different type and a different level of detail information. Data processing is the tool which can satisfy all levels. The assistant foreman in a machine shop requires a much more detailed report of activity in his section than the general manager of the company needs.

To illustrate this let us observe three levels of management and examine the requirements of each in one phase – the control of labor on each job. Assuming a job shop type operation, the *general manager* is interested in the amount of money budgeted for each department for the jobs being worked upon. He is especially concerned when a department goes over the budget, but he also wants to know the departments that are operating efficiently.

The *department managers* who report to the general manager want to know their actual labor costs in relationship to the labor budgeted for their department on the jobs in process. It is not sufficient for them merely to know that they are or are not operating within the budget. They must be able to pinpoint troubles areas; consequently, more detailed information is required. They will want a budget versus actual comparison for each section within their department. They will probably also want a further breakdown by job within each section. This will pinpoint the sections that are causing problems and the jobs upon which losses are being incurred in each section.

First line management, the supervisor who is directly over the people doing the work, needs further detail. It is at this level that extreme care must be exercised. Too much detailed information will require too much of his time for analysis. Too little information will not signal his problem areas. The supervisor will want to know which jobs are exceeding budget in his section. He may also need information on each part being produced or the efficiency rating of each employe or group of employes in his section, depending upon the type of operations.

The general manager is responsible for producing a profit. He needs reports which will place responsibility on a department manager whenever budgets are being overrun. The department manager needs reports which will indicate any of his supervisors that are not operating efficiently. Each supervisor needs reports that pinpoint overrun areas that fall within his area of responsibility.

Data processing is the tool which will consume data and summarize it into reports for each level of management. If this "tool" is to be properly and profitably utilized, certain qualifications must be met. Certainly the first of these is that management be interested in this tool. It almost goes without saying that the user of this tool should at the very least be interested in it. Yet, there are many companies in which management is completely uninterested and even afraid of this tool, and the tool is completely ignored as a curtain of indifference is drawn between it and management.

Obviously this relationship is unhealthy for data processing, for the company and for management. It doesn't mean that a knowledge of the technical aspects is required or that an executive must be an expert on data processing jargon. It merely means that the responsibility be faced up to and not avoided. Only by showing an interest can management hope to live up to its responsibilities of this area.

If management is really interested in this tool and wants to utilize it in the most profitable manner, does it not follow that the placement of this department in the most advantageous position for its effective use would be of paramount importance?

A person would not buy a car and then give the keys to a member of the family who did not know how to drive. Neither would they give them to one member of the family who might be able to use the car only occasionally if it could be shared by all of the family and fully utilized.

This is precisely what happens in many companies with data processing. It is placed on the organization chart of the company in a position where it cannot possibly be fully utilized by the company as a whole.

This subject was touched upon in a prior chapter and it will be recalled that various types of installations were discussed. The "one-application" type which exists solely for one job can usually best serve the company by being placed as a part of the function for which the application is being performed. This type is becoming less popular as the equipment becomes more flexible and as management realizes the potential of clerical reductions and systems improvements in other areas.

The trend is toward the "company-service" type of operation in which a widely diversified group of applications are processed as a service to many departments in the company. It usually functions best in a staff position at a high level. In fact, it can become an object of bitter political feuding if placed within another department. Many data processing departments have been degraded because of bickering among members of the management team. Selfish interests of individual members of management have placed data processing departments in positions where their functions are restricted and their ability to freely move throughout the company has been restrained. The results are piecemeal systems, inefficiency and frustration of competent personnel.

Firm Policies

Another responsibility of management is the establishment of firm policies within the company. Lack of standardization and weak decisions by management will render any system, manual or mechanical, inefficient.

Top level management cannot fulfill this responsibility unless it has firm policies for the over-all managing of the enterprise. These policies will vary with the different types of companies and with the personalities and individual characteristics of the different general managers. Each general manager should have a system of management that is consistent and can be threaded down through the many levels of supervision to accomplish the results expected by him. Absence of a definite system of management by the top level will create confusion at the lower levels and constant bickering will result.

Probably the first and most important area in which firm policies must be established is in the personnel area. Definite policies of pay, vacations, sick leave, holidays, etc. must be established. Lack of uniformity in this area will result not only in inefficient payroll and labor distribution systems but also in personnel problems and poor morale. Weak decisions are soon noticed by employes and generate a lack of respect. Firm logical policies with no exceptions command employe respect and make efficient systems possible.

Other areas where management has a responsibility for establishing firm policies are equally as important but frequently less obvious. An area already discussed – budget and cost control – can be used as an example.

There are many different methods and systems used to control costs. They will vary with the type of company, its organization, products, and philosophy of management. Even in one company there will be more than one good system which can be used.

A trap which top-level management frequently falls into is to let the lower levels dictate the system by which they will control their costs. Each department manager has a different idea of what he needs which confuses systems and makes the data processing system inefficient and vulnerable. The picture is further complicated by periodic changes of department managers. Each new manager wants a different system of control than the prior manager had which throws the whole system into a state of confusion for several weeks. Control is lost while the changeover is being made and until sufficient history is accumulated under the new system to indicate trends.

It is the responsibility of top-level management to edict the system that is to be used. It should be standard for all departments. It must give each level of management the information it needs to control its own area of responsibility. Each level of management must use this system. If anyone cannot or will not conform to it, then they are not properly qualified for the position.

Obviously, it is extremely important that the right system be established. Top-level management is responsible for this by whatever means is necessary. It may order the systems department or the data processing department to research this area and present a proposed system for its consideration, or it may hire an outside consulting service to perform the job.

In either case, prudence must be exercised. For instance, the opinions of the managers of the operating departments should be obtained and certainly the opinions of the finance department should carry a great deal of weight because of the proximity of this particular problem to finance responsibilities.

Management must be certain that the system selected will satisfy the requirements of all levels of management and particularly its own. This pre-supposes that the general manager has a definite system of management and knows what he wants. For instance, the general manager of a manufacturing company may favor the "functional" approach to management which is a system by which each member of management is responsible for a segment of the company's operation and is responsible for the profitable performance of that function. Another system is the "project" approach. It is frequently used in job shop type operations and seems to be more satisfactory in small organizations where supervision overlaps into other areas rather than having clear-cut functional lines as found in large companies. This system places the emphasis on the job as it flows through the company.

In the cost control area, management needs to know if the job is staying within the budget as it progresses through the various stages of engineering and production. A project manager is usually assigned responsibility for riding herd on each job, and it is his responsibility to see that the job is completed at a profit.

Different types of data processing systems are required for these two different types of managerial control philosophies. Indecision as to which system to follow or switching back and forth makes efficient reporting impossible.

Once top management has thoroughly explored a recommended system and is satisfied that it meets all requirements then it is the responsibility of top management to enforce the system with firmness. Changes should be made to a system of this type only after extreme consideration has been given to all sides of the proposed change and it is obvious that improvements can be made by changing.

Beware of changes just for the sake of changing. Changes in systems cost money and sometimes a temporary sacrifice of control. No system is perfect; carefully analyze a proposed change for defects. Progress can come only with change but it is fallacious to assume that every change will bring progress.

People are prone to condemn a system whenever they find erroneous data on reports, especially if the report is placing them in an unfavorable position. It should be remembered that a change in the reporting system will seldom correct the source data. It is not the system, or the machines, or the punched card data processing department that causes erroneous data to appear on reports; it is the people filling out the source documents. No system can be expected to be any more accurate than the source information it receives. Changing the system will not correct the problem; it will only confuse the issue enough to cover up inaccurate data for a while.

The solution is obvious. Management should order that the source data be made accurate immediately. Until this is done, no system will work so it is pointless to expend effort to change the system; all effort should be expended to correct the data.

A common argument used in the cost control area is that production-type employes cannot be expected to accurately record the time that they spend on each job because their responsibility is to get the job done and not to do a lot of writing on job time cards. Members of management are frequently fooled by this argument because it does have a trace of logic. No one will deny that the primary responsibility of these people is to produce the company's products. The thing that is overlooked, however, is that employes have secondary responsibilities. One of these is the accurate recording of their time spent on each job. Ironically, all employes seem to be quite willing to accept the responsibility for accurately recording any records needed for preparing their paychecks. If management wants accurate costs and wants the proper controls at all levels, then it must enforce the accurate recording of facts concerning costs such as job time, material handling, purchasing of parts, etc. by all employes.

It is illogical to expect the punched card data processing department to issue valuable reports if the source data sent to that department is inaccurate.

The example of budget and cost control can be taken one step further to illustrate a common dilemma which management is confronted with. This is the "too little – too much dilemma." One group contends that it does not have enough detailed information to properly control its operations or that it has enough but it's in the wrong sequence or the wrong form. The other side contends that there is too much detail, that it is unnecessary and costly and that much of the detail on reports and some of the reports should be eliminated. These two opposing theories may be present at the same time, championed by opposing elements or they may occur one at a time, alternating back and forth over a long period of time.

The solution for management is to fully analyze the situation at the beginning and be sure that the correct system has been installed and then firmly inform the personnel that they must use it and that they will be held responsible for using it properly. Management must recognize pressure for change as a coverup for inefficiency whenever such is the case and be prepared to take appropriate action. This does not mean that management should be deaf to suggestions and stand behind a system which is obviously outdated and ineffective. It is management's responsibility to be able to recognize the difference.

Mechanize?

It is difficult for the present-day manager, involved in day-to-day problems, to sit back and objectively analyze his operations for the feasibility of mechanization. It is especially difficult in view of the lack of understanding of punched card operations which these people usually possess. The purpose of the next few paragraphs is to aid these people in determining whether their operations are ripe for mechanization.

In the first place, a manager should be neither concerned or ashamed of his lack of knowledge of the technical aspects of punched card data processing. A conversant knowledge is all that is required.

The move from manual systems to mechanical or automated systems should usually be done quite cautiously by inexperienced people. Do not be panicked into it because "everyone else is doing it." Innumeral pitfalls and irreparable damage to a company's systems and to an individual's professional reputation can result.

On the other hand, it is not prudent to be overly cautious because while one is pondering, his competitor may be plunging ahead toward greater efficiencies and cost reductions.

It is said that management has two great fears in regards to mechanization. They are:

1. Fear of a change in system.
2. Fear of the initial cost.

Both of these fears are well founded and if used properly will work to the benefit of management. To fear is healthy if directed in the proper channels but cowardice is weakness. The manager who yields to his fears and merely maintains the *status quo* is yielding to cowardice, but the manager who investigates, is interested in, and is open-minded about new methods is overcoming his fears. It is the responsibility of management to investigate and get the facts before it proceeds into any program of mechanization.

All members of management should be interested in the use of machines to process data because it affects practically every level and every phase of management and its effects are expanding by leaps and bounds. In fact, many of today's management positions will be replaced in the not-too-distant future by machines. It behooves each and every individual to learn all that he can to maintain his position. The broad-minded person with a positive attitude has little to fear.

What characteristics should be looked for in trying to determine whether mechanization is feasible?

Any operation in the manual system that processes a large volume of data, requires a high degree of accuracy and control, or that is on a rigid schedule may be considered a likely candidate. Such applications as invoicing in a distributing company, inventory control in a manufacturing company, and loan accounting in a bank are examples of natural applications.

Systems which require a lot of calculating or which make use of the same data over and over again will bear investigation.

Many companies, especially the smaller ones, do not have one single application that would justify the cost of a punched card data processing department. Collectively, however, several applications may generate enough savings to warrant such a department.

The size of a company is often mistakenly used as a criteria for judging the feasibility of mechanization. The number of employes is one of the factors to consider but is certainly not the most important one. The type of applications to be mechanized and the savings possible, coupled with increased control and improved schedules are the most important considerations. The number of employes becomes important only on such applications as payroll and personnel accounting which are based on the number of employes.

Such operations as billing, inventory control, sales analysis, etc. have practically no connection with the number of persons employed. There are many efficient punched card data processing departments in companies with less than 100 employes and conversely there are companies with more than 1,000 employes that do not have enough adaptable work to justify their own punched card department.

Management should never rule out the possibility of some type of mechanization because of company size. Even if sufficient justification cannot be produced for a complete punched card data processing department within the company, the feasibility of utilizing a service bureau should be considered.

The greatly increased accuracy and standardization of procedures forced by mechanization are not be taken lightly. Errors cause confusion and lost time; exceptions do likewise. Exceptions are common in manual systems because of the extreme flexibility and the prevalent lack of standardization. Standardization builds reliability into a system. One can always rely upon a given condition to be processed in an identical manner each time it occurs in a mechanized system. Under manual operations, human reasoning governs the method of processing each time a condition arises, consequently differences will occur as different people do the processing. Even when the same person performs the processing time after time, he may react differently to a problem one time than another time. This creates a vein of unreliability which is costly and which can be reduced by standardization characteristics inherent in a mechanized system.

Steps Toward Mechanization

Assuming that management suspects that some of its systems could profitably be mechanized by installing a punched card data processing department or, at least, by the use of a service bureau what course of action is proper to pursue.

The first action should be to delegate the responsibility for making a study to some member of management. This should preferably be a manager who is interested in this idea and who has a thorough knowledge of the company's systems.

If a good systems man is available in the company who has had prior experience with punched card systems, he may be chosen to make the study.

On the other hand, if a purely objective and at the same time a quick professional solution is required, the services of a data processing consultant could be solicited.

Other sources of outside assistance which should be considered are the equipment manufacturers. They will probably not be as professional as the consultant and certainly not as objective, but there is no charge for their proposal. If it has already been determined which equipment will be used, providing the decision is made to mechanize, then the bias of the equipment manufacturer is not a disadvantage. Even if a definite decision has not been made, but the field has been narrowed down to two or three companies, each of these companies may be called upon to present a proposal for the mechanization of a company's systems on their line of equipment.

For instance, a company might request proposals from a punched card manufacturer, a bookkeeping machine manufacturer and a service bureau. This may require a lot of time as one proposal will usually have to be made at a time. All companies should be aware that other companies are also presenting proposals and that only one will be accepted, and maybe none will be accepted if management does not feel that there are sufficient advantages to warrant a change. (It would be well to review Chapter XIII for more detail about consulting services.)

During the period that the study is being made, the manager in charge of the study, should be gathering all the information together about the proposed systems that he possibly can. Much information can be obtained from the representatives of the equipment manufacturers and the consultants. One of the most educational actions that can be taken is to visit companies that have systems comparable to those being investigated. Much factual, practical information can be uncovered by these excursions. The equipment manufacturers are only too happy to suggest local companies and to coordinate the visits.

The manager of the study should accumulate this knowledge so that he can intelligently sift through the proposals and arrive at a decision. The decision that he makes will be recommended to the higher levels of management and should be acceptable to them provided he has performed his job properly. It is important to note that regardless of who makes the study, the final decision of whether to mechanize is the responsibility of management.

The problem of whether to mechanize does not stop when a punched card data processing department is installed. In fact, the problem is frequently magnified, especially in the "company service" type organization. The demand for mechanization of applications comes from so many different areas that the whole system may be thrown into a state of confusion unless definite policies are established and schedules set.

In a "specific application"-type punched card data processing department, the problem of what to mechanize is usually solved after the initial application is mechanized because this is the only application that the department is intended to process.

With the ever-increasing knowledge of punched card capabilities and the publicity given to all kinds of data processing methods in the last few years, there is usually considerable pressure exerted by responsible persons throughout the company to get their particular operations mechanized, especially when a company-service type department is installed.

Chapter X covered the controls that must be established within that department to properly record, process, analyze and approve requests. Naturally, the management level to which this department reports has a responsibility to support these controls and to follow the established procedures even for work that they want done for themselves. There is a further responsibility to try to develop an over-all system rather than to mechanize in an unordered sequence. The proposed applications should be scheduled for mechanization in a logical pattern. They should be spaced sufficiently to give the punched card data processing department time to wire control panels, write procedures, set up necessary master decks, and process each application to work the bugs out of it before proceeding to another application. The amount of time that this will take is dependent upon many factors – the size and capacity of the equipment, experience and ability of personnel in the punched card data processing department, cooperation of other departments, and the type of applications being mechanized.

The time required to mechanize an application is not to be underestimated. The conversion from manual to mechanical or automated processes is rather radical. There are always problems and even the simplest operation must be followed closely by an experienced eye to be sure that everything is functioning as it should and that the desired results are being achieved.

Management frequently becomes impatient because applications are not being mechanized rapidly enough. Once the decision has been made to make the conversion of an application they are inclined to expect rapid action. This is a much more complicated change than just changing a manual system. It takes time for the data processing department to do all of the necessary work. This work includes a rather thorough study of the existing system, a determination of the end results required, study of the source documents and possibly redesigning these documents to facilitate key punching, wiring all of the necessary control panels and thoroughly testing them out, key punching any master decks that may be required, writing procedures and flow charts, and instructing all personnel concerned. It is almost always further complicated by other circumstances. The most common of these is inadequate, inaccurate or illegible source material which must be cleaned up.

Another factor is the lack of a basic knowledge of the old and the new systems by the personnel who are responsible for them. All too frequently the people who actually are doing the work know only the mechanics of their job and their supervision knows only the general operation and are unacquainted with the minute details. This makes discussion difficult because it is necessary to communicate with twice as many people and erroneous and conflicting ideas often evolve. If the supervisor of the function for whom the application is being mechanized is fully and completely familiar with it, the job is much easier. It should be the responsibility of first-line supervision to be completely familiar with all operations for which they are charged. It is the responsibility of the next higher level of management not to burden first-line supervisors with so much detailed work that they must personally perform so that it interferes with their jobs as first-line supervisors.

Another obstacle that frequently impedes the progress of an application is insufficient help in the data processing department or personnel not properly qualified. It is the responsibility of management to allow sufficient numbers of people to do the work required and to pay sufficient salaries to attract competent personnel. Most of the classifications in data processing require special training and skill. Some require a great deal of this and considerable experience besides. It is extremely important to the successful operation of the department that well-qualified personnel be available. The qualifications required vary from company to company and will be covered in more detail in a later chapter. It must be remembered that the machines are no better than the people who run them; therefore, it is senseless to pay a lot of money for equipment and then skimp on wages. It would be far better to get good people and skimp on the equipment because in the long run the ability of the people will govern the successfulness of the data processing department.

The progress of mechanizing will also be slowed if the personnel who are working on the project have other duties. For instance, if the supervisor of the data processing department is expected to do most of the work in setting up a new application in addition to his regular duties, it will take longer than if an analyst were available to devote full time to this job. Progress is further impeded as more and more is put on the equipment because each job requires time, and the time spent on each job being processed is taken away from time that formerly was spent on mechanizing new applications.

Under manual systems it is customary to make a sample run or a trial run to see if the system is working properly before going to the expense of making the change on the whole system. Unfortunately, this is almost always impractical with punched card systems because most of the expense must be incurred anyway. Control panels must be wired, master decks punched, procedures prepared and the other preliminary preparations accomplished to produce the sample. It is much better to spend this time and effort in thoroughly planning the job and set it up correctly the first time than to take a trial run approach. If management knows exactly what they want this is not difficult; if they do not know what they want, then they are not ready for mechanization.

Changes to a system can involve a great deal of time, expense and confusion under any type of system, but more so on a mechanized system. In fact, changes can be more difficult than setting a job up originally. The biggest problem with changes is that they are invariably undersimplified and pushed through on a crash basis. Consequently, the effects caused by the change are not thoroughly considered and repercussions develop in associated areas. A change in one system can create an effect in a related system and unless the over-all system is analyzed with each change that is made, problems are certain to develop. It is the responsibility of management to hold system changes to an intelligent minimum and to have full cognizance of the cost, time and problems involved in making them.

The scheduling of applications to be mechanized should be carefully planned. This is especially true of new departments. It is important in scheduling to keep in mind the philosophies and concepts of top level management. What do they want? Answer this question and then try to get the data needed to give them what they want in punched card form. It is usually not possible to jump directly to this because their needs are of such a general nature that much detail must be processed to arrive at the answer.

There are certain applications which are generally considered to be basic in every system. For instance, in a cost control system all of the elements of cost must be captured in punched cards; consequently, labor distribution and accounts payable applications are the first two likely candidates for mechanization. These contain the basic labor and material costs going into each job.

Another reason for getting the basic applications on punched cards first is that there is usually more volume on these, thereby, affecting a quicker reduction in clerical costs.

With the end objectives in mind it is easier to schedule applications in a logical sequence. They should be planned in such a way that data captured on one application can be used on the next application wherever possible. For instance, it is only logical to get labor distribution on punched cards and running smoothly before attempting to compute overhead mechanically because the basic data (straight time labor dollars) is derived from labor distribution. Likewise it is not logical to mechanize the work-in-process ledgers, operating expense ledgers, or any other ledgers until all the data required for the ledgers has already been captured in punched cards as part of a basic application.

The transcribing of data from the language of the source document to machine language (the punched hole) is a non-productive operation and quite time consuming; therefore, it is usually a good policy to use data in punched cards over and over again as many times as possible. This is not to imply that reports should be issued promiscuously just to reuse data. It merely indicates that those operations which are able to reuse existing punched hole data rather than having to create new punched cards for required reports are more efficient because the recording cost has been eliminated.

It is not uncommon for punched card data processing departments to be overloaded with work. The constant demand for more mechanization is extremely difficult to cope with. It is the responsibility of management to follow the problem closely.

One solution is to mechanize only those applications that can be performed more economically by machine than manually. This requires estimates of the manual time and a complete flow-charting of the mechanical operations. By computing time required and multiplying by a rate the cost of each method can be estimated. The development of machine rates that will include all costs can become quite complex. One solution is to use rates that would be charged by an outside processing service. These rates include all costs of operating a processing service plus a profit so they should be ample to cover a company's data processing operation even though it probably will not operate as efficiently as a service bureau.

Even when this method is closely followed, the punched card data processing department still can become overloaded with work. Much work is forced on the department because requirements arise for reports and the only place that the data is readily available is in punched cards; consequently, the report must be prepared by the punched card data processing department.

Some controls can be established to assist management in determining whether to mechanize each application as the question arises. A partial solution is to set up a schedule for mechanization of applications over the coming year. This is especially important in planning the work of a new installation. Each year thereafter it becomes more difficult because the most obvious applications have already been mechanized.

Another control is to require that a request for data processing services be in writing and that it be signed by the manager of the requesting department. This screens out the "nuisance" requests and only leaves those applications which management feels could be best performed by machine.

The manager of the data processing department should investigate each request to determine whether the same or similar information can be extracted from a report which is presently being issued. Assuming that it cannot and that investigation reveals a legitimate need for the report, then it is submitted to the next higher level of management along with recommendations. If the punched card data processing department is working to capacity, then the request should be accompanied by a request for more people or machines as may be needed to fulfill the request.

It is then the responsibility of management to decide whether to mechanize the application and increase the personnel or machines in the data processing department, to reject the request, or to remove another application which is already mechanized but is considered less important, in order to make time available for the proposed application.

The latter approach is usually not advisable because the expense of mechanizing that application originally is wasted. Neither is it always wise to expand the cost of the data processing department. Nor is it wise to continue doing an operation manually which can be done more economically, more accurately and faster by machine.

This dilemma is one that must be worked out between the manager of the data processing department and his superiors when the occasion occurs. One solution to this dilemma which is sometimes overlooked is the use of a service bureau. This is an especially attractive solution if the permanency of the application is questionable or if there is a possibility that the work load in the data processing department will subside at a later date at which time this application can be picked up from the service bureau.

Savings

Up until the past few years, the big selling point for punched card equipment was in clerical savings. Recently, however, this approach has diminished in importance and more emphasis has been placed upon improvements in control, speed, scheduling and in the resultant improvements in a company's profit position. Since the primary objective of management is to insure that the business is profitable, these factors are quite significant.

A significant contribution to the profitable operation of a company can be made by a reduction in capital requirements. Let us take a hypothetical case of two companies which each earned $20,000 profit in a year. Let us assume that company A had only $40,000 of capital invested, whereas company B represented an investment of $1,000,000. Company A would certainly be classified as a profitable business but company B realized such a poor return on invested capital that it could hardly be considered profitable even though it did show a net profit for the year. The investors in company B could have invested their money in bonds and realized more profit without taking all of the risks involved in a business enterprise.

The profitable operation of a business enterprise is affected by both profit and investment. Management should be vitally concerned with both of these factors. Clerical savings generated by mechanization, do not always create a sufficient reduction in costs to materially effect the profit of a company. In fact, there are many documented cases in which the anticipated savings proved to be mythical and an actual increase in costs developed. Even in these cases, management usually found it profitable to retain the punched card equipment because of other benefits which were being realized.

These benefits may be in the form of reductions in capital investments by providing better controls over stock inventories, supplies, work in process, factory equipment, etc. Such reductions in capital investments make the company more profitable because a higher return on the investor's capital is realized even though there is no increase in the net profit. Management should investigate those areas where large amounts of capital are tied up. Is it in stock inventories? Perhaps a system with better control will permit a reduction in the quantity of each item stocked, affecting a considerable reduction in inventory investment. Speed of processing documents and dependable accuracy will further enhance this application's effect upon the profitable position of the company. There are innumerable instances where this one application far surpassed any anticipated clerical cost savings in importance.

Punched card equipment is ideal for processing machine utilization reports and down-time reports. These reports will pinpoint machines which are not being economically utilized so that appropriate action can be taken to put more work on them or to transfer their work to other equipment and getting rid of them. It also records time lost because of maintenance on those machines which require an excessive amount of repairs.

Another area to explore is the handling of cash. The billing, receipt of payments and payments of bills all afford potential capital reduction areas. Faster billing will result in faster payments, thereby improving the company's cash position. Accurate recording and prompt actions on follow-up notices and delinquents will further improve this position. In the accounts payable application the manual system is sometimes so far behind that cash discounts cannot be taken. Payment of bills on the last day before the discount privilege elapses can pay for the rental of the punched card equipment. Take for instance, a company with accounts payable of $1,000,000 per month. By taking cash discounts that average one half of one percent a month, the savings would be $5,000 per month.

Other areas affecting the profitable position of the company are those involving the placement of the company in a better competitive position through improved services, sales and production.

The fast, accurate processing of sales and billing processes have given some distributing companies a jump over their competitors who are burdened with cumbersome manual systems. Sales analysis reports and market research analysis reporting provide management with an up-to-the-minute picture of their sales position. Weak and strong positions can be signalled for management action. Reductions of sales in certain areas can be noticed before the situation becomes too serious. In many types of activities the total sales of certain products can be obtained. By punching this data into cards, a report can be prepared showing the company's sales of a product in relation to its competitors or the percentage of the total market captured by the company's products. This picture becomes especially significant when compared with the same period of last year. Losses or gains in the company's competitive position are brought to light and important trends revealed.

The improvement of a company's competitive position by improving its production has so many facets that it is virtually inexhaustible. Two of the principle elements of cost involved in production are labor and parts or material. Labor is always a problem because it involves the human element. Since humans are not like machines, it takes them a certain amount of time to learn how to make something. The more of a certain part that they produce, the faster their pace should be until a point is reached at which they are producing at their maximum capacity. This decrease in time required for production on a new job is known as the "learning curve." Obviously, an accurate control of the time expended on each job is required as well as frequent cut off points at which the number of good pieces produced can be compared with the time expended to produce them. The analysis of the actual learning curve as compared to the anticipated learning curve will give valuable cost information as well as provide a historical record of experience on which to base future estimates.

Management needs to be sure that it is getting maximum utilization from its labor. Performance reports can supply this information. Standard hours allowed to perform a task can be key punched into cards against which the labor cards recorded for that job are compared. By this report a percent of efficiency is determined at any level desired. Employe performance is usually not wise because it is too detailed and each supervisor should be able to control his employes and evaluate their performance by observation. Efficiency by section or department has been found extremely beneficial in many companies. A single percentage developed by itself is not too significant because the standards may be inaccurate but when these percentages are plotted by section each day over a period of time, they can form a valuable source of information to management. A significant variation in performance in a particular section can indicate a problem area before it becomes serious. It tells factory management the areas in which its attention should be concentrated.

Shop loading, machine loading, manpower forecasting, automatic requisitioning of parts and material and many other production applications can be mechanized to improve the company's competitive position in the production area.

Even in companies which already have punched card data processing departments some of these most profitable types of applications are overlooked. There are many reasons for this, and lack of communication between top-level management and the data processing department is probably the most prevalent. The data processing department is certainly not without blame in this respect. They are undoubtedly working on projects much of the time which would rate a very low priority by the general manager if he were aware of them. By the same token, immediate problems confronting the general manager are not transmitted to the data processing department yet this department is considered a tool of management. It is the responsibility of management to make its problems known and to discuss the areas of large capital investments with the data processing department. Without this line of communication, the data processing department cannot perform its maximum service for the company.

Relationship with the Data Processing Manager

A great deal of the success of the data processing department rests with the manager of the department. His department consists of a mixture of dealing with technical problems, integrated systems, extreme schedules and skilled personnel. The variety of his work requires a knowledge of virtually every function in the company. The manager of data processing realizes that all departments have problems because he has been at the core of them.

The use of tools (punched card equipment) permit him to produce results at amazing speeds but it also requires lightning decisions about the most intricate details of a system. When a problem arises, machines and personnel stop and this costs money. The manager must often make a split-second decision or must know exactly who to contact to get the answer so that the machines and people can get back into production. Most department managers are managing people who are performing a specific function within the company. The task may be quite difficult and may require years of experience but regardless, it is in a limited sphere of operation and is moving at a manual pace. The data processing department is involved in a virtually unlimited sphere of operation and is moving at several times the manual pace. He has all of the personnel problems that normally plague a manager and these are frequently complicated by the fact that there is a scarcity in the labor market for most of the data processing classifications. The machines and equipment involved require technical knowledge and ability and he must possess a thorough knowledge of the capabilities and limitations of all his equipment. He should also keep up on all new machine and systems developments in order that he can evaluate their potential for his company.

It is not the responsibility of management to assist the manager of data processing in the technical aspects of his operation; in fact, he should not be interfered with. His knowledge of this subject should far surpass anyone elses in the company and he should be considered the expert on punched card equipment and systems.

Of course, when he makes a recommendation for more equipment or more personnel, he should be able to prove the need for it and it should be analyzed as objectively as any other request for expenditure of funds by management. They should not "rubber stamp" every move that he makes just because he is an expert in his field.

In the day-to-day operation of the data processing department, his judgment in the proper use of equipment in the best interests of the company must be relied upon. There have been innumerable cases where the manager of a data processing department was reduced to the level of an operator by actions of his superiors. Frequently these superiors have tried to run the data processing department. Some have even gone so far as to wire control panels or make changes in existing panels. Another habit is to explain to the manager of data processing how to do something in great detail rather than informing him of what is needed and letting him figure out how to do it. These actions by management destroy the initiative of subordinates and result in inefficiency and even chaos in the data processing department.

It is the responsibility of management to choose a properly qualified manager of Data Processing and to delegate the management of the data processing department to him. This does not mean that he should be given an unqualified rein of authority. Line authority must be recognized and followed and company policy adhered to in all cases. But the internal operations, especially those with technical aspects, should be vested in the manager of data processing as much as possible.

In the event that his superiors doubt the ability of the manager of data processing to exercise sound judgment, then some type of interference is warranted. Poor judgment will manifest itself in many ways – poor morale, late reports, abnormal number of errors, etc. Even at this point, it is not wise for the superior to roll up his sleeves and start wiring control panels – this will only make a bad situation worse. A discussion is certainly in order; there may be extenuating circumstances that reflect on the operation of the data processing department. The manager of data processing may be unable to cope with certain circumstances that have arisen yet may hesitate to mention them because he is unsure or confused. His superiors may be able to define and correct the problems before they become worse. By frank, courteous discussions much can be done to improve relationships, to solve perplexing problems and to reassure the manager of data processing that his superiors will stand behind him.

What should be done if repeated attempts to solve the problem have produced little or no results? There is always the possibility that the data processing manager is incapable of coping with the requirements of his position. This is more likely to be true if he is lacking in technical experience or administrative background. On the other hand, he may be well-qualified to manage the department but peculiar circumstances with which he is unfamiliar and unable to cope may be plagueing him. These circumstances may be created by poor policies or mediocre management at a higher level. That member of management to whom the data processing manager reports may even be at fault. To be careful that a costly and unfair decision is not made, outside assistance should be sought before severe action is taken. If management has confidence in the punched card equipment sales representatives, their opinions should be solicited. These representatives have contact with many companies and become adept at recognizing the source of problems and in suggesting solutions. Another source of outside assistance is a management consultant service. An analysis made by consultants will be objective. This topic will be covered thoroughly in Chapter XIII.

It must be remembered that there is a scarcity of well-qualified data processing managerial talent just as there is a shortage of all types of executive talents. The scarcity is perhaps more critical in this position because of the technical abilities that are required in addition to the normal managerial abilities. The inherent characteristics of a good technician are seldom molded into the same individual with the basic characteristics required of a good administrator. Outstanding technicians seldom make good managers and many a good technician has been deeply scarred by attempting to progress into this level or by being literally forced into it by his superiors. In selecting a manager for a data processing department, it is more important to select an individual who possesses the basic qualifications normally required of a manager than it is to emphasize the technical aspects of the position although he certainly should possess these aspects also. The ability to lead people, organize work and exercise sound judgment are more important than the ability to wire control panels, operate machines and be an expert on all of the latest equipment. The realization of this fundamental fact frequently influences the management of companies who are installing a new punched card data processing department into an extreme position of selecting one of their own employes, with little or no technical background, as the manager of the new department. This action has certain advantages and certain disadvantages. It represents the unhealthy application of one set of characteristics to the complete disregard of the other set.

For one thing, it solves the problem of screening applicants and going through all the trouble and risks of hiring a new member of management into the company. It is an easy way out, at least for the present. If the new department is replacing people, it is more humanitarian to absorb these employes in the new department wherever possible than to terminate them and hire new people who have the proper qualifications.

Assuming that an employe is available who has demonstrated administrative ability, he can be sent to various classes for indoctrination into the basic concepts of punched card operations. Even then, he still lacks experience and management should recognize this in evaluating his performance. He should not be expected to produce the same quality of results that a well-rounded manager of data processing would produce.

Many of the attempts to utilize existing talent as managers of the new departments have resulted in failure. Some employes who had demonstrated excellent administrative abilities in other areas were found to lack those characteristics necessary to grasp and apply the technical elements of the task. All too often, the person selected to run the new department is not a proven administrator. He is an employe who has done a good job as an accountant, auditor, production control man, etc. He has two strikes against him at the start. It is difficult enough to step into a managerial position, but to attempt to fill this position in a technical field where experience is lacking is unrealistic. Yet, there are some who have succeeded as well as many who have failed. The management of a company who appoints a manager in this manner should recognize the odds and be willing to take the risk involved.

It is better to hire a proven punched card data processing administrator from outside the company than to risk filling this position with an employe who lacks the essential qualifications. Other positions in the punched card data processing department can be filled by trainees, but not the top man. The success or failure of the department rests almost entirely on this one position and it behooves management to fill the position with the best qualified person that they can find and afford.

End of Chapter Questions

1. What is "management"?
2. What tool does management possess?
3. What is "management by exception"?
4. What is a "company service" type data processing department? Where does it function best in the company's organization?

5. What is the first and most important area in which firm policies must be established?
6. What problems are created in the data processing department when management fails to establish firm policies?
7. What is the solution to erroneous data on reports?
8. What is the "too little – too much dilemma"? What does it do to a system?
9. Why should the transition from manual to mechanical or automated systems be approached cautiously? What is the danger of being overly cautious?
10. What are the two great fears of management in regard to mechanization?
11. What characteristics should be looked for in trying to determine whether mechanization of a system is feasible?
12. What is wrong with using the number of employes as a criteria for judging the feasibility of mechanization?
13. If management suspects that some of its systems are adaptable to mechanization what should be the first action?
14. Why should other companies that have comparable systems be visited?
15. How should proposed applications be spaced in the schedule?
16. Why does it take so long to mechanize a system? What conditions frequently hinder mechanization?
17. Why is it difficult to make sample runs?
18. Why should "basic" applications be mechanized first?
19. What action can be taken to prevent overloading the data processing department?
20. What dilemma can a service bureau solve sometimes?
21. What is the difference between operating at a profit and being a profitable operation?
22. How can data processing reduce capital investments?
23. Where does a great deal of the success of the data processing department rest?
24. What is the "tempo" of the data processing department?
25. What part should management play in the technical aspects of data processing?
26. What is the responsibility of management relative to choosing a data processing manager and delegating authority to him?
27. How can management detect incompetence in the data processing manager? What should be done about it?
28. What qualifications should a data processing manager possess? How important is technical ability?
29. What are the disadvantages of training a manager for a new department? Advantages?
30. Who should management select to fill the data processing manager position?

CHAPTER 12

Relationships With the Data Processing Department

The purpose of this chapter is to define and discuss some of the problems encountered by personnel in departments that are using the services of the data processing department.

Most of these problems apply both to the management members employed in these departments as well as to the non-management employes who are performing the individual tasks. In many cases, the employes doing the detail work are key people in the success or failure of a system because they are performing the day-by-day mechanics of the operation. The fact that they are not members of management does not detract from their importance to the successful operation of the system.

Installing the System

Probably the most important single factor in the installation of a punched card system is the attitude of the people involved. Contrary to popular belief, the human element is magnified by the use of machines. The human element is reduced in the drudgery portion of the system but it is expanded at the analysis level. This results in the elevation of the human mind to the heights at which it was created to perform. Analysis of facts and decision-making replace monotonous, drudgery-type thought processes.

Machines make mankind more important – not less important. It has been proven that machines make mankind more important by whole civilizations that were adept in the use of tools and equipment. It is being proven today by people using punched card equipment. Those people with only a marginal interest in machines who are able to get maximum utilization from their services are able to progress at a faster rate. In fact, in many cases, positions have been eliminated by the use of machines and invariably those people who were open-minded and broadened themselves to the new scope possible for the human mind by mechanization were elevated while others were eliminated.

There is practically never a question as to whether an application can be mechanized. The real question is whether it is practical and economical to do so under the existing circumstances. *Any application can be mechanized if the people involved have the desire and the ability to mechanize it.* The lack of these two ingredients is extremely common. Most people are inbred with a fear of change. Even when they are familiar with the advantages of the change, the uncertainty of it as far as their own personal interests are concerned dampens a real desire to make the new system succeed.

It is very important that the people involved be instructed in the mechanics of the new system and its effect upon their jobs. Management is prone to spend great amounts of time and effort in working out a system and then let it bog down in the installation and proving stages by a lack of proper instructions to the people involved. This boils down to one of the most basic problems in the business world today – that of communications. The people who have been doing the planning, figured out the problems and have sold the system to management are naturally quite enthused about it. People who have been plodding along all of this time performing tasks under the old system cannot be expected to share this enthusiasm. They are buried in details. They do not see the broad picture that the planners have been looking at. Upon hearing of a change in system, their first thought is a fear of what this change is going to do to their job or their processing of details. Such resistance is only natural – each person is interested most in his own sphere of activity. The detail worker is much more concerned about the detail operation than about the over-all work. Education is the best solution to this problem. If all questions can be answered about the details, resistance will be replaced by cooperation. If the system has not been thoroughly planned and detailed questions cannot be answered, the resistance will expand and become a threat.

To avoid problems at the time of installation, it is best for the people doing the planning to talk to all people involved at the detail level and find out what they are doing, discuss the proposed system with them, and get their opinions. They will be much more receptive if they feel that they are included. It is almost always a mistake to try to keep information about a proposed change away from people because it invariably leaks out and creates a feeling of distrust among the employes. There is a natural tendency to do this if the change will cause some people to lose their jobs but even in these cases it pays to operate honestly and present the facts. Otherwise, the secrecy and intrigue may adversely affect people who are not even involved, or who are to hold key positions under the proposed system but don't know it.

All of the consideration in human relations preceeds the installation of the system, and is paramount in importance to the success of the installation. Nothing is more important than the attitude of the people involved. A positive state of mind is important. Each person involved must want to make the system work if he is to contribute his utmost toward its success. Passive resistance is common and difficult to cope with. A person who does the minimum amount that he is told to do and contributes nothing on his own is actually resisting just by his lack of positive contributions. Even when he sees a trouble area he will not point it out to the right people but uses it to criticize the system among his fellow workers. This person is doing himself immeasurable harm by impeding progress. Progress is inevitable in spite of his resistance and by his very actions he will be left behind.

There are rare cases of active resistance to a system. These are found in people who haven't been sold on the system and who are frank enough to criticize it openly. These people are frequently mishandled by open arguments. This active resistance is actually much better than the passive type because it is out in the open where it can be answered by logic and truth. This type of person will usually do his share and if he is given the proper answers and his criticisms are received with patience he can be very useful to the installation. He may bring up problems which hadn't been uncovered before. The best way to convince him is to educate him. Once the system's worth is proven he will be just as adamant in praising it as he was in criticizing it.

There is a vast difference between a manual system and a mechanical system which is rather difficult to grasp. Under the manual system, facts are handled individually and spread to the various places they are to be used. Each time a fact is used, it is analyzed or checked to a degree as it is being processed. In the mechanical system facts are handled collectively at high speeds. They are checked only once – at the verifier. Once they pass this point they are not checked again. All facts are processed together for each function they are to perform, then they are all processed together for the next function. This is diametrically opposed to the manual system in which one fact is processed through all of the functions in which it is needed and then the next fact is processed in the same manner. Also, under the manual system, the human mind is ever present and it is operating in a relatively limited sphere. As facts are processed, memory and experience becomes a part of the processing. Details are omitted to save time whenever they are obvious.

Machines do not possess the quality of being able to insert obvious data, nor can they detect and change data which has obviously been recorded incorrectly. Their experience rating is nil. It is possible to detect certain types of errors if the data is such that it can be audited. An example of this would be a field of data such as "employe number." The number of every employe in the company is known. Consequently, if an invalid number is recorded on a source document, it can be detected. For this reason extra special effort must be made to record data properly before it goes to the punched card data processing department. Do not expect this department to correct any errors on the source documents or to fill in blank spaces with the proper data. This is not their job. Their responsibility is to convert the data sent to them into punched cards and to use these cards to accumulate and summarize data into useful reports. The reports issued are no more accurate than the data received.

All source documents sent to the punched card data processing department should be neat, accurate and complete. Every piece of data required must be recorded and it must be written so that it can be easily read by key punch operators who know little or nothing about the application. All data must be written exactly the same way each time it appears and in the same place on the document.

Strangely enough, many manual systems are not efficient. In fact, it often happens that the major savings realized by converting to punched cards are savings that could have been made under the manual system. Standardization, better source documents, better forms design and improved schedules are a few benefits that normally result from mechanization which promote efficiency. These could be realized equally under the manual system but for various reasons they are not inaugurated until mechanization forces the changes.

The importance of standardization is usually difficult for the layman to understand. He seems to feel that it is an insult to human intelligence that something has to be written exactly the same way each time it appears on a source document. The principle that must be understood is that machine intelligence, not human intelligence is involved. It is true that human beings are operating the machines but they do not work with the recorded data as is done under manual systems. If the mechanical operation is to be successful there should be no source data analysis required of these people because this slows down the operation. Source documents should be designed and source data inserted in such a manner that no analysis is required. The responsibility of the data processing department is not to analyze source data; their responsibility is to record, sort, calculate and summarize data into a form which is suitable for management.

Unfortunately, source documents are usually not designed ideally for mechanization; consequently, changes in forms design are sometimes required at the time of mechanization. It often happens, also, that data on source documents must be changed, corrected, or rewritten before any mechanical work can be performed. This requires extra effort by the people who are to feed the source data into the system. These operators are working with documents from many different places and they cannot be expected to understand all of the data they are recording. Their job is to transcribe the data as rapidly as possible. The condition of the source documents will determine how well they can perform their operation.

The workability of a system, whether it is manual or mechanical, is dependent upon the people involved. Examples of this can be demonstrated by a supposedly complex system being simplified by changing a department manager. One manager may have such extreme desires that his systems are burdened by exceptions and constant changes. Decisions are made to solve the immediate problems rather than in adapting them to the existing system. The manager who bases decisions on long-range planning and who respects the system usually makes mechanization easier and more economical.

Problems are to be expected during the period of conversion from a manual to a mechanical system. Problems are to be expected in any system's change but especially in one so radical as the change from manual to machine processing. The existence of problems does not necessarily indicate an inadequacy in the new system. Some problem areas are almost certain to be overlooked in the planning stages. The people involved should point out these problems as they arise so that corrective action can be taken. Never hide or cover up a problem area because it will certainly be brought into the open sooner or later. It is imperative to the new system that problems be faced and solved as soon as possible. The solutions will often tax the ingenuity of the participants. These problems are irritating to the busy individual who is trying to get the detail work done. The installation of a new system usually requires more work on the part of all concerned and savings come only after the operation is functioning smoothly. This transition period is a test for all participants. Each person involved should be mentally conditioned to accept more work temporarily, to make the system work, to be fair and objective about the new system, and to educate himself as much as possible about the new system and in the theories of punched card operations in general.

Errors are inevitable and are not a serious threat to a new system provided they are handled intelligently. These actually occur because of a misunderstanding. More people are involved in the mechanized system; consequently, the communications problems is heightened. The people in data processing do not understand the finite aspects of the system as well as the people responsible for the operation; consequently, they may overlook something that is perfectly obvious. At any rate, the person discovering the error should report it to the responsible party or parties as diplomatically as possible so that corrective action can be taken. Accusations should always be avoided. Cooperation is essential to the success of any system and all parties involved should be broad-minded enough to realize that errors will be made; accusations will only create antagonism.

Errors can usually be corrected rather easily as long as everyone involved is in control of their portion of the system. If, however, the situation gets out of control then the system is in imminent danger. An "out of control" situation can be identified by the inability to balance data totals to controls in the data processing department or by the introduction of such poor data into the system that it cannot be expediently processed. An incorrect flow of data, incorrect processing of data, duplicate documents and inaccurate data can all lead to a loss of controls. Combination of these can confuse the operation to such an extent that the cause is difficult to determine. By correcting errors and solving problems as they arise control can be maintained. If, however, things do get out of control, then an all-out effort must be made to correct the situation immediately.

Poor communications is the root of most problems that arise. It is almost always present but in varying degrees; the degree to which it is present will determine its peril to the system. It is quite common for two individuals to be in complete agreement at the initial stages of a system study only to discover at the installation stage that statements made by one party were interpreted by the second party to mean something quite different than had been intended. This causes a conflict because it appears that certain statements made are being ignored or even violated. In actuality, there is usually no such intent. It is just a misunderstanding caused by the two parties not "speaking the same language." The solution to the problem requires patience and understanding. Once the problem is recognized it is possible to talk it out to a reasonable solution. Unfortunately, suspicions are often aroused and conflicts of personalities may result. This should certainly be avoided because it accomplishes nothing toward the solution of the problem and appears very juvenile to those who appreciate the problem.

Incompetent personnel are a real problem. An integrated system may involve many people from several different departments. The people installing the system often have little or no control, except in an advisory capacity, over the personnel placed in key positions. Some people just do not have the ability or the desire to accept the requirements within a mechanized system. This type of person should obviously not be placed in a position where his cooperation is required for the success of the system. Unfortunately, this is not a trait that is immediately detectable and a system is usually well underway before misfits can be identified. Incompetence can be detected by lack of adherence to procedures. If an individual fails to adher to the agreed upon procedure he should be notified immediately. If the condition continues, it indicates either resistance or incompetence. In either case, the system is in peril and the condition should be reported to the proper authority in as objective a manner as possible.

If incompetence is present in the personnel from the data processing department, it is even more serious because so much is dependent upon their ability and cooperation in the installation of any system. They are usually the hub around which the system is built and are coordinating activities of all departments. In addition they are coordinating the internal systems of the data processing department which is a responsible job in itself. If incompetence is suspected of any of these individuals, it would be well to objectively analyze the situations which activated the suspicions. Is the suspected person really at fault or are others equally to blame? If it appears that the data processing person or persons did not perform as they should have, this matter should be taken up with their immediate supervisor. He is in a position to appraise the questioned individual much better than anyone else because he is familiar with the person and with the problems of the system. The individual may actually be doing an outstanding job in light of the problems which he is facing. He may also lack experience in this particular area but is the only person available for the assignment.

Problems in a system can reflect upon the data processing department regardless of where they originate. Lack of cooperation from almost any area could result in a mistake being made in the data processing department. This, in turn, reflects upon the system and those responsible. Incompetence is difficult to prove in any area and should be handled very cautiously or someone might be unjustly accused. Always get the facts. Do not make wild accusations; this will only create conflict. Only when the facts clearly indicate incompetence should action be taken and this action would flow through the management chain.

In summary, the people who are working with representatives of the data processing department should exercise human relations, be objective, be cooperative, and be prepared to expend extra effort to understand and make the new system work.

Requesting A New Application

The data processing department is a service organization and its purpose is to supply reports that are needed by the other departments in the company. This does not mean that they are obligated to produce every report that is requested by any employe in the company. There are many circumstances that govern the decision to mechanize or not to mechanize a particular application or report. The data processing management must analyze each request and decide whether it is in the best interests of the company. Cost, savings, available machine and personnel time, work load, management philosophies, etc. must be considered in making this decision.

What steps should be taken before submitting a request for data processing services? A request is usually generated by a person who thinks that a particular application is adaptable to punched card methods. The person may or may not have a knowledge of punched card operations. In either case, it is best for the person to talk to his supervisor first if he is below the supervisory level. The purpose of this discussion is to obtain permission to pursue the idea further and to determine if it is practical. In some cases, the supervisor will not approve of further investigation. He may have other applications within his jurisdiction that he would prefer to see mechanized. He should be able to analyze the application and ask penetrating questions which may uncover details that have been overlooked making mechanization less attractive. At any rate, it is always best to have the approval of supervision before approaching the data processing departments. If the request is being generated by a supervisor or if a supervisor is reviewing a suggestion made by an employe, he should follow the principles outlined in Chapter XI.

Once the sanction of the originating department's supervision has been obtained, the next step is to contact the manager of the data processing department. The procedure to follow in doing this will depend somewhat on the degree of formality that is customarily followed within the company. In the informal type companies a phone call to the head of the data processing department would be in order. No attempt to explain the details of the idea should be made on first contact. The purpose of this call should be merely to notify the manager of an application which has mechanization possibilities. An appointment should be arranged to discuss it with him or someone from his department. This type of approach is courteous and indicates a sensible level-headed attitude. Data processing people get many impractical ideas and requests presented to them and they learn to recognize these by the type of approach used. A wild idea or an unformulated plan will invariably be presented in an excited approach. The request that must be discussed immediately and is general in nature obviously has not been well thought out.

No attempt to explain the request over the telephone should be made unless it is very simple. It is very difficult to explain all of the facts and show what is needed over the telephone. The purpose of the phone call should be solely to make an appointment.

At the meeting with the data processing manager or his chosen representatives, the plan should be presented as completely as possible. The purpose of this meeting is to get professional opinion as to the feasibility of the plan. In most cases, this meeting will determine whether it is practical to pursue the plan further. If the plan is unworkable, the data processing representative should be able to give a logical explanation why.

If the company operates on a more formal basis, a letter or memo would be preferable to the telephone call to set up a meeting. The letter should

THE MARQUARDT CORPORATION - POMONA DIVISION

REQUEST FOR MACHINE ACCOUNTING SERVICE

Title of Requested Reports:	
What is the Report to be used for?	
Information to be printed on the Report	
Sequence of the Report	Totals Requested
Number of copies and their distribution	Frequency __ One Time __ Weekly __ Other (Explain) __ Daily __ Monthly
Schedule on which Report is to be issued	Date is requested to begin
Source Documents ______ Volume per week ______ Number of cards to punch per document ______	Estimated cost per week to do the job without Machine Accounting
REMARKS	
Person in Requesting Dept. who will coordinate with Machine Accounting Name ______ Phone ______	Requesting Department ______ By ______ (Signature) (Date)

Estimated Man Hours	FOR MACHINE ACCOUNTING USE ONLY	
	______ Controller (Date) ______ Supervisor, Machine Acctg. (Date)	Scheduled Start Date ______ Report Number ______

Figure 68—Request for Machine Accounting Service

request a conference to discuss the plan. It is not necessary to explain the plan in detail but just a very general idea concerning the topic that is to be discussed.

This approach, be it by the formal or informal method, will save time and generate respect for all parties concerned. Improper approaches and undiplomatic requests can hamper the efficiency of a data processing department and may result in the rejection of good applications and the mechanization of less adaptable ones.

Do not demand service—request it! Think over the request before it is *presented! Discuss it with your supervisor! Approach the Manager of the Data Processing Department – do not try to go around him!*

These suggestions apply to special requests as well as to repetitive-type operations. There is a tendency to rush requests for one-time jobs and to try to rush them through a machine operator without going through the department head. Of course, if the data processing department is properly organized, this will not be possible but it still behooves people to be careful not to attempt it. So many of these one-time jobs sound simple when they start and then have a tendency to multiply in magnitude as they progress. This is usually because the person making the request has not thought it out and determined exactly what is needed.

All requests for service made to the data processing department should be in writing. This includes requests for special jobs. Many data processing departments have special forms for this. See Figure 68. Many data processing people prefer to fill out the form themselves while talking to the person making the request. If the data processing representative is receptive to the idea when it is presented to him at the meeting, he may fill out the form right then while the parties involved are together. This form should be signed by the manager of the department making the request. This is another reason for getting it approved by supervisors of the requesting department before approaching the data processing department. It is useless to pursue the idea without management approval.

When presenting the idea to the data processing representative do not minimize the request. Some people are prone to hold back because they think they are asking for too much. This is because they are thinking in terms of manual systems rather than mechanical systems. The things that seem very complex may be quite simple and the reverse is sometimes true. It is usually preferable to present the whole problem at once rather than trying to get a portion approved now and then more pieces later on. Piece-meal installation can be quite costly. The whole plan should be presented and data processing people should decide the best schedule for installing it. The person presenting the plan should take an objective approach. He should visualize the plan company-wide. Mechanization makes possible broader capabilities, wider ranges and integrated operations. The individual's vision must develop to keep pace with these as he steps from the manual to the mechanical strata.

Once a system has been installed and the personnel are familiarized with the reports being issued and are in frequent communication with the data processing department, some of the formality can be dispensed with. The basic principles still apply. All requests for changes or for extra work such as special reports must still go through the manager of data processing. He cannot possibly manage his department properly unless he is aware of all work being performed. Every request should be in writing and should be signed by the manager of the requesting department. Of course, the initial contact is greatly simplified because it was made previously. Both parties are now familiar with the system that has been established and is operating; therefore, there is much more common ground between them and communication is easier. A special request or a request for a new report based on an existing system can be made rather quickly by a phone call to the manager of data processing. He will probably be able to analyze the request in just a few minutes and appraise its feasibility. If he cannot grasp it completely over the phone, he may request a conference to discuss it more fully. Or if he is too busy to discuss it at the time, he may suggest another time when he will be free to devote sufficient time to it. Data processing managers are trying to give everyone in the company service, manage a department, install new systems, discuss proposed systems and get reports out on a rigid schedule. All of this must be accomplished at a faster pace than normal because the department operates at a machine tempo which is much faster than a manual tempo.

The formal approach of using written communication should be used for the initial contact when management lines are not rigid. When letters to the data processing manager do not produce results, then copies should be sent to the member of management to whom he reports. If results are still unsatisfactory, a complaint should be expressed through the management of the requesting department to the general manager. This should be done with care and only after several attempts at communications have failed.

The data processing department is a service organization and is there to help each department perform its function more easily. On the other hand, it must be remembered that it cannot set up over-all systems and do everything that everybody wants whenever they want it. Some data processing departments are overly cooperative and try to give more service than they are capable of giving. This results in much good-will for awhile until reports start to slow down and control is lost because of an overload in the data processing department.

In requesting service, an attempt should be made to understand the problems faced by the data processing department and cooperation with any plan presented by the data processing manager that is logical. He might ask some penetrating questions about the particular operation. He is trying to determine the feasibility of the request and this cannot be done without the facts. The most common qualification which the rejected requests lack is sufficient volume to warrant the cost of mechanized processing. Before making a request reasonable estimates should be made of the number of transactions that will be processed in a given period of time. This is certain to be one of the first questions asked. There is no set number of transactions above which mechanization is more feasible than manual methods. Much will depend on the type of application and the complexity of the processing. For instance some engineering applications have a very low volume, comparatively speaking, but complex calculations of mathematical formulae make the applications feasible to be calculated by punched card methods.

It is also a good idea to estimate the time that would be required to perform the application by the manual system. This will assist the data processing manager in determining the feasibility of the request by a comparison with the time and cost of performing it mechanically.

The existing system should be thoroughly understood. Requests should not be made by people who do not have a thorough knowledge of the existing system. Ideas sometimes sound good only because all of the facts aren't known. The person making the request should thoroughly understand the existing system and the effect upon it of the mechanization being proposed. It should not be necessary for the data processing personnel to study the existing system in minute details to uncover any pitfalls that might exist. It frequently happens that data processing personnel know more about the operational details of some departments than do the people who are working in those departments. This is caused by the inability of these people to answer questions. Consequently, the data processing people have to probe every corner to get their answers. This is very educational for the people in data processing but is quite time-consuming and is certainly not the most practical approach to mechanization.

In making a request never try to explain how it can be accomplished; always explain what is required. Some people who have been to a computer class or read a book on the basic principles of punched card data processing consider themselves experts in the field. This is a mistake. Unless an individual is directly engaged in this profession, this knowledge is only useful insofar as it will assist that individual in performing his assigned task.

Telling the manager of data processing how to set up a report is not the way to get service. He is the expert – let him decide how. The individual making the request has achieved his purpose if he is able to quickly communicate his ideas to the data processing manager. The exact method used to accomplish the desired results and the feasibility of mechanization should be left entirely up to the data processing manager or his representative.

Changing A System

Systems are dynamic. A report which is good today may have to be revised for tomorrow. Changes are inevitable in our business society for it is in a progressive, dynamic state and progress can come only with change.

The need for flexibility has been recognized by the manufacturers of punched card equipment and constant progress has been made in the flexibility of the equipment. The mechanized system must be able to keep pace with necessary changes just as much as the manual systems. The problem is that it is usually more difficult to make a change in a mechanical system than in a manual system. While this is sometimes a problem, it can also be a blessing by blocking changes that are not beneficial. The axiom that progress can come only with change is not necessarily true in reverse. Changes can be made that are not progressive. Therefore, every proposed change should be thoroughly analyzed before it is incorporated. The over-all system, its objectives, and its principles must be understood and respected. Poor judgment in making changes can breed confusion from what started out as a good system. There is a tendency to push through changes to solve a problem in a particular area. This is very dangerous because this type of change is often quite logical on the surface but damages the system as a whole. People who are working in a localized area and are disinterested in the system as a whole are the most difficult to cope with because their viewpoint is narrow and their objectives are limited.

When proposing a system's change, always analyze the over-all system and not just the segment directly related to the change.

Assume that Department A has an application established on a mechanical system and reports are being received from the data processing department on a regular basis and are serving the purpose for which they were intended quite well. Department A has an added requirement placed upon it which is costly to do manually. The people in Department A discuss this new requirement and observe that there is a possibility of fulfilling this requirement by making some modifications to the application which is mechanized. The effects of this change on the present system are thoroughly analyzed, and it is concluded that the change would not damage the existing system. In fact, it would tend to produce a better system in the long run. It may be necessary to consult with the manager of data processing to determine this. Once an application is mechanized, changes become so involved with internal data processing operations that professional assistance is required in analyzing the effect of changes. Before data processing people are contacted, the fact should be firmly established that the change is necessary and it should be clearly defined.

It is not uncommon for the data processing department to recommend changes that will increase the efficiency of the system. Sometimes a minor change can be made that will save several hours of processing in the data processing department and have no ill effects upon the system. Whenever such a change is suggested, its effect upon the reports issued and the use being made of them must be thoroughly analyzed. The purpose of this type of change is to save the company money. If the change is going to create problems in other areas that will offset the savings made in the data processing department, then the purpose is being defeated and the change should not be made. Requests for this type of change should be received open-mindedly and reviewed in a cooperative manner. If analysis shows that the change will benefit the company, then it should be made; if benefits will be offset in other areas, then it should not be made.

Changes to systems should be thoroughly analyzed and scheduled into the data processing department much the same as new systems. Major changes sometime require just as much coordination and set-up time as the installation of a new application. Minor changes may require anywhere from a few minutes to several man-days of effort in the data processing department.

One type of change that is to be avoided whenever possible is the expansion of the size of a field in a card. This is necessary when sufficient space was not allowed in the first place. For instance, in setting up a payroll application, let us assume that four digits have been reserved for rate, two digits for whole dollars, and two digits for cents. Three years later the rate structure of the company is changed and under the new structure, three digits are allowed for cents. This makes possible a rate such as $1.75½ per hour which is recorded in the card as "01755." The expansion of a field by a change such as this usually causes a major revision in card forms because the field was originally set up as 4 digits and now 5 digits are needed. Invariably, there is not an empty column available in the position in which it is needed. A revision of a card form tends to obsolete all of the cards that are stored as historical records for that application. It also forces a rewiring of control panels which is very time consuming. Procedures must be changed and operators oriented to the change. Obviously, every effort should be made to allow adequate space for each field at the time the application is installed.

Reports should be prepared in the most usable sequence possible. If a report would be more useful in another sequence or with other levels of totals, the data processing department should be so notified. Sometimes it is not practical to make the change because of other requirements. Other times it may be very simple to make the change and may even simplify the operation. This is impossible for the layman to determine; therefore, it is best to merely make the suggestion to the data processing manager and let him decide which action to take. He cannot be expected to take any action unless he is notified of the situation. All sound suggestions for improving a system should be cleared with supervision and then relayed to the manager of data processing. As much time as possible should be allowed in making a change, so that it can be appropriately scheduled without disrupting the day-to-day operations of the department.

Discontinuing Reports

"There are too many reports." This statement is common in every company that uses punched card methods regardless of how austere the operation is. The statement is almost never made by a person who visualizes the overall picture; it establishes a lack of objectivity on the part of the person making the statement. This is not always the case; sometimes there really are too many reports which are the result of a complicated system. In companies where management philosophies are uncertain and constantly changing, a variety of reports is more likely to result than in a stable, well-managed company. It is not necessarily the fault of the data processing department; it may be beyond their control. Each individual in a company who receives reports from the data processing department can assist in this by notifying the department of any report that is no longer being used and ask to be removed from the distribution of that report.

A phone call is usually sufficient for this; however, a written memo may be used. If the report continues to be received it indicates that the request was forgotten or handled improperly and a follow-up should be made to the data processing department. Some people go overboard on dropping reports during an austerity program and then they are revived one by one in the months that follow. This can be quite costly and time consuming. Always be positive that a report is no longer needed before requesting that it be stopped.

It is not possible to measure if there are too many reports. The number of reports necessary will vary with the size and type of company, the kinds of applications involved and the degree of mechanization. The reports are undergoing a never-ending analysis by the people preparing them and by the people using them. It is logical to assume that most reports issued are necessary. At any rate an intelligent person will not criticize until he has analyzed the reports issued and found that many are unnecessary. Strangely enough, the statement is sometimes made by people receiving reports yet when they are questioned as to which reports that they receive can be discontinued they are unable to reply satisfactorily.

Some data processing departments attach a card to each copy of each report periodically (about every six months) requesting that the recipient analyze the report for possible discontinuance. The recipient is requested to sign the card certifying that he is using the report if such is the case, and to return the card to the data processing department. The data processing department processes the returned cards and makes no changes on reports on which the cards have been returned.

The reports for which cards have not been received are discontinued. If several copies have been returned and some have not, the number of copies is merely reduced to correspond to the number of cards returned. Even a reduction in the number of copies can reduce costs. No processing time is saved but paper costs are reduced and the costs of removing carbons, bursting and distributing reports are reduced. Most people do not realize the increase in paper costs as extra copies are added. For instance, on stock paper which is just plain fanfold, lined paper, two parts cost three times as much as one part and three copies cost almost five times as much as one copy. One type of form costs as follows:

1 part –	$4.00 per thousand sets
2 parts –	$12.00 per thousand sets
3 parts –	$19.00 per thousand sets

Errors

The data processing department does make errors. To expect otherwise is unreasonable. Mechanization should reduce the number of errors but it can increase the intensity of the errors that do occur. For instance, under a manual system small errors will occur rather frequently but large, glaring errors will be caught because of the constant human analysis. In the mechanical system, everything is standardized and the machines seldom make errors so the number of errors is greatly reduced. If, however, a serious error does occur such as $10.00 being recorded as $10,000.00, it is less likely to be caught because human beings are not analyzing the data. For this reason, source data must be thoroughly checked before it is sent to the data processing department. Likewise, the finished reports should be scanned as they are received to audit for anything that looks unusual.

Errors should be very uncommon. Amount fields should be controlled by predetermined totals whenever possible. That is, an adding machine tape of the amount field on the source documents should be prepared to accompany the documents to the data processing departments and all punched card decks and reports must balance to these tapes.

Every error should be brought to the attention of the manager of data processing. Do not go to the operator who ran the report. Reruns must be tightly controlled in a data processing department because they represent lost time and can cause havoc with schedules; therefore, the manager should know about them.

Errors are most likely to occur when inefficiency exists, when changes are being made to the system, or when exceptions are being made to the processing. Errors should be uncommon in a standardized procedure where reports are being processed in the same manner each time. This is another reason for standardization – it develops accuracy. Exceptions should be avoided wherever possible and handled manually, if necessary, to keep the mechanical system functioning efficiently. Whenever a change in system is being made or when exceptions are being processed, extra effort should be expended in auditing the reports that are issued to catch any errors that might be made as soon as possible. Another time when extra auditing may be profitable is when the procedure is being processed by a new operator in the data processing department. New employes will invariably make some mistakes until they become familiar with the company.

Errors take many shapes and forms in the mechanical system. Probably the most common error on reports is the sequence. Sorting is a rather tedious task and the human element is more involved in this operation than in most; consequently, errors are more common. An error made in sorting will usually be reflected in the final report by causing the data to be out of sequence. An illustration of this would be on a job cost distribution which is supposed to be in order by job number but comes out like this:

Job Number	*Hours*
1000	100.5
1001	91.2
1002	7.6
1012	84.3
1009	76.2
1015	2.6

Note that the cards for job number 1012 are out of sequence. They fall between job number 1002 and job number 1009 but they should be after job number 1009.

A type of error that should be extremely uncommon is for a report to be out of balance. It is the responsibility of the data processing department to issue reports that balance. To do otherwise is a serious error on the part of this department.

Do not be too hasty in accusing the data processing department of making an error. About 75 per cent of the complaints received by data processing departments are unwarranted. They come as a result of people jumping to conclusions and as a result of a lack of understanding of the system. Many people who receive reports do not have a thorough understanding of the system nor of the report which they receive. Before accusing the data processing department of making an error, a little analysis should be made. The content of the report should be reviewed and any exceptions that have been forced through the system should be considered for the possible effect that they could have had on the report in question. The error may also have been caused by an error on the source data, in which case, no blame should be placed on the data processing department. If the report can be used and no ill effects will result from the error or if it can be corrected manually without too much trouble, then that course of action should be taken. Always report the error to the data processing department even if it does not require a rerun. In most cases the data processing manager will be satisfied with this and will merely take whatever corrective action is necessary to prevent the error from reoccuring. In some cases, however, he may insist upon rerunning the report because of its importance or the possibility that the error could cause future problems. As previously stated, be sure to report every error to the data processing department.

Most data processing people take pride in the accomplishments that they can perform by using their equipment. One of their principal attributes is accuracy; therefore, they are inclined to be even more sensitive than most people about being accused of making errors. By the same token, they want to know every error that occurs so that they can do something about it.

Whenever a report is received which appears to be in error, the first step should be to try to reason out a logical explanation for the data being as it is shown on the report. If no logical explanation of the error can be found, then the data processing department should be contacted and the part of the report in question pointed out to them. They should be able to give a logical explanation of the condition. If they agree that an error has occurred the need for a rerun should be discussed. Schedules may not permit the time required to rerun or a rerun may not be necessary provided the error can be corrected or circumvented manually. At any rate, the thing to consider is whether a rerun is in the best interests of the company as a whole. If it is the opinion of the parties involved that the expense of rerunning the report would not be worthwhile for the company, then it should not be rerun. If on the other hand, it is felt that the report should be corrected in the best interests of the company in spite of the amount that a rerun would cost, the report should be corrected.

Machines are certainly not perfect but they make very few errors which are not detected by some mechanical or procedural checking feature. The possibilities of a human error or a procedural flaw are infinitely greater than a machine error and the layman should not guess as to what caused the error.

Many things that appear to be errors are really not errors at all. Statistics are very deceiving. If, after careful deliberation, the report still appears incorrect, contact should be made with the data processing department to request assistance in analyzing the report.

Schedules

Unfortunately, data processing departments sometimes miss schedules. This reputation is not always justified because many things can cause reports to be issued behind schedule, some of which are beyond the control of the data processing department.

Probably the most common reason for missing schedules is because the source documents upon which the completed report relied are received in the data processing department too late. Source documents that are late disrupt the planning and scheduling of operations within the data processing department and not only cause reports to be issued late but also cause inefficiency in the data processing department and can cause increased costs due to overtime work which may be necessitated. The department should not be blamed for issuing reports behind schedule when the source data was received late, but they usually are. The people receiving reports are often not the same people who are preparing the source documents. Consequently, they are not fully cognizant of the situation all of the time. There is a tendency to blame someone and since the data processing department issued the report late, they get the blame, even though an analysis might show they are not at fault at all.

Changes to the system and exceptions can also cause missing schedules. They create more work in the data processing department and require much more supervision than routine operations. Special requests can also disrupt schedules. It is not uncommon for the data processing department to be notified to drop everything else and get out a special report for management. Naturally, all of the regular report schedules suffer under such conditions.

Schedules are usually set rather tight in a data processing department. One of the advantages of mechanization is speed; therefore, reports are issued as rapidly as data can be processed. If something goes wrong internally, such as a machine breakdown or a report being out of balance, much time can be lost and reports will be issued behind schedule. It is best to keep schedules tight and be reconciled to an occasional slip than to make the schedules so loose that the schedule will never be missed. These tight schedules keep everyone on their toes and prevent other jobs from being scheduled in ahead.

It is usually not necessary to notify the data processing department when a report is received late. There should be a record of the distribution of reports in the data processing department and a control over late reports. If a report is habitually received late, then contact should be made. Perhaps the schedule is too tight or there may be a misunderstanding about the schedule. At any rate, the data processing manager should be consulted about the problem so that some type of action can be taken.

One of the other principal advantages of mechanization is speed. Consequently, the data processing people are sensitive about schedules so they should be approached diplomatically. No track star likes to be accused of being slow on his feet. It is best to approach the data processing department with a request that the schedule on the particular report be analyzed.

End of Chapter Questions

1. What is probably the most important single factor in the installation of a punched card system?
2. What human elements are decreased by mechanization? Increased?
3. What two human ingredients are necessary for mechanizing a system? Why are they often lacking?
4. Why is communications so important in installing a system?
5. Why isn't it advisable to keep the plans for a proposed punched card system secret?
6. Discuss passive and active resistance to a new system.

7. What are the basic differences between manual and mechanical systems?
8. Why should source data going into a mechanical system be checked before being sent to the data processing department?
9. What benefits normally result from mechanization that could have been achieved with the manual system?
10. Why is standardization so vital?
11. Upon what is the workability of a system dependent?
12. How should a person who is participating in the mechanization of a system be mentally conditioned?
13. How should errors be handled?
14. What is the root of most problems that arise?
15. How should incompetence be handled?
16. What steps should be taken before submitting a request for data processing services?
17. To whom should all requests for new reports, special reports and changes to reports be directed?
18. What actions are necessary when requesting work from those data processing departments that have the reputation of taking a negative approach to all requests for their services?
19. What is the most common qualification that rejected requests lack?
20. Why shouldn't the person making the request tell the manager of the data processing department how it should be accomplished?
21. What should be considered when proposing a change to a system?
22. Which type of change should be avoided?
23. How can a person determine whether "too-many" reports are being prepared?
24. How much does the sheet cost increase from one copy paper to two copies? To three copies?
25. What effect does mechanization have on errors?
26. When are errors most likely to occur?
27. What is the most common error on reports?
28. Why should every error be reported to the data processing manager?
29. What is the most common reason for missing schedules?
30. Why isn't it necessary to notify the data processing department when a report is received late?

CHAPTER 13

Data Processing Services

A substantial portion of the data processing sphere is involved in the performance and sale of services. These services fall generally into two types:

1. Consulting Services
2. Processing Services

They are usually performed by companies which are organized solely to perform this type of service for other companies.

Consulting Services

Consultants have become an important part of the business and industrial world. It has been estimated that more than $200 million is spent each year in the United States for consultant fees. Because of the rise of mechanization and automation in the office and the extreme popularity it has experienced with management, it is assumed that a substantial portion of this amount was spent on punched card systems.

The Need For Consultants

Today's management is involved with so many problems that it must call upon outside help to solve some of the more complex technical problems.

The problems of an expanding clerical force is common as has been discussed in earlier chapters. Rising overhead costs that skim away the profit can create nightmares for the management of a company. The systems become so complex and interwoven that the members of management cannot find time to weed out the unnecessary from the necessary. Neither do they have the time nor the ability to thoroughly analyze the problems and decide upon the proper systems changes and the correct amount and type of mechanization for their individual cases. This is no reflection on management, they are human and cannot be expected to know everything. In fact, in some cases, members of management are quite capable of doing this because of their backgrounds and experience, but these will have limitations in other areas. Many companies have decided to mechanize and have installed equipment and revised systems successfully without any outside help. Others have been unsuccessful and have failed completely, have called for outside consulting services, or have hired competent personnel to solve their problems.

A consultant supplies management with the facts about a particular problem. The final decision still rests with management, just as the success or failure of the solution will rest with them. It might be said that a consultant merely sells opinions. Because he is a specialist in a given field, his opinion should be based upon years of experience and research of the problems involved. One of the primary considerations to make when considering a consultant is to examine his qualifications.

Selecting A Consultant

There are a number of pseudo-experts in the field of data processing who pass themselves off as management consultants. Beware of systems men, auditors, accountants, etc. who have been to a few computer classes and claim to be experienced in the field of data processing. Be sure that the individual who will come into your company and make the study has several years' experience directly in the punched card data processing field. You are buying a service and you have a right to know whether the person selling has the proper qualifications to deliver the goods.

Consulting services can be received from a number of different organizations. Management consultant firms are probably the most common. Some of the larger auditing companies have management consulting sections which specialize in this type of work also. Data processing service organizations usually offer this type of service along with machine processing services. An often overlooked source of expert advice is the equipment manufacturers. They have specialists in virtually every facet of data processing who will come in and offer advice at no charge. There are also a few firms that specialize in data processing consulting services and offer a few highly trained people who do this type of consulting and nothing else.

Needless to say, some of these organizations offer a more objective point of view than others. One can hardly expect an equipment manufacturer to recommend that a company purchase their competitor's equipment, even though it may be more adaptable to that company's particular problem.

The type of assistance that is needed may have a bearing upon the best type of consulting service to employ.

Some of the problems for which data processing consultants are employed are as follows:

1. Management may want an investigation of overhead costs that are mounting as a result of increased volume of paperwork and expanding clerical sections.
2. Management may feel that present systems are not capable of getting reports out soon enough.
3. Management may want an analysis of inaccuracies and lack of control in present systems.
4. Management may desire a purely objective and impartial opinion of ways that its operations can be improved.
5. Management may realize the value of and the need for mechaniza-

tion but does not have the technical ability available nor the time to make a study and install the necessary systems.

6. Management may realize that the solution to a given problem lies in mechanization but it doesn't know how much equipment is economically feasible nor which line or type of equipment to install.
7. Management may want to move rapidly to install a system which will generate substantial savings. Top-notch assistance is needed for a short duration.
8. Management may have political problems within its company and desire someone who is completely objective to step in and coordinate the installation of a system.
9. Management may suspect that the punched card data processing department in their company is not producing as much as it should or that it is poorly managed.
10. Management may suspect that its punched card data processing operation is producing unnecessary reports or that its applications are poorly planned and uncoordinated.

A well-qualified data processing consultant will invariably produce a savings to the company within a year which will exceed his fee and it will usually be several times greater. No system is perfect and an experienced person can quickly spot changes which will result in better control, faster processing, or elimination of duplicate efforts. This is only true, of course, if there has not been a systems study in the past several months.

The amount of money spent for consultant fees mentioned earlier indicates that management has accepted the need for and the desirability of using outside assistance in solving some of its problems. This gives management a sense of security by having virtually an unlimited staff of experts available to solve specific problems at any time without having to employ each type of expert full time on its own payroll.

The most frequent error made is in employing a management consultant to solve data processing problems who is really not an expert in this particular field. Be absolutely sure that the person who is going to come in and make the study is well-qualified because you are buying his opinions and they will be no better than his qualifications. This person should have several years' experience in the punched card data processing field and have a reputation in the installation of successful machine systems. A few machine classes simply do not make anyone an expert and it is dishonest for these pseudo-experts to pass themselves off as specialists.

There are many competent people available but there are many incompetents also. A consultant should be selected with care.

To give an example of the qualifications which are frequently required, let us take the case of a "feasibility study." This is a term that has sprung into general use since the advent of electronic computers. It refers to an extensive study which is made of a company's systems to determine where improvements can be made. The study is usually begun with the thought of determining whether it is feasible for the company to get an electronic computer. It frequently happens, however, that a feasibility study reveals the impracticality of a computer for the particular systems involved and conventional punched card equipment, accounting machine equipment or even continued manual systems are recommended. Assuming that the recommendation is made to get computers or conventional punched card equipment, the question then becomes which equipment to select.

The persons selected to make a feasibility study should have several qualifications. They must be expert systems people because the existing systems must be thoroughly explored and understood by them. A systems background will enable them to spot weaknesses in the existing systems and recommend improvements.

They must have a thorough knowledge of the various functions of a company and how each fits into the overall operation. The operations of engineering, manufacturing, finance and other activities must be understood individually and as they fit into the integrated whole. They must understand the philosophies and goals of the company's management and be able to inject these into the integrated systems wherever possible.

They should know a great deal about the various types of equipment and its capabilities. Otherwise, they will not be able to intelligently recommend the best equipment for the company's individual needs.

They must assume an objective point of view and approach each problem from the viewpoint of management. Patience must be one of their virtues because feasibility studies frequently require several man-months to complete, and the more involved ones can require several man-years.

Of course, the people assigned to a feasibility study team are expected to be able to get along well with others and possess the necessary tact and diplomacy to accomplish their task without arousing personnel problems and creating ill-will toward the action being undertaken.

No one person could possibly possess all of these qualifications. Management is usually hard pressed to find any suitable personnel within its own company who can be released from their present duties to conduct a feasibility study. This is the reason why outside help is frequently obtained. This is not to imply that a consulting firm possesses all of this talent in one man, but they do have people who specialize and have made it their life's work. On larger studies, several people may be used to work along with personnel in the company. On smaller studies, management may want one person to come in and coordinate the study through a rapid, well-organized plan of action which will arrive at a conclusion with the least possible disturbance of present operations and personnel. In any case, the person conducting the feasibility study must have a variety of unique talents and a varied background. This type of person is most likely to be found in a reputable consulting service organization.

A company desirous of obtaining outside assistance should first determine exactly what it expects and then investigate the various types of consulting firms. One should be selected which has a good reputation in the specific areas in which assistance is required.

The best way to ascertain the capabilities of the various data processing consultants in each locality is to contact various companies who have used their services and get their recommendations. The companies contacted should be those who required data processing recommendations; it would accomplish little to find that a given management consulting firm had an excellent reputation in the engineering field. The important thing is, what was their record in the data processing field?

If it is impossible to gain this information from other companies, the next best thing is to contact a few consulting firms and inquire concerning their capabilities in the data processing area. Naturally, the information received will be much less objective. By sifting the facts from the sales talk, it may be possible to select a competent consultant on this basis.

It is usually not necessary to sign a contract when engaging for consulting services as far as the consulting firm is concerned; however, in some cases the company or organization may require that a contract be signed, particularly in government organizations. If the consultant's work is unsatisfactory, it would be of little benefit for the company to have a contract which would require the completion of the job. The consulting firm does not usually want a signed contract any more than would any other professional group, such as lawyers or doctors. It is customary, however, to furnish a letter of agreement which includes the work to be performed, estimated fees and target completion date.

Many different fee arrangements are used. The fee can be on an hourly, daily, weekly or monthly basis. The multiplication of the fee by the time required to do the engagement is the cost to the client. Other expenses such as travel, if required, can be either included in the fee or billed separately. There should be a clarification of this point if extra expenses are involved. This would be especially true where a company has two or more widely separated locations which the consultant must visit. In this case the cost of travel, per diem, etc. should be billed separately to the client at a predetermined rate.

It is not advisable for a company to pay a data processing consultant on the basis of savings that are realized as a result of his study. While this seems to have some merit on the surface, it has been found to be unworkable in most cases. The difficulty arises in ascertaining how much savings came as a result of the consultant's recommendations as opposed to company personnel suggestions. The intangibles involved and the possibility of open disputes over who should receive recognition for which savings make this plan unworkable.

When the services of a data processing consultant are required, it is not advisable to get estimates from several different firms. The reputable firms operate on a professional basis and practice a strict code of ethics. The important point is to select a well-qualified reputable firm. This does not mean that only the large nation-wide firms are acceptable. There are many small firms that are just as reputable and may have representatives in certain localities that are more competent.

Cost, while important, should not be the major consideration. When buying opinions, the qualifications of the consultant and the integrity of his firm are far more important. A reputable firm will give a cost estimate based on the maximum length of time that the engagement will require and every effort will be made to complete within that length of time. When competitive estimates are solicited, an unethical firm has the advantage by presenting a minimum time requirement to complete the assignment. If the unethical firm receives the assignment, he must then skimp on the work or persuade the client that unforeseen circumstances have arisen which will require more time. Consequently, either an unsatisfactory job will result at the lower cost or, if allowed to spend more time, the unethical firm will end up costing just as much, or more, than the competent, ethical firm would have cost.

Utilizing the Consultant

Once an agreement has been reached and a data processing consultant is on the scene, utmost cooperation should be shown to him. It is in the best interests of the company that he be made aware of the company's problems as quickly as possible. He will have many questions to ask which are designed to penetrate to the core of the company's operations in the shortest possible length of time. The personnel with whom he is put in contact should be those best qualified to answer his questions.

If there is an existing punched card data processing department, there will undoubtedly be very deep penetration into its activities. It will behoove this department to have available a list of all reports issued and their distribution (the names of persons and the departments to whom the various copies of the reports are sent). Sample copies of all reports will probably be required also. An up-to-date organization chart of the department which includes all data processing personnel, their classifications, rates of pay and the shift on which they work will be required as well as any machine utilization records that are available.

When a data processing consultant has made a study and submitted a proposal, it is sometimes practical to retain the consultant to implement the plan provided it receives the approval of management. If competent personnel are available within the company, this probably will not be necessary. If management accepts the proposal and wants to insure its successful implementation but is in doubt concerning the ability of its own employes to accomplish this, then it logically follows that the consultant who made the recommendations be retained for the implementation.

Many good plans have been spoiled by poor implementation. Expert advice is needed just as much in installing a new system as was needed in originating it. If the recommendation is to mechanize a system or application, a rather drastic change in systems will result. Personnel must be oriented, machines and supplies must be ordered, forms must be changed and countless other details must be taken care of, especially when a punched card data processing department is being installed. In this case, it may be wise to hire a competent manager for the new department long before the machines are installed to do the necessary systems work and take care of the many details required. If a well-qualified manager cannot be obtained, then consideration should be given to the retention of a data processing consultant to guide the intricate installation of the new department and assist in getting the first few applications converted from manual to punched card systems. Consultants retained for this purpose do not normally assume line authority in the company; that is, they do not actually give orders, but merely advise and recommend how and when to take the necessary actions. The company's employes should do the actual work. The consultant's responsibility is to train, counsel, advise and guide the company's employes.

It is obvious that the cooperation of the firm's personnel is essential because, in the final analysis, they are the ones who must actually make the system work. The company's management can pave the way by keeping its personnel informed of what is happening and what the future plans are. One of the greatest handicaps that a consultant can encounter is resistance from the people with whom he must work.

Another service furnished by some of the larger consulting firms consists of highly technical advice. In the field of data processing, this type of service might be utilized where a "special purpose" type machine is needed that does not exist. This group of highly-trained technical people (most of whom are Ph.D's) will develop the desired machine. In other areas, they may analyze a company's product to determine why sales are not meeting expectations. They will even re-engineer the product, if necessary, and improve its weak points. They will assist in developing new markets, even in foreign countries. These services are quite expensive but some of the results achieved have been quite good returning their investment many times over.

In conclusion to this section on data processing consulting services, Article I of the Association of Consulting Management Engineers, Inc. Code of Ethics is quoted.*

> "We recognize that the practice of management consulting is a profession and that the chief characteristics of the professional approach are objectivity and integrity. The true professional assumes responsibility for seeing that the client benefits from his services, and the amount of his financial return is not the principal measure of success."

Processing Services

Punched card data processing services are performed by a wide variety of different organizations. These different organizations have at least one characteristic in common and that is that they process data and issue reports for other companies by utilizing punched card equipment.

Some of the different types of organizations engaged in this business are:

1. Large nation-wide companies with branches in most of the principal cities.
2. Medium-sized companies with a few offices localized in a small section of the country.
3. Small single-location companies.
4. Companies engaged in other types of business who gain extra revenue by renting time on the equipment in their punched card data processing department.

*Professional Practice in Management Consulting by Association of Consulting Management Engineers, Inc.

Service Bureaus

Service bureaus bring the advantages of punched card data processing within the grasp of virtually any company regardless of its size. The services performed are paid for on the basis of the time required to perform them.

Why do companies use service bureaus?

Some companies, because of their limited size or type of activity, simply do not have sufficient applications to justify their own punched card data processing department. Yet, they may have one or two applications such as payroll and labor distribution which are ideal punched card jobs. The source documents can be sent to a service bureau and the pay checks and labor distribution reports will be prepared on punched card equipment. Thus, the small company reaps the benefits of the most up-to-date data processing equipment plus years of experience by qualified people which would be completely uneconomical and impractical for them to attempt to achieve within their own company.

One of the most frequent uses of this type of service is to process seasonal and peak load work. Many companies are faced with an abnormal amount of data to process at certain times of the year. Food processors are busiest during the harvest season, distribution companies can require yearly sales analysis reports and many companies have yearly inventories.

Each of these has a tremendous amount of data to process at one time and it usually must be performed on a rather tight schedule. This creates a problem, even in companies with their own punched card equipment, because it is usually fully utilized with the regular jobs which must continue to go out on schedule. The service bureaus offer an ideal solution to this problem because they can handle the peak load work without disrupting the company's regular operations. Without this type of outside assistance, chaos can result and the result could be much more expensive than if the job had been "farmed out."

One of the complaints frequently voiced about punched card data processing departments is that the costs are difficult to control. There are machines involved, extra shift rental, personnel, supplies, etc. There is a tendency for these departments to grow and grow as one report after another is added. If the machines are available and a report is needed, it alone does not cost the company anything to mechanize. This is a common vein of logic which is used by people desiring to have their own work performed by machines. It is true only to a point; at some time a saturation point is reached, at which time additional costs must be incurred. This frequently happens in expanding companies. Increased volumes of data on all applications soon use up all available machine and personnel time and force significant additional costs. When this saturation point is reached, it is very difficult to screen out the "marginal" applications and stop doing them to avoid incurring additional costs. Conversely, it frequently happens that reports can be discontinued but no savings to the company is apparent because the same amount of money is being spent for personnel and machines.

By using the service bureaus, the exact cost of each job can be determined. Before an application is mechanized, the savings can be compared against what it will cost. The picture is much clearer. If it costs more to have it done outside, it is probably better to continue with the present method unless other factors such as better controls or schedules affect the difference in cost. Likewise, whenever a report is no longer needed it can be dropped and immediate cost savings will result.

Naturally, this flexibility which a company has by using these processing services becomes impractical when the cost consistently exceeds the cost of having one's own punched card data processing department. There are also disadvantages of having work performed outside the company which must be considered. These will be discussed later in this chapter.

Companies with significant fluctuations in their general economy should consider doing their work at a service bureau because the cost varies directly with the amount of work being performed. Immediate cost savings can be realized when austerity demands it by dropping reports and reducing volumes. Rapid expansion is possible as the economic pendulum swings the other way. Reports can be added as they are needed and can be afforded. This control over expenditures is exceedingly difficult with a punched card data processing department because many of the costs are fixed and switching equipment and personnel to keep pace with the economic picture is difficult and expensive.

Some executives are inclined toward mechanization and its advantages but they desire to move with caution. They want to see it work on their own jobs before they will commit their company to an installation of equipment.

The service bureaus offer these executives an opportunity to test out their own jobs. This gives a company the advantage of expert advice and assistance immediately. It also gives them a chance to get their problem application mechanized and work the "bugs" out of it. It further familiarizes their employes with some of the principles and peculiarities of punched card data processing. All of this paves the way and makes for smoother sailing when and if they decide to install their own punched card data processing department.

In the event that the application should prove to be unsatisfactory, it is a great deal less expensive to return to the original system than it would be to "scrap" a punched card data processing department.

Surprisingly enough, a great deal of the work performed by service bureaus is for companies which have their own punched card data processing department. This is usually for a peak-load type project. These departments are frequently loaded to capacity with regular work and large special jobs are sent outside the company because it costs less than overtime would cost or because the company simply does not have adequate equipment or sufficient personnel to handle the job. If the job which arises is a large one-time operation or if it is a peak-load caused by an abnormal volume of data which is considered to be temporary on a regular application, it is well to consider getting assistance from a service bureau. If, however, the abnormal volume is expected to extend over a long period of time, or if the job is expected to be repetitive on some semblance of a scheduled basis, it may be well to consider an expansion of the punched card data processing department.

The supervision of the data processing department has a responsibility to study each work load problem as it arisis and make recommendations to management for the best course of action to follow in each individual case. The supervision must exercise judgment and prudence in maintaining an efficiently-operated department that has a proportionate balance of personnel and equipment to work load. If sufficient machines and people are kept available to handle peak loads, then the department will operate inefficiently during a normal work load period. Obviously, this is not economically sound. Sound management dictates that only enough equipment and personnel will be maintained to process the normal work load.

Peak loads can then be sent to a service bureau for processing without disrupting the normal work flow. Sometimes the additional work can be absorbed by overtime. The smaller special jobs and temporary abnormal volumes of work on existing applications can often be easily processed by working extra hours. There are many disadvantages to overtime which tend to make it impractical for prolonged periods. It creates a strain on the personnel and affects the quality of the regular work. It may also cause excessive absenteeism which nullifies the effect of the time gained by working overtime. It is also much more expensive (usually 50 per cent more) and tends to be less productive because people are tired from working their regular hours and, consequently, operate less efficiently. The machines, of course, do not tire and cost nothing extra for overtime worked in addition to a normal work shift. Prolonged overtime may affect the equipment by increasing the amount of maintenance required to keep it functioning properly.

These factors must all be considered in determining how to process peak loads. The supervisor of the data processing department must carefully weigh the pros and cons of each individual case and make a decision in the best interests of the company. The fact that service bureaus exist and are available for just such work on a short notice gives supervision more flexibility and an opportunity to serve the company better.

Many service bureaus operate on a 24 hour day – seven day a week basis. This makes overnight and week-end service available on those special jobs that require immediate action. They usually have sufficient equipment and personnel to handle virtually any sized job. The larger service bureau companies have the further flexibility of being able to spread the extra large jobs out over several branches.

Another reason why a punched card data processing department might use the services of a service bureau is because of excessive absenteeism. Illness sometimes strikes several persons in a department rendering it virtually inoperative. Since this type of person is skilled, it is usually impossible to obtain people on a temporary basis. Many service bureaus will send experienced people into a company to operate equipment and process applications as well as processing work in their own installations. It is good to know that such a service is available in case it is needed. It is comparable to an insurance policy except no premiums are required unless catastrophe strikes and assistance is needed.

It might be well to emphasize here the importance of having well-written up-to-date procedures. This type of assistance is virtually impossible without adequate procedures to follow. It would be almost useless to bring anyone in, regardless of their experience and capability, and expect them to process your work if good procedures do not exist. No pretext is made that this is an easy solution to the problem. Even with the best of procedures, it would be difficult for experienced personnel to come into your department and begin issuing reports unassisted. In an emergency it would be difficult but possible, especially if someone fairly familiar with the work or the reports issued could assist. Again, good procedures are a must!

Sometimes reports are required which cannot be prepared on the equipment which exists in the company. This is especially true of the small installations which usually have low-capacity equipment. In the larger metropolitan areas practically any size and type of equipment is available in one or more of the service bureaus in the area. These range all the way from a simple numeric key punch to a large-scale computer.

It has been estimated that 10 to 15 percent of the work now performed on conventional punched card equipment could be processed more economically on a computer. Undoubtedly much of this work is performed in companies which cannot now and probably never will have sufficient volumes to warrant a computer of their own. Many of these companies utilize a service bureau computer to process their applications which are particularly adaptable to a computer operation. This course of action is frequently more desirable than an expansion of the company's data processing department.

Here again, the responsibility of determining the practicability of this approach with alternative possibilities lies with the supervision of the data processing department. They should be sufficiently familiar with the company's systems, with their own operations, and with existing service bureaus facilities available in the locale to make a wise decision concerning the best course of action for the company to follow. This requires a very objective approach because the personal ambitions of the supervisor may be involved. It is his duty to take a purely objective approach and make a decision without regard to his own personal stake. Only in this way can he fulfill his responsibility to the company.

In commenting on computer service bureaus, John L. Burns, president of Radio Corporation of America, had this to say, "The computer service center is a kind of electronic gas station where small businessmen can have their paperwork serviced while they wait. . . . The day may not be far off when it will be as easy for a small businessman to visit a data processing center as it is for a housewife to visit a laundromat."*

The number of service bureaus which have sprung up is truly amazing. For instance, in 1960, the Los Angeles area contained 20 separate companies engaged in processing data punched in cards as their main source of income. This does not include dozens of other companies whose punched card data processing departments do work for other companies. Other metropolitan areas have a proportionate number. Even relatively isolated areas which contain a fair amount of industry frequently have a service bureau available.

*"John L. Burns on Automation," Business Automation, Sept., 1959.

Disadvantages

One of the principle disadvantages of service bureaus is the physical separation of the company for whom the work is being performed and the service bureau. This creates communications, confidence and delivery problems. The telephone helps alleviate some of the communications problems but it certainly is not as advantageous as having the equipment available in one's own company. The physical separation creates problems of getting the source data to the service bureau and picking up the completed reports. The degree of inconvenience which this creates varies with the work being performed, the number of trips required, the efficiency of the application, the distance that must be traveled, and the personalities involved. The expenses generated because of this physical separation such as mileage to pick up and deliver, cost of person's time making trips, etc. should be added to the service bureau's charges in evaluating the feasibility of this type of an arrangement.

The fact that source documents must be released can be a problem. Reference to source information is virtually impossible while it is being key punched by a service bureau. Documents leaving the company can be especially troublesome where government confidential work is involved such as is frequently found in companies engaged in government contract work.

This problem is sometimes solved by the rental of key punches and verifiers and recording all data in punched card form before it is sent to a service bureau. Since these are relatively inexpensive machines, this often proves to be the most economical, especially when weight is given to the retention of source documents within the company.

Another disadvantage frequently voiced is that some service bureaus do not get work out on schedule or that the reports which are issued are incorrect in some manner. This is very unfortunate since these organizations pose as experts at this type of operation. As in every other type of business there are some who are not well qualified. It is always advisable to meet and investigate the persons managing the service bureau. Do they have good reputations in their field? Are they well qualified? Are other customers satisfied? This is a very competitive field. In most areas there is more than one service bureau to choose from. Only a well-qualified one is worthy of a company's contract.

This does not mean a well-qualified service bureau will never issue a report late and will never make a mistake. Everyone is human and errors will occur. Some people, however, are more conscientious and will establish controls to assure a reasonable degree of accuracy. This is why it is well to investigate. Extremely low prices are suspect. This is frequently an indication of poor quality. Low prices are inconsistent with the salaries expected by qualified operators and with the cost of adequate controls and balancing operations.

Of course the disadvantages just expressed are not unique with service bureaus. It can also be found in data processing departments within companies. It does seem more alarming, however, when found in a service bureau because this is a company exclusively engaged in this type of work and selling its services at a profit. It behooves such a company to maintain a competent staff because it is posing as an expert in this field. The personnel found in punched card data processing departments are frequently not real experts in the field. In fact, they may be quite inexperienced in managing installations of this type. They are there because the company cannot afford to pay the wages required to obtain an expert or because an expert could not be found. The management of a service bureau is expected to be of a high calibre. The success of their company depends upon them. They should be thoroughly qualified and should be paid accordingly. In fact, the availability of this outstanding talent is one of the advantages of using a service bureau; it is possible to obtain expert advice and assistance in developing mechanized systems.

Methods of Charging

There are numerous methods of charging used by service bureaus. All of these have as their basis the time required to process an application through each machine. The hourly rate of each machine is different because the rental paid by the service bureau to the equipment manufacturer varies. When a service bureau is making an estimate of the cost to perform a potential job, they must first flow chart the entire operation step-by-step. The time is then developed which will be required for each step. This varies with the volume of cards, amount of machine set-up time required, handling time, etc. Charts are available which indicate the processing speed of each machine. Experience dictates the amount of time to allow for variables. Once the time has been inserted for each step based on a predetermined volume of cards, it is extended by the charge for the machine used. The charge includes machine cost, operator's salary, overhead, and profit.

The costs of all steps are then added together for a total cost to perform the job. This is frequently quoted on a "per thousand card" basis. This means that the customer pays the estimated amount for each one thousand cards processed on the "per thousand card" basis.

Some estimates include the costs of supplies such as cards and paper, others do not. This should be specified in the contract which is signed between the service bureau and the customer. Other charges which can be indicated separately or pro-rated over several months' fees are the costs of setting up the job such as wiring control panels, writing procedures and assisting in systems work for the customer.

Some customers want their own control panels wired because they contemplate having their own installation some day or they may already have it and furnish the panels for the job. Other customers have their applications wired on panels owned by the service bureau.

It is obvious that the costs of service bureau work are not cut and dried. The person estimating the cost must be well-qualified to arrive at a fair bid to both the customer and the service bureau. When getting bids, it is usually wise to contact two or three different reliable service bureaus if there are that many available. Each bid must be analyzed to be sure that all contain the same things. Obviously a bid which contains only processing costs would be less than one which includes material cost or control panel wiring changes. This does not imply that it is wise to scour the area for the lowest bid. Quality is extremely important and the service bureau which can give quality and good scheduling at a reasonable cost may be better than the lowest bid which, out of necessity, shortcuts controls and good operating techniques.

Another method of charging used is to keep a record of the time on each machine used and to charge the customer an hourly rate for each machine which is the same rate used in estimating. Supplies are charged on top of this or the customer can furnish his own. Under this method, the customer can make all of the changes that he wants to or get special jobs and extra operations performed at will without changing the contract. The more work the customer creates, the more it costs him. Under the card volume type of contract, it is not as flexible because changes are not built into the estimate and the cost of changes would eat away the profit for the service bureau. Consequently, added work or changes to existing jobs usually requires a change to the contract.

This method places a certain amount of trust in the service bureau to keep time properly and to always have competent people working on the application. This is not as difficult to control as it might seem, especially if an estimate has been submitted at the time the job is started and each bill is compared with the prior month's bill for each application. Requests for changes should be made in writing and filed with the bills received from the service bureau to substantiate the increased costs which they generate.

Many service bureaus try to standardize certain applications to give their customers a better price. This usually requires that the customer sacrifice something that he wants for the sake of standardization which results in lower cost to him. Common applications for standardization are payroll and labor distribution. One service bureau could have ten different customers whose payrolls vary from 25 to 500 employes each. The payrolls and labor distribution reports for these ten companies are processed together giving each company the benefit of increased efficiency by a volume operation. The same procedure is followed and the same control panels are used thereby eliminating the usual set-up costs. At the point of writing paychecks, the cards are sorted apart by customer code number and each customer's paychecks are listed on that company's paycheck form. The layout of all of the paychecks are the same so that the same control panel is used for all ten sets of paychecks. Only the company name, bank name and number and signature is changed to suit each company.

This standardization reduces systems work, control panel wiring, cost of control panels and wires, and handling time. There is a customer code number punched in the cards so that they can be segregated on the Sorter at any time. Under this standardized system the labor distribution, paychecks, payroll register, deduction registers, quarterly payroll reports, and W-2 statements can be prepared much more economically than if each company had its own peculiar system.

Any company, regardless of size, which has one or more systems that require considerable clerical time should investigate the possibility of utilizing this type of service. There is no cost to investigate and it is a good method of obtaining professional advice. A service bureau representative will examine a company's operation and advise whether mechanization appears practical. If desired, a study will be made and an estimate submitted which can be analyzed and compared with present costs. Even if the decision is against mechanization, some benefit is usually derived from a systems survey by an outside party.

End of Chapter Questions

1. What are the two types of services offered in the data processing field?
2. Why does the management of a company use the services of a consultant?
3. What is the primary consideration when arranging for a consultant?
4. Where can data processing consulting services be obtained? Which is the least objective?
5. What are some of the problems for which data processing consultants are employed?
6. How does a data processing consultant produce substantial net savings to his client? When might he fail to do this?
7. What is the most common pitfall in employing a management consultant to solve data processing problems?
8. What qualities does a well-qualified data processing consultant possess?
9. How can the qualifications of a data processing consultant be checked?
10. Why is a signed contract of little value?
11. Why isn't it advisable to pay a data processing consultant on the basis of savings realized from his effort?
12. Is it advisable to get estimates from several different firms? Why?
13. What consideration should be given to cost?
14. What information should be presented to a data processing consultant at the time he begins his study?
15. What are the consultant's responsibilities to the company's employes?
16. What are the chief characteristics of the professional approach?
17. What types of organizations perform data processing services?
18. Why is the term "service bureau" applied to data processing service organizations?
19. Why does a company have work performed by a service bureau?
20. When does the cost of using a service bureau become impractical?
21. What are the advantages of using a service bureau? Disadvantages?
22. When do companies with their own data processing department utilize the services of a service bureau?
23. Why is it advisable to have clear procedures in the data processing department?
24. What methods of charging for their services are used by service bureaus?
25. What are the advantages of "standardized" applications? Disadvantages?

CHAPTER 14

The Future — A Challenge

What does the future hold for punched card data processing?

It has been stated that someday the punched card will take its place in the Smithsonian Institution alongside the notched stick. This may be true. The ever-increasing volumes of data to be processed clamor for a faster method of recording, processing and reporting.

In the meantime the economies offered by the slower series of machines offered by equipment manufacturers will make possible a more universal use of punched card equipment. The low cost of this equipment makes it possible to bring the advantages of data processing into the smallest companies. The day is rapidly approaching when data processing will be universally accepted as an integral part of business organizations just as purchasing, sales, accounting and engineering are considered integral functions.

The significance of data processing in the business and industrial world has made great strides in the past decade, and there is every indication that it will be even more phenomenal in the next 10 years. An ever-increasing number of companies are elevating the data processing department to a staff position directly under the general manager or executive vice president. Many managers of data processing departments now have the title of vice president, especially in insurance and financial institutions. The elevation of this department permits it to service the whole company, not just a segment of it. It is an accepted fact that whenever this service department is placed under another function, that function will invariably get the greater share of the service. This is natural because each department tends to exploit the resources at its command and, of course, the data processing people are human – they are anxious to please their boss. This combination often results in marginal applications being mechanized while more fertile areas in other departments remain untouched. Elevation of the data processing department a high level in the company facilitates its utilization for the welfare of the whole company.

Another trend in the development of data processing is to centralize data processing functions within the data processing department. Exponents of this theory contend that the operations of processing data, whether manual, mechanical or automated, are a science in themselves and can be performed more efficiently by specialists in this field. The processing of data is extracted from the various departments of a company and assigned to the data processing department. This relieves production control people of paperwork and allows them to concentrate on production control, sales people can concentrate on selling, etc. The duplication of data processing functions that is so prevalent in most companies today would be abolished because the processing of data would all be performed within one department. Likewise, systems improvement would be easier because of the elimination of departmental barriers.

This theory certainly has a lot of merit and is slowly gaining in popularity. Many small companies have been operating this way on a limited scale for years, especially in the operation of payroll and accounting. Some larger companies are now experimenting in limited areas and it seems to be working satisfactorily. One of the problems encountered is the wide variety of talents that must be assembled under one manager to process the gauntlet of data that circulates through a company.

Unquestionably, the greatest advancement in the field of data processing as a whole and specifically in punched card data processing was the invention of the electronic computer. In fact this has been proclaimed by some to be one of the greatest achievements of the 20th century. It is certainly true that many of the scientific advancements of our century would have been extremely difficult and even impossible without the assistance of these machines.

There have been hundreds of books written about computers and it is not our intent to duplicate their efforts here. It is felt, however, that a brief introduction will be beneficial to the reader in making him conversant with this subject and assisting him to bridge the gap from mechanization to automation of data processing.

Introduction to IBM Data Processing Systems*

Technological advance in data processing is fast moving and far reaching. What is in the future? No one really knows. The undiscovered ways in which data processing systems can probably be used seem almost boundless. With each new application, data processing systems have demonstrated still newer ways in which they can be used to help man enlarge his capabilities and advance civilization a little farther.

In the opinion of some scholars, data processing is not just one more new industry or innovation, but a giant step forward in man's utilization of science and knowledge as a means to progress. Ultimately, some say, the changes that may come in the wake of these developments will prove more momentous than those of the industrial revolution. Infinitely more is ahead than is in the past.

Data Processing:

Data processing systems ordinarily consist of a combination of units including input, storage, processing and output devices (Figure 69). They are designed to handle business or scientific data at electronic speeds with self-

*Reprinted from *Introduction to IBM Data Processing Systems,* (c) 1960, by International Business Machines Corporation.

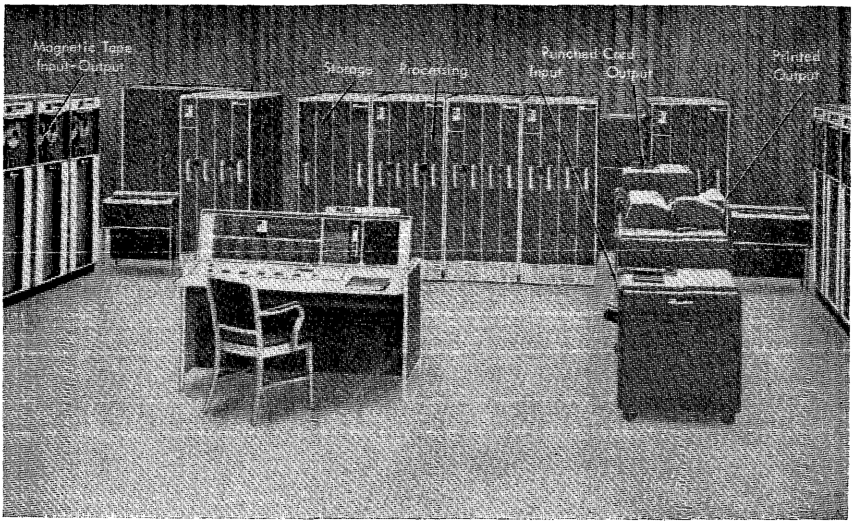


Figure 69—IBM 7090 Data Processing System

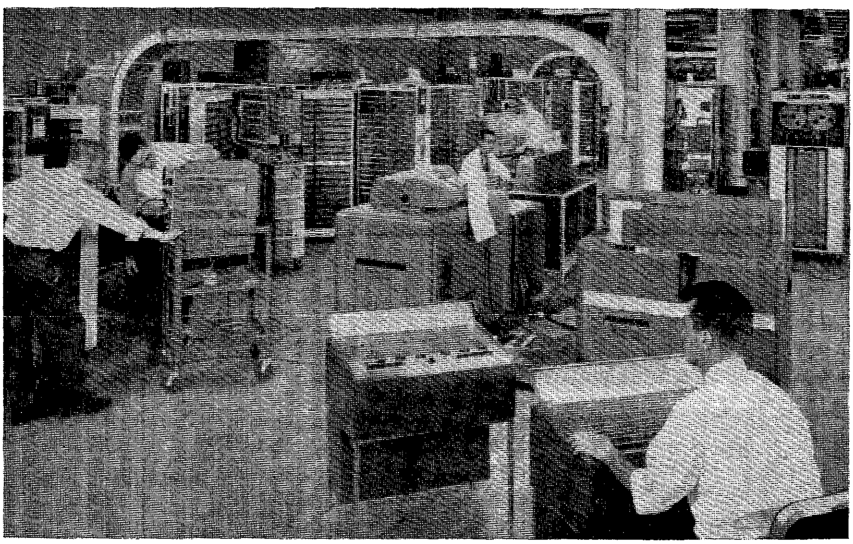


Figure 70—In-manufacture Test of Large-scale IBM Data Processing System

checking accuracy. The key element of these systems is the processing unit, a high-speed electronic computer.

These electronic data processing systems are a post-World War II innovation. Within two decades, they have progressed from experimental laboratory equipment to machines whose capabilities are exceeded only by the range of applications to which they can be put (Figure 70).

Machines are devised by men for a purpose. In the case of data processing machines, the purpose can be expressed simply: they offer man a means to increase his productivity.

They do this in two ways. First, they enable man to increase his output per hour and the quality of his output; this is true whether it be in research, production, problem solving, or the distribution of goods and services. Second, these machines increase productivity by encouraging careful and intelligent planning.

Data processing machines came into being primarily to meet the increasing need for information under increasingly complex conditions. High-speed data processing machines were not essential to the agricultural economy of a century ago. If they were, much greater effort would have gone into their development at a much earlier date. For while electronic techniques are new, the concept of automatic data processing is not; others perceived it more than a century ago.

As a manufacturing economy developed during the 19th century, it became clear that expanded markets would require mass production techniques. Machinery was introduced to increase productivity. It became possible to turn out more and more goods with less human effort. The work week shortened. Wages and profits went up. Benefits spread throughout the whole economy.

During the last quarter century, further changes have taken place. In many respects, they are as significant as the changeover from an agricultural to an industrial nation. Science has moved into the forefront of human activity. Research has grown to a multibillion dollar a year undertaking. New technology has provided a new impetus for corporate growth. Service industries have multiplied. Patterns of consumer spending have changed.

As these changes gained force, they manifested themselves in many ways. Informational needs greatly increased. Data assumed new importance. Clerical tasks multiplied. Paper-handling tasks appeared as if they would overwhelm all productive activities.

Today, more people are engaged in the handling, processing, and distribution of goods and services than are engaged in their production. One dollar out of every eight in wages and salaries in the United States now goes to a clerical worker. White-collar workers in manufacturing industries have increased by more than 50 percent in the past 10 years, while employment in all manufacturing has increased by only six percent.

Despite these fundamental changes in our economy, clerical mechanization has not kept pace with production line developments in the factory.

Great opportunities and challenges lie ahead. An example of what can be done is the development of magnetic character sensing for the banking industry. The estimated 10 billion checks that circulate annually in the United States present a staggering task in data handling for banks. Each check drawn on a bank must be handled at least six times before it is cancelled and returned. Even when business machines were introduced to handle part of this chore, operators were needed to transfer data from the checks to a form in which the data could be used by the machines.

Magnetic character sensing, developed by computer manufacturers in co-operation with the American Bankers Association (ABA), permits data to

Figure 71—Magnetic Character Sensing

be read directly by both man and machine (Figure 71). By agreement among computer manufacturers, check printers, and the ABA, banking documents such as checks, deposit slips, and debit and credit memos can be printed in magnetic ink. Printed information about the bank of origin, depositor's account number and other essential data can be read directly by the machine. Only the specific amount of each check or deposit slip need be recorded on the document in magnetic print. And this need be done only once by an operator to process the document through its whole routine.

In addition to the growing need for mechanization of clerical routines and management procedures, there is the tremendously expanded need for data processing to match the new rate of technological growth and scientific research. The demands for information are enormous. More and more, data processing systems are depended on for information to run enterprises, administer institutions, direct research and plan endeavors.

Regardless of the product or problem, the nature of the enterprise or institution, wherever there is need for information upon which human judgments can be based, there may also exist a need for a data processing machine.

The Growth of IBM Data Processing:

Although data processing equipment is a tool of astonishing versatility, the automatic processing of data is so recent that only 30 years are needed to trace its biggest period of growth.

Punched cards were introduced during the census of 1890, but the data processing industry, as recently as 1930, amounted to little more than a fledgling, although a lively one.

Three significant achievements appeared in the late 1920's and early 1930's.

The first was a punched card that provided 80 columns of information – almost twice the capacity of the older 45-column cards. The second was the automatic multiplier; previous machines had been able only to add or subtract. The third was the alphabetic accounting machine. Modest though these improvements might seem in the light of current technology, they represented substantial advances in the speed, versatility, and usefulness of business machine systems.

Most of the development in the middle 1930's came in punched card equipment and in key driven accounting machine systems. In the postwar years, long after electronics had profoundly changed the industry, these electromechanical developments continued and new devices appeared from year to year. Far from side-tracking electromechanical developments, the new computers gave fresh impetus to advances in this field.

For example, before the appearance of electronic data processing machines, it was thought that 150 lines per minute was maximum for a printer. Today, many electromechanical printers print 500 lines per minute; some go as high as 1,000.

World War II caused a swift change of pace in data processing developments. Much of the momentum came from the urgent demands of science which was suddenly put to work on an unprecedented scale developing new weapons. In aircraft design and ordance development, new and prodigious requirements for data were encountered. And as work got underway on the atomic bomb, scientists found themselves faced with new dimensions in calculation.

Both here and abroad, the first two large scale computers were developed in university laboratories. The earliest, the ENIAC, came from the University of Pennsylvania; Europe's first, the EDSAC, came from the laboratories of Cambridge University in England.

In these machines, the switching and control functions, once entrusted to relays, were handled by vacuum tubes. Thus, the relatively slow movements of switches in electromechanical computers were replaced by the swift motion of electrons. By this changeover, it became possible to increase the speed of calculation and perform computations 1,000 times as fast as before.

Almost concurrently with the use of electronics came another major development that was to widen the capabilities of data processing systems and expand their opportunities for application. This advance is embodied in what is called a stored program computer. At the start, machine instructions were programed on interchangeable control panels, cards, or paper tapes. Detailed instructions had to be wired in or read into the machine as the work progressed. Data put into the computer were processed according to the instructions contained in these preset devices. Only in a limited way could the computer depart from the fixed sequence of its program.

It soon became apparent that these programing techniques inhibited the performance of the computer. To give the computer greater latitude in working problems without operator assistance, scientists proposed that the computer store its program in a high-speed internal memory or storage unit. Thus, it would have immediate access to instructions as rapidly as it called for them.

With an internal storage system, the computer could process a program in much the same way that it processed data. It could even be made to modify its own instructions as dictated by developing stages of work.

The earliest computer to incorporate this feature was completed in 1948. Subsequent computers extended the principle until it became possible for a computer to generate a considerable part of its own instructions.

Because the computer is capable of making simple decisions, and because it is capable of modifying instructions, the user is relieved of a vast amount of costly and repetitive programing.

The early 1950's saw the introduction of medium and large scale data processing systems, specifically designed to take over the burdensome clerical chores that beset so many growing companies.

Though essentially similar to previous computers in the way they processed data, these new business systems differed substantially in various parts of their make-up. In scientific research, most problems call for relatively small numbers of items to be subjected to intensive machine processing. In business operations, the reverse is more often true. Here the need is for machines that accommodate vast numbers of items while the processing, by comparison, is ordinarily quite simple.

Modifications in these new business systems were addressed to the twin problems of input and output.

Early computers had used punched cards and paper tapes for the input of information. Now a method was perfected for storing information as magnetized spots on magnetic tape. This new technique provided input speed 50 to 75 times that of cards. It brought improvement in input, output, and storage.

After the Korean War, man's need always seemed to be one jump ahead of the computer's ability to handle the logical and arithmetic labors of his reasoning. The demand quickened especially in such fields as nuclear physics and space technology where work on the H-bomb and ballistic missiles presented problems that put a severe strain on the capacities of existing machines. Still more speed was needed.

A substitute for earlier storage devices appeared in the early 1950's — the magnetic core. A magnetic core is a small ring of ferromagnetic material. When strung on a complex of fine wires (Figure 72), these cores can be made up into a high-speed internal storage system. An array of cores — some magnetized in one direction, some in the other — represents items of information. Items in a core storage can be located and made ready for processing in a few millionths of a second.

Almost at the same time, other engineers perfected magnetic drum storage. Access time on the drum was substantially slower than that on the core system, but storage capacity was substantially increased. And while access time on the drum was slower than that of the core, it was faster than that of magnetic tape.

Other conditions peculiar to business led to still more developments. A major one is a system that overcomes a problem — batching — often encountered in data processing. For example, when magnetic tapes are used to store information in a computer, the user must accumulate information in batches before putting it on tape. Otherwise, the computer would be prohibitively costly and time consuming. But when this limitation is applied to business practice, it means that each item of information can be only as current as the batch in which it is bundled for delivery to the computer. In ordinary operations, hours and sometimes days may elapse between batches.

The limitation is compounded when the user calls for the retrieval of a piece of information. The computer is forced to search through a long reel of information for the piece. Access is slow; time is lost.

Batching and searching requirements frequently present serious drawbacks, even in scientific work. In business, the difficulty becomes much more acute, especially in accounting procedures. Here is a requirement that can be met only by in-line data processing.

In-line data processing came with the development in the middle 1950's of random access systems, such as the IBM RAMAC® 305. A stack of magnetic disks in the RAMAC (Figure 73) stores up to 10 million digits of information. The discs rotate at 1,200 revolutions per minute past access arms that move quickly to any point of any disc to deposit or retrieve data.

Meanwhile, continuing developments in pulse electronics and solid state physics led to still newer and better components. There are practical limits to the size and capacity of a machine operated on vacuum tubes. Tubes are bulky; they demand considerable power; they produce heat and create air conditioning problems.

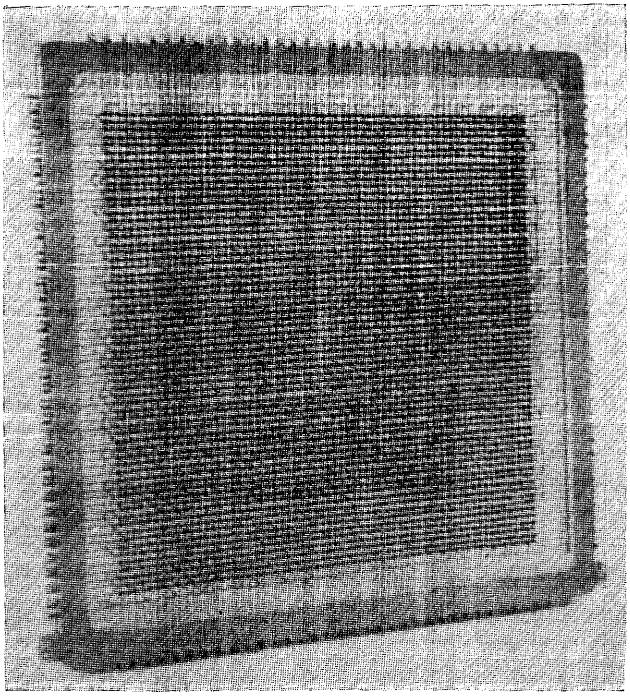


Figure 72—Magnetic Core Plan

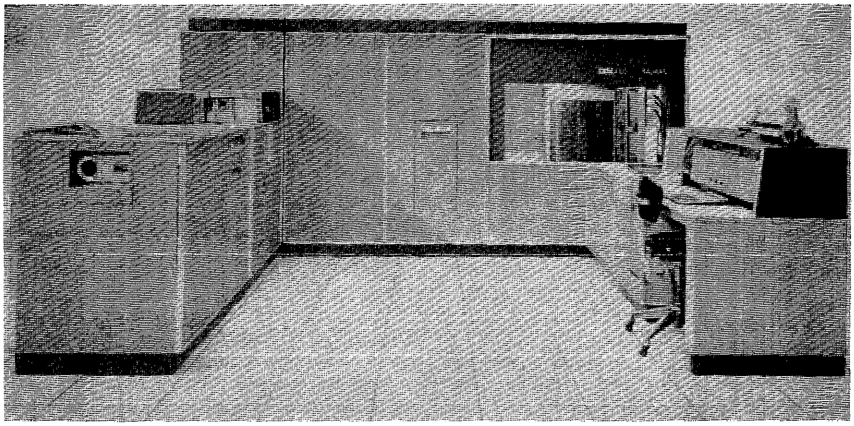


Figure 73—IBM RAMAC® 305

In some switching functions, the vacuum tube was replaced by a smaller semi-conductor diode that has the advantage of demanding less power. A further advance came when tiny transistors were introduced in place of the vacuum tubes in the computer. Not only can these transistors be packed into smaller units, but they have greater reliability. The changeover to transistors is now accomplished.

Research scientists have already advanced to still further stages in design. Some are studying the use of microwave phenomena as a medium for performing computer logic. Others are studying the behavior of materials and electrons at extremely low temperatures (cryogenics).

As always, the objective is to develop a better, more versatile, more useful computer – one that will work faster, store more information, demand fewer instructions, require less power, and occupy less space.

The Future:

Future computers will inevitably introduce changes in the way we work, in the way we learn, and even in the way we provide for our armed defense. Research even now points the way to some changes which may be nearer at hand than we suspect.

For the moment, computer users are handicapped in communicating with these machines. Instructions must be coded laboriously into machine language. Instructions conveyed in a few spoken words to a human being may require hundreds of logical movements in a computer – and this is a problem because the computer must be instructed in each movement.

The new science of automatic programing seeks to make programing easier and more manageable. The goal is to build and program computers so that they accept instructions in everyday English. Ultimately, computer scientists hope to develop machines that read ordinary printed matter and respond to spoken words.

Soon there will be a common national – or international – machine language for computers. With a common language, machines will be designed to operate by the same instructional language. A program generated for one machine can then be used by any other; the difficult task of creating a program need be tackled only once. Greater cooperation will be possible among users, and progress will be speeded in the science of computer use.

Already there is one significant step forward in the case of machines that read. Magnetic character sensing, as previously indicated, utilizes numbers and letters printed in a way that can be read by machines as well as man.

Another development points to further mechanization in engineering design work. Computers will eventually assume routine engineering tasks, freeing engineers for more productive work. Not too far in the future engineers should be able to call on computers for the design of highly complex systems. All that will be required is a statement of the engineering problem in mathematical equations. The greatest difficulty in achieving this technique is that of stating design criteria unequivocally and in a form that can be programed into a computer.

Computers, by 1980, will probably be quite different from today's. Storage and processing units as powerful as today's largest may be the size of a television set, perhaps smaller. Already there are systems where a single computer serves a number of inquiry stations. Such systems can be expanded to produce larger networks and integrate widely scattered business operations. Beyond that, it may be possible to query the computer merely by talking into a microphone. Eventually, the computers may even be able to answer by voice.

Among the problems that challenge systems engineers is the paperwork that gluts so many administrative channels. Information, they say, can be communicated and processed more accurately and cheaply by network-integrated data processing systems. Some even contemplate a time when paper bank checks will disappear in many transactions.

Instead of handing an employe his paycheck, a paymaster in 1985 may simply instruct a computer, housed in a bank, to credit the employe's earnings to his bank account.

At this point, a chain reaction begins. The company's account is debited by the amount of the paycheck. This information goes to the company's accounting machines for processing and storage. Now, assume that the employe wants to buy something that costs more than he wishes to pay for in cash. The salesclerk asks for identification, a card that identifies the customer to the salesclerk and to the computer. The clerk instructs the bank computer to debit the customer's account by the amount of his purchases. The same amount is credited automatically to the store's account. Information on the sale goes to the store's computer for processing with sales, financial, and inventory data. Periodically, the customer gets a statement on his deposits and computer transactions.

Still other scientists have turned their talents to developing what they prophetically call information centers.

The science of information retrieval by machine is under rigorous study. As our society grows, the information it generates will increase; the task of finding what one is looking for will become increasingly difficult and time consuming.

Information centers of the future would collect, catalog, and retrieve information electronically by machine. Queried about a subject, a center could provide specific source references, cross-references and subdivisions of subject matter. Or, asked a question, it could give a direct answer.

Such a development would mean immediate access to more information than was ever before instantly available. A man might never have the ability to know all that he might want to know, but he would have the means of finding it as he had need.

Everywhere the pace of technological advances has quickened. During the next 25 years, man will journey into space; he may reach the nearest planets. He will look about him on earth. He will pose questions and search for knowledge. He will make discoveries not yet imagined.

In such a world and at such a time, man will have greater and more pressing need for business machines than ever before. These needs, in turn will dictate machine advances.

The Data Processing System

Data processing is a series of planned actions and operations upon information to achieve a desired result. The procedures and devices used constitute a data processing system (Figure 75). The devices may vary; all operations may be done by machine, or the devices may be only pencil and paper. The procedures, however, remain basically the same.

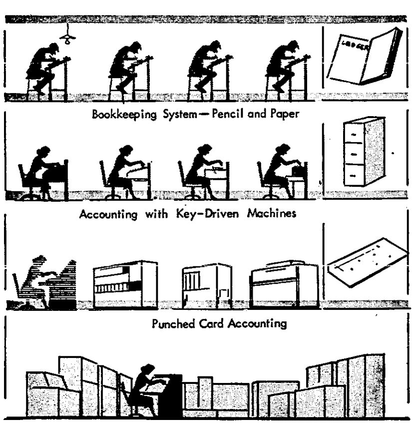


Figure 75—Data Processing Systems

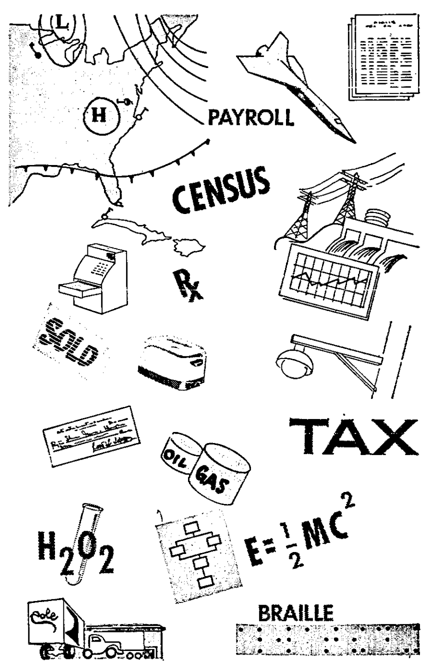


Figure 76—Sources of Data

There are many types of data processing systems. These systems vary in size, complexity, speed, cost and application. But, regardless of the information to be processed or the equipment used, all data processing involves at least three basic considerations:

1. The source data or *input* entering the system.
2. The orderly, planned *processing* within the system.
3. The end result or *output* from the system.

Input may consist of any type of data: commercial, scientific, statistical, engineering and so on (Figure 76).

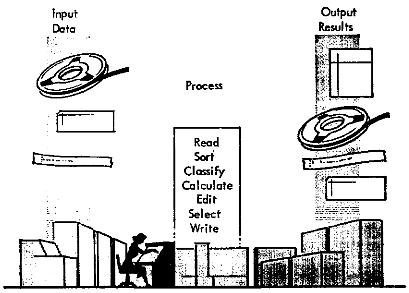


Figure 77—Data Processing by Computer

Processing is carried out in a pre-established sequence of instructions that are followed automatically by the computer (Figure 77). The plan of processing is always of human orgin. By calculation, sorting, analysis or other operations, the computer arrives at a result that may be used for further processing or recorded as reports or files of data.

Functional Units:

All data processing systems can be divided into four types of functional units: input devices, output devices, storage, and central processing unit.

Input and Output Devices:

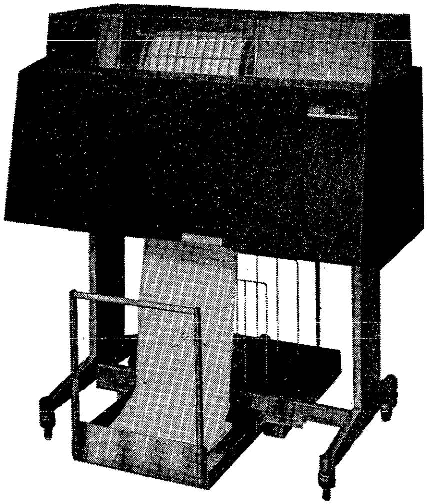
The data processing system requires, as a necessary part of its information-handling ability, features that can enter data into the system and record data from the system. These functions are performed by input-output devices (Figure 78) linked directly to the system.

Input devices read or sense coded data that are recorded on a prescribed medium and make this information available to the computer. Data for input are recorded in punched cards and paper tape as punched holes; on magnetic tape, as magnetized spots along the length of the tape; and on paper documents as characters printed in magnetic ink.

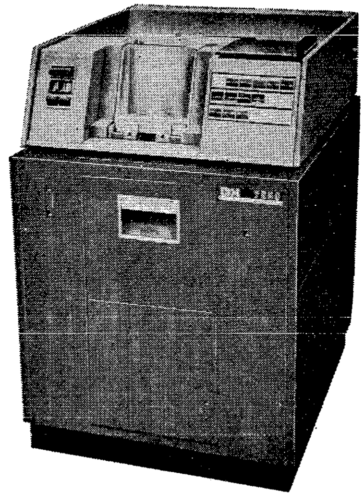
The method of recording data for machine use and the characteristics of each medium are discussed later.

Output devices record or write information from the computer on IBM cards, paper tape, magnetic tape, or as printed information on paper. The number and type of input-output devices connected directly to the computer depend on the design of the system and its application.

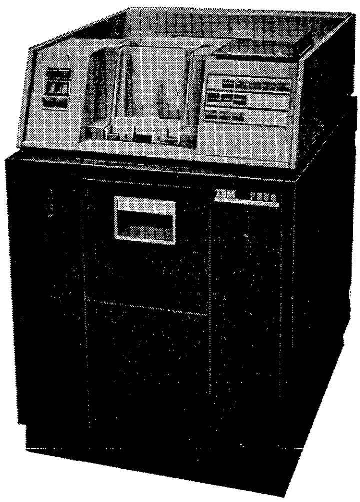
Special data conversion operations are associated with all computer systems to transcribe information recorded on one medium to another. For example, information on punched cards can be transcribed automatically to magnetic



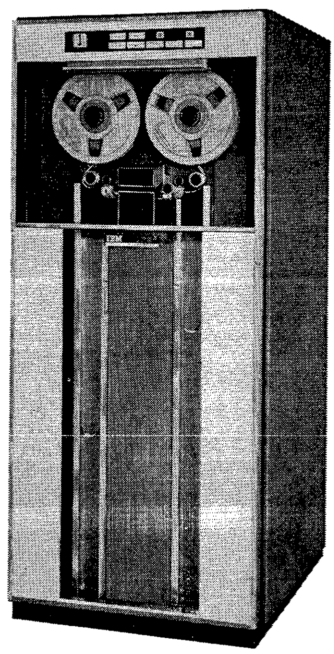
IBM 1403 Printer



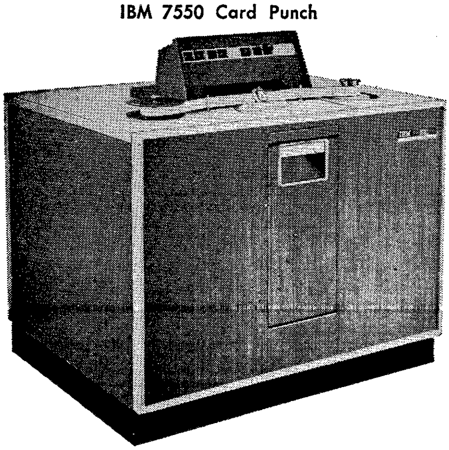
IBM 7500 Card Reader



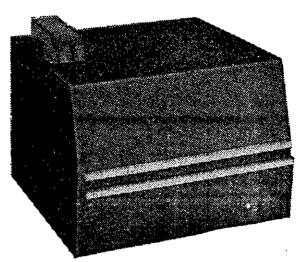
IBM 7550 Card Punch



IBM 729 IV Magnetic Tape Unit



IBM 382 Paper Tape Reader



IBM 962 Tape Punch

Figure 78—Input-Output Devices *(Courtesy of International Business Machines Corporation)* tape. This operation may take place on-line, utilizing the computer, or off-line, utilizing input-output devices independently.

Storage:

Storage is somewhat like an electronic filing cabinet, completely indexed and almost instantaneously accessible to the computer.

All data must be placed in storage before they can be processed by the computer. Information is read into storage by an input unit and is then available for internal processing. Each location, position, or section of storage is numbered so that the stored data can be readily located by the computer as needed.

The computer may rearrange 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 from storage, 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, storage 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.

Central Processing Unit:

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

1. The arithmetic-logical unit.
2. The control section.

The arithmetic-logical unit performs such operations as addition, subtraction, multiplication, division, shifting, transferring, comparing and storing. It also has logical ability – the ability to test various conditions encountered during processing and to take action called for by the result.

The control section directs and coordinates the entire computer system as a single multi-purpose machine. These functions involve controlling the input-output units and the arithmetic-logical 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.

For example, the computer may have the operation of multiplication built into its circuits in much the same way that the ability to add is built into a simple desk adding machine. There must be some means of directing the computer to perform multiplication just as the adding machine is directed by depressing keys. There must also be a way to instruct the computer where in storage it can find the factors to multiply.

Further, the comparatively simple operation of multiplication implies other activity that must precede and follow the calculation. The multiplicand and multiplier must be read into storage by an input device. This device must previously have had access to the record or records from which these factors are to be supplied. Once the calculation is performed, the product must be returned to storage at a specified location, from which it may be written out by an output device.

Any calculation, therefore, involves reading, locating factors in storage, perhaps adjusting the result, returning the result to storage, and writing out the completed result. Even the simplest portion of a procedure involves a number of planned steps that must be spelled out to the computer if the procedure is to be accomplished.

An entire procedure is composed of these individual steps grouped in a sequence that directs the computer to produce a desired result. 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.

The possible variations of a stored program provides the data processing system with almost unlimited flexibility. One computer can be applied to a great number of different procedures by simply reading in or loading 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.

The stored program is accessible to the machine, providing the computer with the ability to alter its own program in response to conditions encountered during an operation. Consequently, the machine exercises a limited degree of judgment within the framework of the possible operations that can be performed.

Console:

The console provides external control of the data processing system. Keys turn power on or off, start or stop operation and control various devices in the system. Data may be entered directly by manually depressing keys. Lights are provided so that data in the system may be visually displayed. The system may also be operated from the console to trace or check out a procedure one step at a time.

On some systems, a console typewriter provides limited output. The typewriter may print messages, signaling the end of processing or an error condition. It may also print totals or other information that enable the operator to monitor and supervise operation.

Data Representation

Symbols convey information; the symbol itself is not the information but merely represents it. The printed characters are symbols and, when understood, convey the writer's meaning.

The meaning of symbols is one of convention. A symbol may convey one meaning to some persons, a different meaning to others, and no meaning to those who do not know its significance.

Presenting data to the computer system is similar in many ways to communicating with another person by letter. The intelligence to be conveyed must be reduced to a set of symbols. In the English language, these are the familiar letters of the alphabet, numbers, and punctuation. The symbols are recorded on paper in a prescribed sequence and transported to another person who reads and interprets them.

Similarly, communication with the computer system requires that data be reduced to a set of symbols that can be read and interpreted by data processing machines. The symbols differ from those commonly used by people, because the information to be represented must conform to the design and operation of the machine. The choice of these symbols and their meaning is a matter of convention on the part of the designers. The important fact is that information can be represented by symbols, which become a language for the communication between people and machines.

Information to be used with the computer systems can be recorded on four media: punched cards, paper tape, magnetic tape and magnetic ink characters. Data are represented on the punched card by the presence or absence of small rectangular holes in specific locations of the card. In a similar manner, small circular holes along a paper tape represent data. On magnetic tape, the symbols are small magnetized areas, called spots or bits, arranged in specific patterns. Magnetic ink characters – the arabic numerals 0 to 9 and four special characters – are printed on paper. The shape of the characters and the magnetic properties of the ink permit the printed data to be read by both man and machine.

Each medium requires a code or specific arrangement of symbols to represent data. These codes are described later in this section.

An input device of the computer system is a machine designed to sense or read information from one of the recording media. In the reading process, recorded data are converted to or symbolized in electronic form; the data then can be used by the machine to perform data processing operations. An output device is a machine that receives information from the computer system and records the information on either punched cards, paper tape, magnetic tape or printed forms.

All input-output devices cannot be used directly with all computer systems. Data recorded on one medium, however, can be transcribed to another medium for use with a different system. For example, data on punched cards or paper tape can be transcribed onto magnetic tape. Conversely, data on magnetic tape can be converted to cards, paper tape or printed reports.

As there is communication between people and machines, there is also

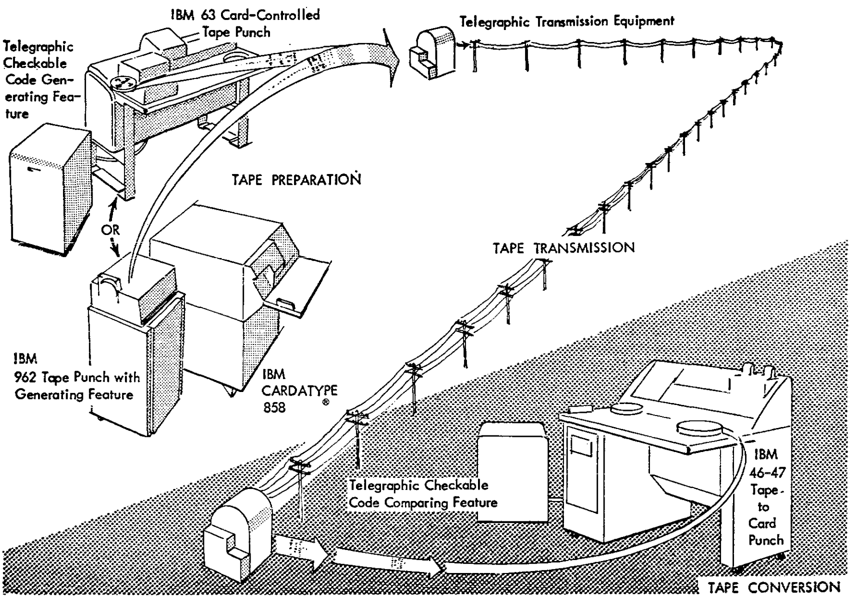


Figure 79—Machine-to-Machine Communication

communication from one machine to another (Figure 79). This intercommunication may be the direct exchange of data, in electronic form, over wires, cables or radio waves; or, recorded output of one machine or system may be used as input to another machine or system.

Computer Data Representation:

Not only must there be a method of representing data on punched cards, paper tape, magnetic tape, and in magnetic ink characters, but there must also be a method of representing data within a machine.

In the computer, data are represented by many electronic components: vacuum tubes, transistors, magnetic cores, wires and so on. The storage and flow of data through these devices are represented as electronic signals or indications. The presence or absence of these signals in specific circuitry is the method of representing data, much as the presence or absence of holes in an punched card represents data.

Binary Mode:

Computers function in what is called a binary mode. This term simply means that the computer components can indicate only two possible states or conditions. For example, the ordinary light bulb operates in a binary mode: it is either on, producing light; or it is off, not producing light. The presence or absence of light indicates whether the bulb is on or off. Likewise, within the computer, vacuum tubes or transistors are maintained either conducting or nonconducting; magnetic materials are magnetized in one direction or in an opposite direction; and specific voltage potentials are present or absent (Figure

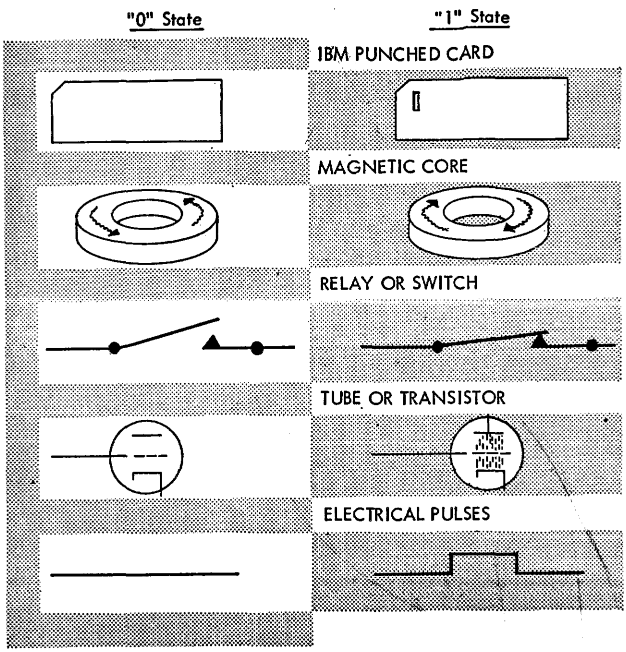


Figure 80—Binary Indicators

80). The binary modes of operation of the components are signals to the computer, as the presence or absence of light from an electric light bulb is to a person.

Representing data within the computer is accomplished by assigning or associating a specific value to a binary indication or group of binary indications. For example, a device to represent decimal values could be designed with four electric light bulbs and switches to turn each bulb on or off (Figure 81).

The bulbs are assigned arbitrary decimal values of 1, 2, 4, and 8. When a light is on, it represents the decimal value associated with it. When a light is off, the decimal value is not considered. With such an arrangement, the single decimal value represented by the four bulbs will be the numeric sum indicated by the lighted bulbs.

Decimal values 0 through 15 can be represented. The numeric value 0 is represented by all lights off; the value 15, by all lights on; 9, by having the 8 and 1 lights on and the 4 and 2 lights off; 5, with the 1 and 4 lights on and the 8 and 2 lights off; and so on.

The value assigned to each bulb or indicator in the example could have been something other than the values used. This change would involve assigning new values and determining a scheme of operation. In a computer, the values assigned to a specific number of binary indications become the code or language for representing data.

Because binary indications represent data within a computer, a binary method of notation is used to illustrate these indications. The binary system of notations uses only two symbols, zero (0) or one (1), to represent all quantities. In any one position of binary notation, the 0 represents the absence of a related or assigned value and the 1 represents the presence of a related or assigned value. For example, to illustrate the indications of the light bulb in Figure 81, the following binary notation would be used: 0101.

The binary notations 0 and 1 are commonly called bits. The 0 bit is described as no bit and the 1 bit is described as a bit. Although 0 or 1 bits are necessary to illustrate the condition of a binary indication or a group of binary indications, the 1 bits are the bits generally referred to. For example, the binary notation 0101 of Figure 81 would be described as having a bit in the 1 and 4 bit positions. The assumption is that there are no bits (0 bits) in the 2 and 8 bit positions.

Binary Number System:

In some computers, the values associated with the binary notation are related directly to the binary number system. This system is not used in all computers, but the method of representing values using this numbering system is useful in learning the general concept of data representation.

The common decimal number system uses ten symbols or digits to represent all quantities, and the place value of the digits signifies units, tens, hundreds, thousands, and so on. The binary or base-two number system uses only two symbols or digits: 0 and 1. The position value of the bit symbols (0 or 1) is based on the progression of powers of 2; the units position of a

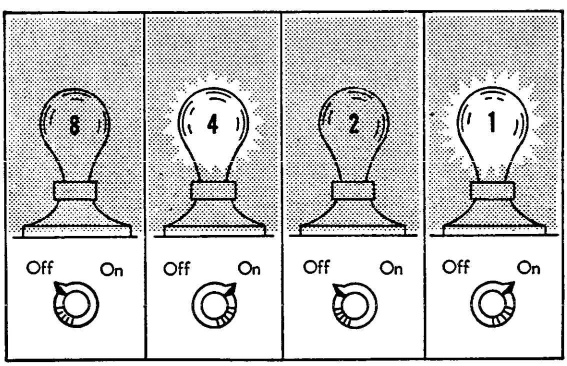


Figure 81—Representing Decimal Data

8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1

Figure 82—Place Value of Binary Number

Decimal Value	Place Value 16	8	4	2	1
0	0	0	0	0	0
1	0	0	0	0	1
2	0	0	0	1	0
3	0	0	0	1	1
4	0	0	1	0	0
5	0	0	1	0	1
6	0	0	1	1	0
7	0	0	1	1	1
8	0	1	0	0	0
9	0	1	0	0	1
10	0	1	0	1	0
11	0	1	0	1	1
12	0	1	1	0	0
13	0	1	1	0	1
14	0	1	1	1	0
15	0	1	1	1	1
16	1	0	0	0	0

Figure 83—Binary Representation of Decimal Values 0-16

Decimal Digits	2	6	5	4	9	8
Binary Value	0 0 1 0	0 1 1 0	0 1 0 1	0 1 0 0	1 0 0 1	1 0 0 0
Place Value	8 4 2 1	8 4 2 1	8 4 2 1	8 4 2 1	8 4 2 1	8 4 2 1

Figure 84—Binary Coded Decimal

binary number has the value of 1; the next position, a value of 2; the next, 4; the next, 8; the next, 16; and so on (Figure 82).

In pure binary notation, the binary digits or bits indicate whether the corresponding power of 2 is absent or present in each position of the number. The 1 bit represents the presence of the value and the 0 bit represents the absence of the value. The place value of the digits does not signify units, tens, hundreds or thousands, as in the decimal system; instead, the place value signifies units, twos, fours, eights, sixteens and so on. Using this system the quantity 12, for example, is expressed with the symbols 1100, meaning $(1 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (0 \times 2^0)$, or $(1 \times 8) + (1 \times 4) + (0 \times 2) + 0 \times 1)$.

Figure 83 shows the binary representation of the decimal values 0 through 16. Note that the decimal digits 0 through 9 are expressed by four binary digits. The system of coding or expressing decimal digits in an equivalent binary value is known as binary coded decimal (BCD). For example, the decimal value 265,498 would appear in binary coded decimal form as shown in Figure 84.

Computer Codes

The method or system used to represent (symbolize) data is known as a code. In the computer, the code relates data to a fixed number of binary indications (symbols). For example, a code used to represent numeric and alphabetic characters may use seven positions of binary indication. By the proper arrangement of the binary indications (bit, no bit), all characters can be represented by a different combination of bits.

Some computer codes in use are: seven-bit alphameric code, two-out-of-five fixed count code, bi-quinary code, six-bit numeric code, and the binary system.

Code Checking:

Most computer codes are self-checking; that is, they are provided with a built-in method of checking the validity of the coded information. This code checking occurs automatically within the machine as the data processing operations are carried out. The method of validity checking is a part of the design of the code.

In some codes, each unit or character of data is represented by a specific number of bit positions which must always contain an even number of 1 bits. Different characters are made up of different combinations of 1 bits, but the number of 1 bits in any valid character is always even. With this code system, a character with an odd number of 1 bits is detected and an error is indicated. Likewise, a code may be used in which all characters must have an odd number of 1 bits; an error is indicated when characters with an even number of 1 bits are detected.

This type of checking is known as a parity check. Codes which use an even number of 1 bits are said to have even parity. Codes which use an odd number of bits are said to have odd parity.

In other codes, the number of 1 bits present in each unit of data is fixed. For example, a code may use five bit positions to code all digits but only two 1

Check Bit	Zone Bits		Numeric Bits			
C	B	A	8	4	2	1

Figure 85—Bit Positions, Seven-Bit Alphameric Code

Decimal Digit	Place Value 8	4	2	1
0	1	0	1	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

Figure 86—Numeric Bit Configurations Decimal Digits 0-9 Seven-Bit Alphameric Code

	CHAR.	C BA 8421	CHAR.	C BA 8421	CHAR.	C BA 8421	Storage Mark and Drum Mark	
	&	0 11 0000	-	1 10 0000	Blank	1 01 0000	0 0 00 0000	
ALPHABETIC	A	1 11 0001	J	0 10 0001	/	0 01 0001	CH. C BA 8421 1 1 00 0001	NUMERICAL
	B	1 11 0010	K	0 10 0010	S	0 01 0010	2 1 00 0010	
	C	0 11 0011	L	1 10 0011	T	1 01 0011	3 0 00 0011	
	D	1 11 0100	M	0 10 0100	U	0 01 0100	4 1 00 0100	
	E	0 11 0101	N	1 10 0101	V	1 01 0101	5 0 00 0101	
	F	0 11 0110	O	1 10 0110	W	1 01 0110	6 0 00 0110	
	G	1 11 0111	P	0 10 0111	X	0 01 0111	7 1 00 0111	
	H	1 11 1000	Q	0 10 1000	Y	0 01 1000	8 1 00 1000	
	I	0 11 1001.	R	1 10 1001	Z	1 01 1001	9 0 00 1001	
	Plus Zero	0 0 11 1010	Minus Zero	0 1 10 1010	Record Mark	1 01 1010	Numerical Zero 0 0 00 1010	
SPECIAL CHAR	.	1 11 1011	$	0 10 1011	,	0 01 1011	# 1 00 1011	
	⌑	0 11 1100	*	1 10 1100	%	1 01 1100	@ 0 00 1100	
	Group Mark	0 11 1111					Tape Mark 0 00 1111	

Decimal Digit	Place Value 0	1	2	3	6
0	0	1	1	0	0
1	1	1	0	0	0
2	1	0	1	0	0
3	1	0	0	1	0
4	0	1	0	1	0
5	0	0	1	1	0
6	1	0	0	0	1
7	0	1	0	0	1
8	0	0	1	0	1
9	0	0	0	1	1

Figure 88—Two-Out-of-Five Code

Figure 87—IBM 705 Character Code Chart

bits will be present in each digit. Digits having more or fewer than two 1 bits cause an error indication. This system of checking is known as a fixed count check.

Seven-Bit Alphameric Code (Binary Coded Decimal):

In this code, all characters – numeric, alphabetic and special – are represented (coded) using seven positions of binary notation. These positions are divided into three groups: one check position, two zone positions and four numeric positions (Figure 85).

The four numeric positions are assigned decimal values of 8, 4, 2, and 1 and represent, in binary coded decimal form, the numeric digits 0 through 9 (Figure 86). Note that 0 is represented as 1010, actually the binary number for 10. The B and A zone bits are not present (00) when the numeric digits 0 through 9 are represented.

Combinations of zone and numeric bits represent alphabetic and special characters. The B and A bits provide for three possible bit combinations: 10, 01, and 11. Figure 87 shows the zone and numeric bit combinations used to represent numeric, alphabetic, and special characters in the IBM 705 Data Processing System. In other systems using this code, there may be special

One Digit					One Digit				
0	1	2	3	6	0	1	2	3	6
1	0	0	0	1	1	1	0	0	0

Figure 89—Letter A in Two-Out-of-Five Code

Decimal Digit	Binary Position		Quinary Position				
	0	5	0	1	2	3	4
0	1	0	1	0	0	0	0
1	1	0	0	1	0	0	0
2	1	0	0	0	1	0	0
3	1	0	0	0	0	1	0
4	1	0	0	0	0	0	1
5	0	1	1	0	0	0	0
6	0	1	0	1	0	0	0
7	0	1	0	0	1	0	0
8	0	1	0	0	0	1	0
9	0	1	0	0	0	0	1

Figure 90—Bi-quinary Code

One Digit							One Digit						
0	5	0	1	2	3	4	0	5	0	1	2	3	4
0	1	0	1	0	0	0	1	0	0	1	0	0	0

Figure 91—Letter A in Bi-quinary Code

characters not shown; these characters, however, follow the same scheme of bit arrangement.

The C position, known as the check bit, is used for code checking only. Because the seven-bit alphameric code is an even parity code, the number of bits used to represent a character must have an even number of bits or the character is considered invalid. The check is present in a character when the sum of the zone and numeric bits used to represent the character is odd. If the number of bits in a character is even without the C bit, the C bit is not used.

Two-Out-of-Five Fixed Count Code:

This code uses five positions of binary notation with the assigned values of 0, 1 2, 3, and 6. In the basic code, decimal values are represented by bits present in only two of the five bit positions (Figure 88). The total number of possible combinations is ten – one for each decimal digits. The digits 1 through 9 are each composed of two bits, the position value sum of which equals the number to be represented. Zero is designated by the 1-2 bit combination.

Alphabetic and special characters are represented as a two-digit number. For example, the letter A is equal to the coded decimal value of 61 and is composed of the two coded decimal digits of 6 and 1 (Figure 89).

Each digit that is moved in data processing operations is tested to assure that it has two bits, neither more nor less. This is a fixed count check.

Bi-quinary Code:

The bi-quinary code consists of seven positions of binary notation. Two positions, the binary positions, have assigned values of 0 and 5. The remaining positions, the quinary positions, have assigned values of 0, 1, 2, 3, and 4.

The digits 0 through 9 are coded by a combination of one binary bit and one quinary bit. The sum of the bit position values equals the number to be represented. Figure 90 illustrates the bit combinations used to code the digits 0 through 9.

Alphabetic and special characters are represented as two digits. For example, a letter A is equal to a decimal value of 61 and is composed of the coded decimal values, 6 and 1 (Figure 91).

Each digit that is moved in the various processing operations is tested to assure that it is composed of one binary bit and one quinary bit only.

Six-Bit Numeric Code:

In this code, six positions of binary notation are used. The positions are divided into three groups: one check bit, one flag bit, and four numeric bits with the assigned values of 8, 4, 2, and 1 (Figure 92). The decimal digits 0-9 are represented in binary coded decimal form, using the four numeric bit positions (Figure 93). Only bit combinations whose sum is 9 or less are used.

The F (flag) bit is used for special indications not related to the actual coding of the digits. For example, the presence or absence of a flag bit in the units digit of a numeric data field determines the sign (+ or –) of the field.

The C bit is used for parity checking. The six-bit numeric code is an odd parity code, so each digit must consist of an odd total number of bits, including C and F bits. The C bit is present only when an even total number of bits are in the numeric bit and F bit positions.

Alphabetic and special characters are represented as a special two-digit numeric value. For example, the letter A is equal to a decimal value of 41, and is composed of the coded decimal digit 4 and 1 (Figure 94).

Binary System:

Computers using this system of data representation are typified by the IBM 704, 709, and 7090 data processing systems.

For these systems, the basic unit of information is the word. A word consists of 36 consecutive bit positions of information which are interpreted as a unit, much as a character or a digit in other systems (Figure 95).

The bit positions within the word have a place significance related to the binary number system. That is, the place position of a bit in the word determines the value of the bit. In the binary number system, the decimal values

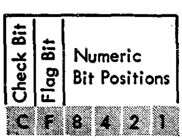


Figure 92—Bit Positions, Six-Bit Numeric Code

Decimal Digit	C	F	8	4	2	1
0	1	0	0	0	0	0
1	0	0	0	0	0	1
2	0	0	0	0	1	0
3	1	0	0	0	1	1
4	0	0	0	1	0	0
5	1	0	0	1	0	1
6	1	0	0	1	1	0
7	0	0	0	1	1	1
8	0	0	1	0	0	0
9	1	0	1	0	0	1

(Place Value: C F 8 4 2 1)

Figure 93—Six-Bit Numeric Code

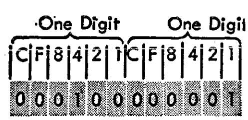


Figure 94—Letter A in Six-Bit Numeric Code

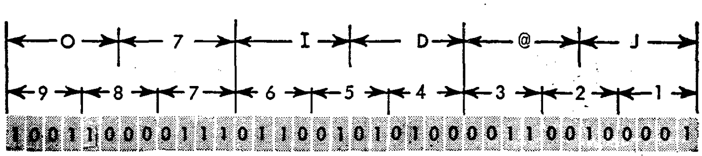


Figure 95—The Binary System

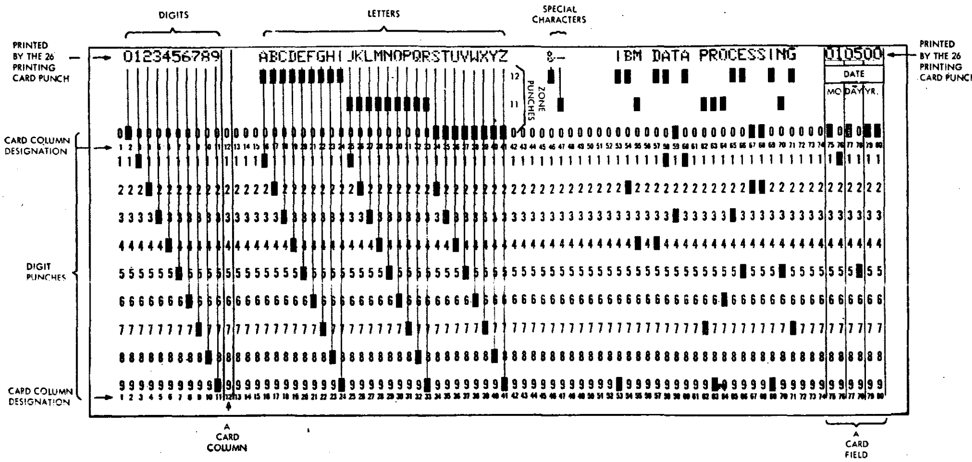


Figure 96—IBM Card—Standard Card Code

of the places (from right to left) are 0, 1, 2, 4, 8, 16, 32, 64, and so on (Figure 95).

Although the place values of the bits of a word are always that of the binary number system, they can be interpreted or processed in such a way as to represent other than a binary number. For example, a 36-bit word (Figure 95) can be interpreted as one 36-place binary number, as a 9-digit decimal number, as six alphameric characters, or as any predetermined representation established by the programmer.

Data Recording Media

Punched Cards:

The punched card is one of the most successful media for communication with machines. Information is recorded as small rectangular holes punched in specific locations in a standard size card (Figure 96). Information, represented (coded) by the presence or absence of holes in specific locations, can be read or sensed as the card is moved through a card reading machine.

Reading or sensing the card is basically a process of automatically converting data recorded as holes to an electronic language and entering the data into the machine. Cards are used both for entering data into a machine and for recording or punching information from a machine. Thus, the punched card is not only a means of transferring data from some original source to a machine, but also is a common medium for the exchange of information between machines.

Punched cards provide 80 vertical columns with twelve punching positions in each column. The twelve punching positions form twelve horizontal rows across the card. One or more punches in a single column represents a character. The number of columns used depends on the amount of data to be represented.

The card is often called a unit record because the data are restricted to the 80 columns and the card is read or punched as a unit of information. The actual data on the card, however, may consist of part of a record, one record, or more than one record. If more than 80 columns are needed to contain the data of a record, two or more cards may be used. Continuity between the cards of one record may be established by punching identifying information in designated columns of each card.

Information punched in cards is read or interpreted by a machine called a card reader and is recorded (punched) in a card by a machine called a card punch. Data are transcribed from source documents to punched cards by manually operated card punch machines.

Punched Card Code:

The standard punched card code uses the twelve possible punching positions of a vertical column on a card to represent a numeric, alphabetic or special character (Figure 96). The 12 punching positions are divided into two areas: numeric and zone. The first nine punching positions from the bottom edge of the card are the numeric punching positions and have an assigned value of 9, 8, 7, 6, 5, 4, 3, 2, and 1, respectively. The remaining three positions 0, 11, and 12 are the zone positions. (The 0 position is considered to be both a numeric and zone position).

The numeric characters 0 through 9 are represented by a single punch in a vertical column. For example, 0 is represented by a single punch in the 0 zone position of the column.

The alphabetic characters are represented by two punches in a single vertical column: one numeric punch and one zone punch. The alphabetic characters A through I use the 12 zone punch and a numeric punch 1 through 9, respectively. The alphabetic characters J through R use the 11 zone punch and a numeric punch 1 through 9, respectively. The alphabetic characters S through Z use the 0 zone punch and a numeric punch 2 through 9, respectively.

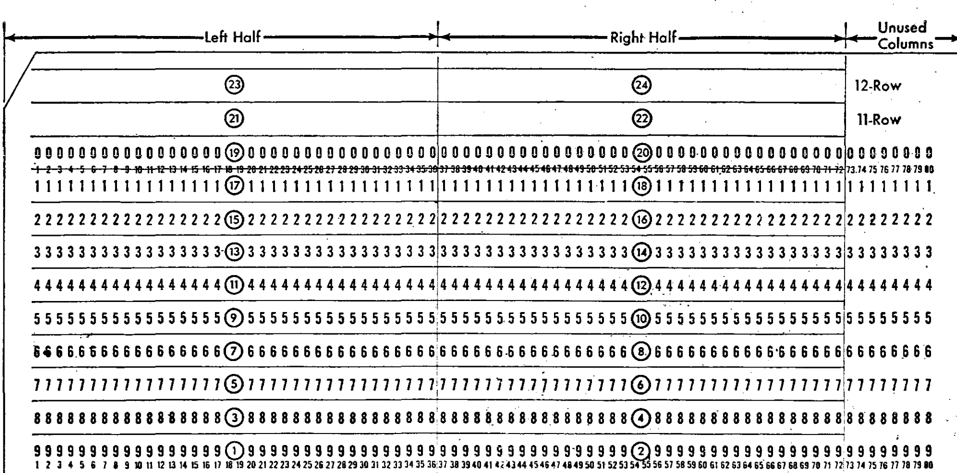


Figure 97—IBM Card—Row Binary

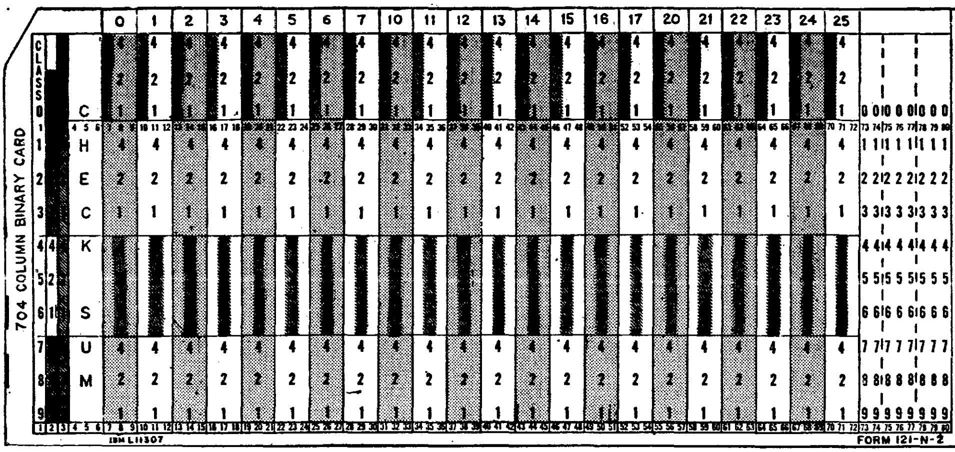


Figure 98—IBM Card—Column Binary

The standard special characters $ * % and so on, are represented by one, two, or three punches in a column of the card and consist of punch configurations not used to represent numeric or alphabetic characters.

Row Binary Data Representation:

Row binary describes one method of recording binary information on cards. In this system, the information is arranged serially across each row of the card (left to right) starting at the 9-row, continuing to, and including the 12-row (Figure 97). Each punched hole is regarded as a binary 1. No punch indicates a binary 0.

In the IBM 704, 709, and 7090 systems, 72 columns of the card are used. Binary information is represented as follows: each of the 12 rows of the card is split into two parts; the left half consists of columns 1 through 36, and the right half consists of columns 37 through 72. One full word of binary information (36 bits) can be punched in any half row; 24 words may be contained on a card.

Column Binary Data Representation:

Binary information may also be recorded in a columnar binary fashion. With this method, data are arranged in parallel with each column of the card containing 12 information bits. Thus, one full 36-bit word for the IBM 704, 709, or 7090 systems would require three card columns. The entire card could contain twenty-six 36-bit words (Figure 98).

Paper Tape:

Punched paper tape serves much the same purpose as punched cards. Developed for transmitting telegraph messages over wires between two machines, paper tape is now used for communication with other machines as well. For long distance transmission of data, machines convert data from punched cards to paper tape, information is sent over telephone or telegraph wires to produce a duplicate paper tape at the other end of the wire, and reconvert the information to punched cards (Figure 79).

Data are recorded as a special arrangement of punched holes, precisely arranged along the length of a paper tape (Figures 99 and 100). Paper tape is a continuous recording medium, as compared to cards which are fixed in length. Thus, paper tape can be used to record data in records of any length, limited only by the capacity of the storage medium into which the data are to be placed or from which data are received.

Data punched in paper tape are read or interpreted by a paper tape reader and recorded by a paper tape punch. Data are transcribed from source documents to paper tape by manually operated tape punching devices.

Eight-Channel Code:

Data are recorded (punched) and read as holes located in eight parallel channels along the length of the paper tape. One column of the eight possible punching positions (one for each channel) across the width of the tape is used to code numeric, alphabetic, special, and function characters. Figure 99 shows a section of a paper tape illustrating the eight channels and several coded characters.

The lower four channels of the tape (excluding the feed holes) are labeled 1, 2, 4, and 8 and are used to record numeric characters. The numeric characters 0 through 9 are represented as a punch or punches in these four positions. The sum of the position values indicates the numeric value of the character. For example, a hole in channel 1 is used to represent a numeric one; a combination of a 1 and a 2 punch represents a numeric 3.

The X and 0 channels are similar to the zone punches in punched cards. These channels are used in combination with the numeric channels to record alphabetic and special characters. The coding for the alphabetic and special characters is shown in Figure 99.

To check that each character is recorded correctly, each column of the tape is punched with an odd number of holes. A check hole must be present

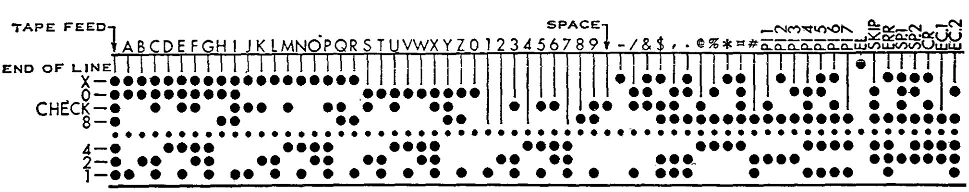


Figure 99—Paper Tape—Eight-Channel Code

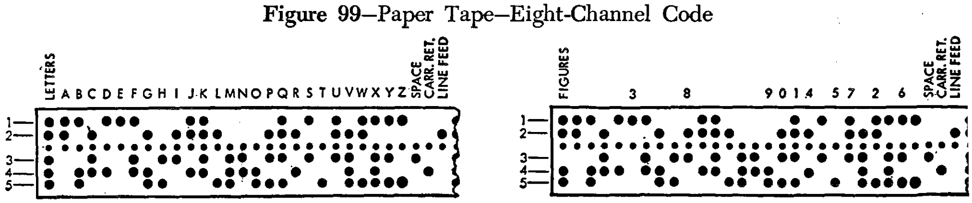


Figure 100—Paper Tape—Five-Channel Code

in any column whose basic code (X, 0, 8, 4, 2, 1) consists of an even number of holes.

A punch in the EL channel is a special function character used to mark the end of a record on the tape. The tape feed code consists of punches in the X, 0, 8, 4, 2, and 1 channels and is used to indicate blank character positions. The paper tape reader automatically skips over areas of tape punched with the tape feed code.

Five-Channel Code:

Data are recorded (punched) and read as holes in five parallel channels along the length of the paper tape. One column of the five possible punching positions (one for each channel) across the width of the tape is used to code numeric, alphabetic, special, and function characters. Figure 100 shows a section of paper tape illustrating the five channels and several coded characters.

Because there are only 31 possible combinations of punches, using the five punching positions, a shift system is used to double the number of available codes. When the letters (LTRS) code punch precedes a section of tape, the characters that follow are interpreted as alphabetic characters (Figure 100). When the figures (FIGS) code punch precedes a section of tape, the coded punches are interpreted as numeric or special characters.

Ten of the 31 codes are used for coding both the alphabetic characters P, Q, W, E, R, T, Y, U, I, and O and the decimal digits 0 through 9, respectively. Interpretation depends on the shift code, LTRS or FIGS, preceding these characters. Likewise, the code for special characters is identical to that of other alphabetic characters. The actual alphabetic code that is equivalent to a given special character code varies, depending on customer requirements.

The function characters – space, carriage return (CR), and line feed (LF) – are the same in either LTRS or FIGS shift. The space code is used to indicate the absence of data on tape. The actual function of the CR and LF characters depends on the machine with which they are used.

Magnetic Tape:

Magnetic tape is the most recently developed medium for recording data for machine processing; it is the principal input-output medium used by computer systems.

Magnetic tape is similar to the tape used in home tape recorders. It is a plastic tape, one-half inch wide, and coated on one side with a metallic oxide. Data are recorded as magnetized spots or bits in the metallic oxide (Figures 101 and 102). Information recorded on tape is permanent and can be retained for an indefinite time. Previous recordings are destroyed as new information is written. This means that tape can be used repetitively with significant savings in recording costs. Several types of magnetic tape are available to meet varying requirements of strength, durability, reliability and cost.

For handling and processing, tape is wound on plastic reels containing up to 2400 feet of tape. (Lengths as short as 50 feet may be used.) The magnetic tape u[illegible] which functions both as an input and output device, moves the [illegible] and accomplishes the actual reading or writing of information

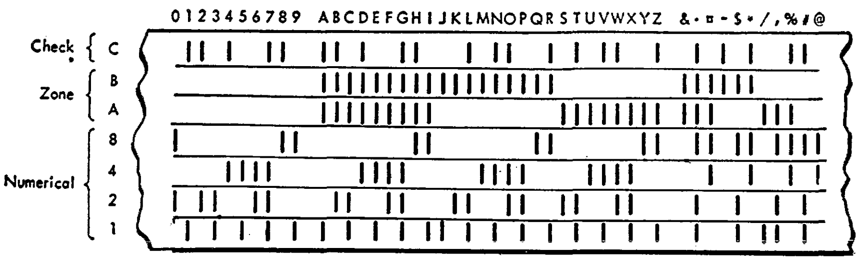


Figure 101—Magnetic Tape—Seven-Bit Alphameric Code

on the tape. Data are recorded in seven parallel channels or tracks along the tape. Seven bit positions across the width of the tape (one in each channel) provide one column of data. The spacing between columns of bits is automatically established by the magnetic tape unit used in writing.

Records of data on tape may range from one or two characters to several thousand. The size of the record is limited only by the length of tape or the capacity of the storage units that data will be placed in or removed from.

Seven-Bit Alphameric Code:

The seven recording tracks or channels on tape are labeled C, B, A, 8, 4, 2, 1 and correspond to the seven bit positions of the seven-bit alphameric code. A character is represented by the presence or absence of bits in the seven channel positions of one column, across the width of the tape. Figure 101 shows characters in the seven-bit alphameric code as they appear on tape.

To verify tape reading and writing, each character is checked for even parity. In addition to this vertical parity check, a horizontal (longitudinal) parity check is made on each record. At the time a record is written, the bits in each horizontal row are counted. At the end of the record, a check character is recorded. This character has a bit corresponding to each channel row with an odd bit count. Thus, when the record is read, each channel row of the complete record, including the check character, should satisfy the even parity condition. The check character serves this purpose only, and is never included as part of the record when data are transferred to the computer system.

Tape written in the seven-bit alphameric code can be used by several data processing systems, providing a means of intercommunication from one system to another. There are instances, however, where special characters, peculiar to only one system, are written on tape. For this reason, consideration must be given to the characters used when tape written on one system may be used on another.

Binary System:

Binary information recorded on tape is related primarily to the IBM 704. 709, and 7090 data processing systems. With these systems the basic unit of information is the word – 36 consecutive bits – compared to the character or digit of other systems.

To record a word of data on tape, the seven bit positions

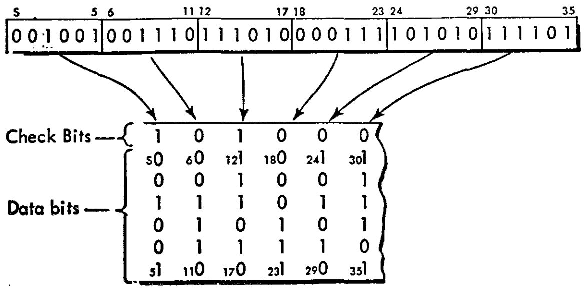


Figure 102—Magnetic Tape—Binary System

on tape are used; however, the C bit position of the column is for parity checking purposes only, and is not considered a part of the word. Thus, six bits of information can be recorded in each column. A word of 36 bits is represented in six consecutive columns on tape (Figure 102).

To verify accuracy of tape reading and writing, each column of bits must consist of an odd number of bits and is tested to insure odd parity. As tape is written, check bits are automatically added to the columns that have an even number of bits. In addition to this vertical parity check, a horizontal (longitudinal) parity check is made on each record. At the time a record is written, the bits of each horizontal row are counted.

At the end of the record, a check character is recorded. This character has a bit corresponding to each row with an odd bit count. When the record is read, each row of the completed record, including the check character, should satisfy the odd parity condition.

Magnetic Ink Characters:

Another method of representing data on paper media for machine processing is with magnetic ink characters — a language readable by both man and

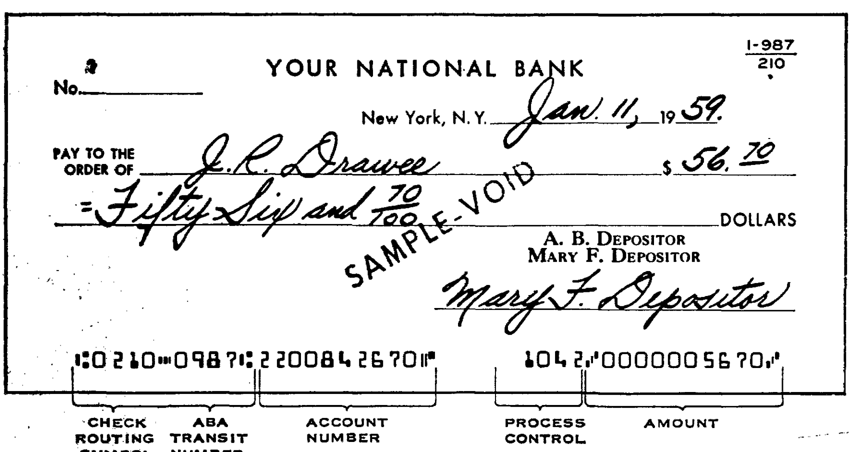


Figure 103—Magnetic Ink Inscribed Characters

machine. Magnetic ink characters are printed on paper as the arabic numerals 0 to 9 and four special characters (Figure 103). The shape of the characters permits easy visual interpretation; the special magnetic ink allows reading or interpretation by machine.

The printing (inscribing) of magnetic ink characters on the paper documents is done by machine. The paper documents, primarily bank checks and deposit slips, may be random size paper or cards ranging from 2¾ inches to 3⅔ inches wide, from 6 inches to 8¾ inches long, and from .003 inch to .007 inch thick.

The IBM 1201 proof inscriber inscribes documents in addition to performing the normal proving functions related to banking procedures. The IBM 1202 utility inscriber, a specially designed electric typewriter, is also used to inscribe documents. After documents are inscribed, the IBM 1210 reader sorter reads the inscribed information from the documents and converts this information to a machine language. At this point, the information may be entered directly into an IBM 650 data processing system or recorded on magnetic tape as input to other systems.

End of Chapter Questions

1. Why is it advisable to elevate the data processing department to a high level in the company?
2. What are the advantages of centralizing the data processing functions of a company within one department.
3. What has been the greatest advancement in the field of data processing?
4. What is the purpose of data processing machines? How do they accomplish this?
5. Explain the stored program concept.
6. How much did magnetic tape improve the input speed of computers?
7. What is meant by in-line data processing?
8. How can computers eliminate checks?
9. What is the science of information retrieval? How can it be assisted by computers?
10. What are the three basic considerations of data processing?
11. What are the four types of functional units that comprise a computer?
12. What are the various methods of recording input data for machine use?
13. What are the various methods of recording output from the computer?
14. What determines the amount of information that can be held within a computer at any one time?
15. What are the functions of the central processing unit?
16. What is a program?
17. What is the purpose of the console?
18. What is a word?
19. What is one of the most successful media for communicating with data processing machines?
20. What is the fastest input-output media used by computers?

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