

A SURVEY OF PUNCHED CARD DEVELOPMENT

by

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S. B., Massachusetts Institute of Technology

1955

SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
1956

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94 Topliff Street
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May 21, 1956

Professor L. F. Hamilton
Secretary of the Faculty
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

Dear Professor Hamilton:

In accordance with the requirements for graduation, I herewith submit
a thesis entitled, " A SURVEY OF PUNCHED CARD DEVELOPMENT".

At this time, I would like to express my sincere appreciation to Prof-
essor Robert H. Gregory for his patient guidance during this study. His
help was kindly offered and gratefully accepted.

Sincerely yours,

George Jordan *(handwritten flourish)*

Rec'd (2nd. Reg'd) Oct. 22, 1956

ABSTRACT

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Submitted to the School of Industrial Management on May 21, 1956 in partial fulfillment of the requirements for the degree of Master of Science.

Punched card machine systems have developed from simple statistical systems to one of modern business' most potent management tools, have had a profound effect upon the data processing habits and techniques of American business, and have given rise to one of our major industries. Therefore a complete study of punched card systems over the entire history of their development in business would not only be an interesting bit of American business history but also would be a valuable aid in the future development of data processings systems in general.

This thesis, the beginning of such a study, offers a pattern of punched card development, derived from a history of the developments of punched cards from 1880 to 1920 and a chronicle of the equipment developments and business application from 1930 to 1940. A partially annotated supplementary bibliography of punched card business application during 1920-1930 and 1940-1950 and a chronology of machine developments in those years are offered as aids in the further study of punched card development.

With the population growth of the country and the growth of American business from small individual enterprises into large and complex organizations, the need for the development of methods to handle the information generated became an increasingly important problem. The continued improvements of the punched card inventions of Hollerith and Powers have answered this need to satisfy the demands of business to a great extent.

As the capabilities of the systems increased and the advantage of speed, accuracy and control became evident, more accounting was done using punched cards. This resulted in the acceptance of business records in other than classic forms, helped initiate the concept of central data processing as a part of management information systems and facilitated management use of detailed statistical analysis in their daily operation. Although the punched card systems were highly capable, early awareness of their limitations led to continual attempts to develop completely automatic data processing systems.

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CHAPTER I

INTRODUCTION

Punched card machine systems have developed from simplified procedures that could handle only elementary statistical operations to one of modern business' most potent management tools. Punched card systems have had a profound effect upon the data processing habits and techniques of American business, and also have given rise to an industry whose sales in 1951 were in excess of four hundred forty million dollars. The systems reached the zenith of their development in the late 1940's. The emergence of the electronic computer, a much more powerful data processing tool, has brought to a close a fascinating era in the development of data processing tools for management.

A complete study of punched card systems over the entire history of their development would not only be an interesting bit of American business history but also would be a valuable aid in the future development of data processing systems in general. The enumeration of the forces which influenced this development and a portrait of the pattern of development could serve as historical data for use in future data processing developmental decisions.

From time to time there have been studies of and bibliographies on the uses of punched card machine systems in colleges and universities, in science, and in library work. No study has been made which presents the developments of the machine systems in their most important area of usage, business. The business applications of the punched card machine systems have provided a major impetus for the continuous development and improvement of the data processing systems.

Thesis Objective

This thesis is intended to be the beginning of a complete survey of punched card machine system developments. Recognising the magnitude of such a survey, the objectives of this paper are:

1. Provide a history of the early developments of punched cards from 1880 to 1920.
2. Chronicle the equipment developments and the business applications of punched cards in the decade 1930-1940.
3. Develop the pattern of punched card development from an analysis of the decade 1930-1940 and the history of tabulating equipment.
4. Provide a supplementary bibliography on business applications of punched card machine systems during 1920-1930 and 1940-1950 which may serve as a guide in further study in this area.

General Scope of Work Done

An exhaustive search was made of the Dewey Library card file, the Industrial Arts Index, the Harvard Business School Library card files, and the Kirstein Branch of the Boston Public Library. The relevant material consisted of more than thirty texts and two hundred, ten periodical references.

Attempts to obtain historical rental figures for IBM and Remington Rand comparisons from the local offices proved fruitless and doubt was expressed by the individuals contacted about the ready availability of these statistics.

Because of the great amount of material involved, it was felt that the detailed presentation and analysis of one decade would be a manageable period bearing in mind the limited amount of time available for this study. The analysis of 1930-1940 will serve as a starting point with the thought in mind that further study would cover the other developments in punched card machine systems. The references not used in this thesis form the partially annotated Supplementary Bibliography.

The development of punched card machine systems in foreign countries is excluded from this study; although, because of the structure of the annual reports of IBM and Remington Rand, income of foreign subsidiaries is included in the income statistics.

The chronological method of presentation of applications was adopted to provide a contimuity of development. The chronological reports of equipment developments in the decades 1920-1930 and 1940-1950 are designed to serve as guides for future study and to provide a continuity for the complete development of the punched card industry.

The reports of applications in periodical literature serve as the base for determining the trends of punched card development. Many of the applications reported in the literature were obviously in use prior to the publication date of the reference, and in most cases, reports of equipment developments did not mean the equipment was in commercial use. This displacement of the time factor is unavoidable and no effort has been made to adjust it.

No attempt has been made to explain in detail the routine procedures that are used in each application reported for these varied considerably for each particular situation. General detailed procedures are available in publications by the manufacturers. The principal aim in this work has been to show what the punched card method accomplished and why it could do it.

Consultation with Professor Gregory throughout the thesis work served to guide this writer in his efforts.

CHAPTER II

HISTORICAL DEVELOPMENT OF TABULATING MACHINES 1880-1920.

The decade 1880-1890 was one of the most important in the transformation of American business from small individual enterprises into large and complex organizations. It was the time of the active growth of industrial giants such as the Standard Oil Company and of the first practical industrial application of electricity.

With the growth of business and the country, the need for the development of methods to handle the information generated became an increasingly important problem. This need was to be answered by the inventions of Dr. Herman Hollerith and James Powers.

A. Hollerith

In 1880, Dr. Herman Hollerith, then a noted statistician, was engaged by the United States Government as a special agent for the 1880 census which took seven and a half years to complete. His words best describe the situation which he encountered.

"Few, who have not come directly in contact with a census office, can form any adequate idea of the labor involved in the compilation of a census of 50,000,000 persons, as was the case with the last census, or of over 62,000,000 as will be the case in the census to be taken in June, 1890.

While engaged in work upon the tenth census, the writer's attention was called to the methods employed in the tabulation of population statistics and the enormous expense involved. These methods were at the time described as "barbarous", and the suggestion was made that some machine ought to be devised for the purpose of facilitating such tabulations."¹

Since the 1880 census was not finished until 1887, people were worried that the 1890 census would not be finished before its information was completely

¹Herman Hollerith, "An Electric Tabulating System," The Quarterly, Columbia School of Mines, April, 1889, p. 258.

worthless. Dr. Hollerith continues:

"This led the writer to a thorough study of the details of the methods used, which were no doubt the most approved ever employed in compiling a census..., the method which forms the subject of this paper is confidently offered as a means for facilitating this work.

The work of a census can be divided into two branches: that of enumeration and that of compilation or tabulation."²

Hollerith then proceeded to go into the costs of this work and also pointed out the inadequacy of the compilations.

"Many of the facts enumerated were not compiled at all, or if they were compiled, were treated in so simple a manner as to leave much to be desired."³

Dr. Hollerith observed that not only the raw data were of interest, but also that combinations between various categories of enumeration in the census were of interest to many parties. Hollerith foresaw the use of his invention in life insurance as one example of the value of relative fact analysis.

"We have in a census, besides data relating to our living population, records regarding the deaths during the previous year. In both cases we have the information regarding age and occupation. If the living population were tabulated by combinations of age and occupation, and likewise the deaths....., we would then have data from which some reliable inference might be drawn regarding the effects of various occupations upon length of life. It might even be possible to construct life tables for the various occupations as we now do for the different states and cities."⁴

²Ibid.

³Ibid., p. 240

⁴Ibid., p. 243

Other existing methods of census compilation were described and their disadvantages pointed out.

The Machines

Next, the machine system, a fundamentally simple and yet highly ingenious one, was described by the inventor. A card with holes punched in it, a "pin-press", a punch, electromagnetic counters and a "sorting box" made up the entire system.

The first machine, completed in 1886, used punched strips of paper which were soon replaced by thin manilla cards. A coding scheme for each application was set up for the cards which were 3" x 5" and were divided into $\frac{1}{4}$ " squares. The cards had one corner cut off for proper orientation when used.

Punching of the cards was accomplished either with an ordinary ticket punch or by the use of machines, which Hollerith developed, called the keyboard punch. It had a movable punch which could punch a hole in five or six cards simultaneously with the identical information. The punched cards were read by placing them over a complete card of a different color.

From the punched cards, the compilation of the statistics was accomplished by the use of a "pin-press" or circuit-closing device. The inventor describes this as follows:

"The press consists of a hard rubber plate...provided with suitable stops or gauges against which the record cards can be placed. This hard rubber plate is provided with a number of holes or cups corresponding in number and relative position with the centres of the spaces of the card. An iron wire nail is securely driven through a hole in the bottom of each cup, and a wire, connecting at the other end with a binding post on the back of the press frame, is securely held under the head of each nail. Each cup is partly filled with mercury, which, through the nail and the wire, is thus in electrical connection with the corresponding binding post. Above the hard rubber plate is a reciprocating box provided with a number of projecting spring-activated points, corresponding in number and arrangement with the centres of the

mercury cups... If a card is placed on the rubber plate against the stops, it is of course apparent that, when the box is brought down by the handle, the pins will all be pressed back, excepting such as correspond with the punched spaces of the card which project into the mercury, and are thus in electrical connection with the corresponding binding post on back of the press frame.⁵

The counters were actuated by electromagnets and could register up to 10,000. They were completely interchangeable and any number could be used.

The sorting of cards was done using a sorting box with lids closed against the tension of a spring. The closing of an electric circuit in the pin-press released the lid to open the box. The lid remained open while the card was manually placed in the particular box and then was closed by hand.

A complete resume' of the operation of the system may serve to clarify its operation. A punched card was placed in the press. To obtain the desired statistics, the corresponding binding posts on the the back of the press frame were connected with the binding posts of the desired counters. If combinations were to be counted, small relays controlled the secondary circuits through the counters. The connection of the magnets of the sorting box in exactly the same manner as described for the counters allowed the simultaneous counting and sorting of the cards. When the card was placed in the press, one of the lids of the sorting box opened and the card could be placed in the correct box.

The accuracy of the system is obvious and the only possible source of error is in the punching of the cards. Hollerith, however, pointed out that such an error would result in only a single incorrect unit, whereas with the other manual methods, a single error could involve an error of

⁵Ibid., p. 250.

much greater magnitude.

Hollerith remarked:

"It is firmly believed that in regard to cost, time, and accuracy, this method possesses very great advantages in doing the work that has heretofore been done, but this is believed to be insignificant in comparison with the fact that a thorough compilation would be possible, within reasonable limits of cost, while such compilation is practically impossible, by ordinary methods, on account of the expenses involved.⁶

Some sources erroneously report the first use of the system to have been the use by New York City. Actually, the city of Baltimore, not New York City nor the Census Bureau, was Dr. Hollerith's first customer for he had persuaded the city authorities to let him try mechanical tabulation on the city's mortality statistics in order to demonstrate the capabilities of his system.

Other early users were the Bureau of Vital Statistics of New Jersey, the Board of Health of New York City and the government of Austria-Hungary. One other user must be added to this early list. In his article in 1889, Hollerith mentioned being in the process of setting up the format of a card for the Board of Health of New York City and he also mentioned that cards were already in use by the Surgeon-General of the United States Army.

In the summer of 1889, a commission of three experienced statisticians, appointed by the Superintendent of the Census, was very busy with a series of exhaustive tests of all the then known mechanical methods and systems for counting, adding, or tabulating data which might have been practicable for use in the Eleventh Census to be taken the following year. On November 30, 1889, this commission reported favorably on the Hollerith System which led to the United States Government officially adopting the Hollerith System for compiling census returns.

⁶Ibid., p. 255.

The Franklin Institute reported on the Hollerith System. Their report of January 2, 1890, explained the operation of the system and stated the card size was 3" x 6 5/8" (a change from Hollerith's article.) This report mentioned a series of checks on accuracy of the system ranging from thrusting a piece of wire through the common hole of a sorted group of cards to electric bells which sounded when the card was not registered. The Franklin Institute report gave the data on the Census Commission study which compared three methods of compiling census returns.

"...the 'chip' method,...cards and tally sheets, and the method of Mr. Hollerith... . The test selected was the retabulation of certain returns from the Census of 1880 from four districts containing 10,491 inhabitants.

...The results show the Hollerith method of punching cards was done in three-fourths the time required by the other systems for enumeration, and that the figures could be tabulated in one eighth the time."⁷

As a result of this report, the Franklin Institute bestowed upon Dr. Hollerith the Elliot Cresson Medal.

The census installation attracted wide attention by completing all work in two and a half years. The logical outgrowth of the work at the Census Bureau brought about experimentation for industrial and social applications.

The Company

Following the success and completion of his work in the Census Bureau, Dr. Hollerith withdrew from the government service and shortly thereafter obtained patents on his machines. In 1896, after securing the necessary capital, he incorporated his company under the laws of the State of New York

⁷Franklin Institute, Report on the Hollerith Electric Tabulating System, Philadelphia, Pa.: Franklin Institute, 1890, p.6.

as the Tabulating Machine Company. Soon thereafter, in 1901, he introduced the basic form of a numeric punch keyboard.

The Hollerith System became well known and its usage by industry increased. The continued progress of the Tabulating Machine Company, the Computing Scale Company of America and the International Time Recording Company in the years after 1907 attracted the attention and interest of Mr. Charles Flint who became convinced that the merger of these three companies would be a very profitable venture. The basic concept involved in the proposed merger was the offering of a complete service to business—the measurement of material and of working time, and the organization and tabulation of the facts obtained by the measurement. This concept of offering a complete service was to crop up again when Remington Rand, Inc., was formed.

The merger was accomplished in 1911 and the new corporation was named the Computing Tabulating Recording Company. In 1914 Thomas J. Watson took over the corporation's leadership and the forerunner of IBM was well under way.

Dr. Hollerith retired in 1914, but not before his company introduced the accumulation tabulator, a new sorter, and a lever-set gang punch for use with a 38 column card. In 1915 more than three hundred firms were using the Hollerith System and its fame was world-wide.

B. Powers

During the year 1907, Mr. S.N.D. North, the new Director of the United States Census Bureau, was making plans to take the 1910 census. To accomplish this monumental task he sought improved methods over those used in the

previous census of 1900. One of the many problems confronting him was the need to provide more satisfactory statistical equipment than had been formerly used. The Hollerith System entailed too much time and effort in the manual punching and verification of the cards, too large a number of erroneously punched cards, and inefficient manual handling of the cards in the sorting operation.

Mr. North, having decided to develop machines capable of the desired results, investigated a number of individuals who could produce such machines. He called James Powers, an engineer, to Washington to work on the development of the machines. Power's principal contributions were the Census Punching Machine, of which three hundred were manufactured and a two deck horizontal sorter.

The Machines

The Powers machines differed from the Hollerith in that they were completely mechanical in operation. The punching machine consisted of a keyboard with 240 keys, a holder for the data with a movable horizontal index bar across the holder, and an automatic feeding and ejecting mechanism. In the punching machine operation, the unpunched cards were fed from the rear of the machine to their proper place on a die. The operator pulled the keys corresponding to the information to be punched to the edge of the keyboard. The operator could then read along the edge to verify the setting and correct it if necessary before punching the card. The keys could be individually reset or locked. After the data setting was verified, the operator pressed a foot mechanism which tripped a clutch, raised the die and card against the punch, and perforated the entire number of holes desired in one operation. After the die returned to its original position, the punched card was ejected to a front holder. At the same time the line spacer or horizontal bar on the data holder above

moved down one notch, which facilitated the transfer of data and did away with the uncertainty of which line the operator should next transcribe.

The cards used in the Powers Machines had forty five columns with twelve horizontal rows per column. In sorting these cards the different values were picked out from each horizontal line by twelve plungers. Each plunger mechanically controlled the operation of shutters, or switches, which diverted the cards into their proper compartments according to the punched holes.

The cards were automatically fed and when a card passed under the guide plate, the corresponding plunger dropped through the hole setting the guide bar beneath which diverted the card to the proper pocket. As soon as the levers had been set, the plungers rose out of the card, which was then moved under rubber covered wheels to its proper compartment. At the same time, another card was fed so that cards were sorted at the rate of 250 - 270 cards per minute.

The Company

While associated with the United States Government, Mr. Powers was granted the rights to make an application for U.S. patents on his inventions. When his governmental services were completed, he obtained capital and in 1911, started his own company, the Powers Accounting Machine Company in Maine. This company and the machines it manufactured were the beginnings of the present tabulating machines produced by Remington Rand.

Powers entered the commercial field with an improved punching machine and the two deck horizontal sorter. In 1912, Powers moved to Newark, New Jersey and W. W. Lasker joined the company.

One major drawback in the use of punched cards lay in the necessity for manual transcription of the totals on the counters to a ledger, bill, or statistical analysis. Human speed and error were obviously introduced

by such a procedure. A major step forward in the use of punched card systems was brought about through the development by W. W. Lasker of the Powers Tabulator Printer in 1914. This machine, capable of tabulation and printing of the information processed, was completely mechanical and contained the adding mechanism of the Comptograph combined with a portion of the Dalton Adding Machine mechanism. During the years 1914 to 1916, in addition to the Tabulator Printer, W. W. Lasker perfected a running total mechanism, an automatic zero device, a seven unit tabulator, a twelve key keyboard and the first automatic numbering attachment.

The Powers Accounting Machine Company moved to Brooklyn, New York, in 1914, surrendered its Maine charter and reincorporated in Delaware. In 1915, the original foreign subsidiary, now known as Power-Samas Accounting Machine Limited, was formed to develop the market in Great Britain, the Dominions, and in parts of Europe.

C. The Peirce System

The Peirce System of perforated cards was reportedly used in public utility work before 1915, and consisted of a perforating machine, a distributing machine, and an automatic ledger machine.

The entire cycle of operations on customer accounts of a utility firm, from taking the meter reading to making out the bill, posting both debits and credits to the ledger and rendering monthly statements was performed automatically. The meter under this system was equipped with a small, inexpensive perforating attachment activated by a key after the card was placed in the attachment.

Although details on its workings are unavailable, the system did offer three highly distinctive features which were designed to eliminate major shortcomings of contemporary systems. The cards contained the original entry which cut costs and increased accuracy by eliminating the clerical

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intermediaries. The contents of the card were printed as well as perforated (the first printing punch) and, as a result, this considerably improved the handling, the use, and the filing/as permanent records. A distinct improvement in the utilization of card space arose through the representation of characters by combinations of holes.

A bright future was seen for applications of Peirce systems to other branches of accounting such as payroll and cost accounting; but in 1921, the Computer Tabulating Recording Company (IBM) purchased the patents and some of the other assets of the Peirce Accounting Machine Company which was subsequently dissolved.

D. Equipment Developments and Applications 1890-1920

After the first inventions of Dr. Hollerith and James Powers, tremendous strides were made in improving punched card machine accounting equipment. In addition to Hollerith and Powers, men like W. W. Lasker, Peirce and many others contributed to the further equipment improvements, as well as to the development of systems utilizing this improved equipment. The early uses and improvements of punched card machines are important in the derivation of the pattern of development of the industry.

Before World War I

The Hollerith method when originally developed was a manually operated machine method of tabulating information. As Hollerith had foreseen, insurance companies were very early users of his equipment. Another very early business application was found in the office of the Freight Accounts Auditor of the New York Central Railroad for use in the handling of transportation and commodity statistics.⁸ Still another application was the use, about 1900, in the Works Accounting Billing and Storage Departments

⁸G. W. Baehne, Practical Applications of Punched Card Method in Colleges and Universities, New York: Columbia University Press, 1935, p. 6.

at the main office of the Pennsylvania Steel Company in Steelton, Pa.⁹

In 1903 the auditor of the New York Edison Company visited the Steelton office of the Pennsylvania Steel Company in order to inspect the tabulating equipment in use there and, as a result, in 1903, installed Hollerith machines in his company.¹⁰ These machines were much the same as Hollerith's original machines except that the punch had been improved in 1901 by the development of a numeric keyboard.

The expansion of industry into large and complex organizations, brought forth a demand for the development of tabulating equipment in order to simplify industrial accounting techniques. As effort was being expended to further improve the machines, other companies began using the Hollerith system.

W. E. Freeman commented in 1909:

"... the trend of invention in the pay-roll and cost keeping field seems to be along the line of computing machines automatically controlled by the electric contact principle..."¹¹

Freeman quoted reports of other applications from pertinent papers presented before the National Electric Light Association. Punched card systems were used before 1911 to tabulate the monthly electric sales and perform various statistical analyses at one firm. Voucher distribution was also in the process of being accomplished by the machines at the same installation. In 1912, another company used the system for sales analysis, consumer trend analysis, and bill extension checking and was planning to take care of cost allocation and job order numbers by merely changing the design of

⁹W. E. Freeman, Automatic, Mechanical Punching, Counting, Sorting, Tabulating, and Printing Machines, New York: National Electric Association, 1915, p. 13.

¹⁰Ibid.

¹¹Ibid., p. 55.

the card. Reports of the use of the system in inventory work were also given.

The demands for commercial applications of the punched card method of accounting necessitated the development of a regular adding counter that could be used for accumulation of quantities and values in contrast to the tally operation of the Hollerith Census Tabulator. This development was called the Integrating Tabulator and was shortly followed by the development of automatic feeding and ejecting devices which permitted the tabulation of 150 cards per minute instead of 50 to 80 when done manually. Among the limitations of the early Hollerith tabulating machines was its inflexibility because of the permanent wiring of the components. A plug board similar to a telephone switchboard was developed to provide flexibility in the use of the machines.

One paper quoted by Freeman contained a pithy observation about some of the major opposition to the acceptance of punched card machines throughout their short development.

"...some accountants fear the system because the record it produces is not displayed in the form of nice statements or reports."¹²

This fear is recognizable throughout the development of punched card systems and methods were found to overcome these objections which eventually has led to the acceptance by accountants of information processing records in many forms.

By 1914, the art of using the Hollerith tabulating equipment had been applied to so many different fields of accounting that engineering development was aimed at developing an overall automatic machine. This concept of general continually applied developmental work was one of the first policies instituted by Thomas Watson when he took over the guiding of the

¹²Ibid., p.61.

Computer Tabulating Recording Company. (C.T.R.Co.)

The advent of the Powers Accounting Machine Company in 1911 provided another impetus for the intensification of equipment development efforts. The verification feature and mechanical accuracy of the Powers systems were quite attractive to the business community. The greatest achievement of the Powers company to that day was the development by the ingenious Mr. Lasker of the Tabulator Printer. This machine surmounted numerous sales resistances and was one of the most important developments in the history of tabulating machines. The other improvements by Lasker such as the running total mechanism; the automatic zero device, and the seven unit tabulator were also of the utmost importance since they made the use of the machines much more convenient.

A description of one of the first uses of the Powers Tabulator Printer was given by W. E. Freeman.¹³ The New York Edison Company had refrained from the use of tabulating systems because the equipment gave no printed record for reference and other demands of the business. After the commercial introduction of the Powers Tabulator Printer, the company, in 1915, installed the machines to take care of consumer deposit accounts. Highly satisfactory results were achieved with the machines for trial balances were completely compiled the first day of the month instead of the fifteenth and approximately fifty per cent of the clerical labor and expenses formerly involved were saved. Many other uses were planned for the machine.

The Rock Island Railroad used tabulating machines for compilation of freight commodity statistics in 1906 and in 1916 the East Bay Water Company of Oakland, California installed a system for use in handling customer's

¹³Ibid., p. 34.

accounts. The applications which are reported here are but a few of the over three hundred uses of Hollerith and Powers systems in 1915 but they do indicate the trend of development.

World War I - 1920

The entrance of the United States into World War I brought enormous demand for methods to increase the speed and accuracy of accounting and record-keeping for the control of the tremendous production of munitions, goods of all types, and governmental record keeping. Tabulating equipment consequently became a much more important factor in the accounting world.

It must be borne in mind that the established manufacturer of tabulating equipment was the C.T.R. Company for it had been operating since 1896. The Powers company was but a few years old and, in fact, had just (1914) set up their plant in Brooklyn. Consequently, the majority of machines sold in World War I were C.T.R. machines.

The major use of the equipment during the war was in the handling of an almost astronomical (in those days) quantity of business and governmental statistics. The C.T.R. Company continued to make improvements in their equipment even during the war when they developed the mechanical verifier and the electric key punch. The verifier automatically locked if, when the information was again punched into the card on the verifier, it did not coincide with the previous punching. This verifier did not however discriminate against holes which were present in an area in which no hole should be present. The electric key punch afforded the opportunity to use less effort in punching the cards because the holes were punched by electromagnetic instead of manual pressure.

Improvements notwithstanding, however, generally the machines in use during World War I replaced only the hand labor of tabulating statistics, for the results of the tabulations on C.T.R. machines still had to be read

from the counters and subsequently transcribed in a presentable report form. The users of Powers machines were not bothered with this problem, but they were in the minority.

The growth of the tabulating industry during the first World War was followed by a surplus of used machines brought about by the demobilization following the war. This surplus of machines was a serious problem for the C.T.R. Company because the machines they were capable of making were no different from the surplus used machines. Powers was not faced with that problem since their system was considerably superior to the C.T.R. machines by virtue of the Tabulator Printer machine. This surplus of machines created a problem for C.T.R. much more serious than the depression of 1929. This competition of the surplus used machines was a great impetus in the continuing emphasis upon engineering product development since the only way to survive the situation was to develop a better product. This was done by C.T.R. in the 1920's.

In the meantime, the Powers Company and its British subsidiary were continuing their progress. In 1919 Lasker developed a single deck sorter for Powers and Powers-Samas of Great Britain placed an alphabetic printing tabulator on the market. The parent company did not offer an alphabetic printing tabulator until 1924, consequently comment on this most important development in tabulating equipment will be deferred.

CHAPTER III

ANALYSIS OF PUNCHED CARD SYSTEM DEVELOPMENTS IN 1930-1940

Although applications of punched card systems in the decade 1920-1930 are not presented, the following chronology of machine and industry developments is needed to effect a coherent transition to the state of the industry in 1930.

Chronology of Machine and Industry Developments 1920-1930

In the decade 1920-1930, major machine and industry developments occurred which had a definite influence upon the business application of the punched card systems and upon the structure of the punched card industry.

- 1920. C.T.R. bought the Peirce patents and introduced its first five-bank tabulator printer.
- 1921. Powers added counters to its sorters while C.T.R. introduced automatic control for its tabulators.
- 1922. The Samas Company was incorporated in France by the British subsidiary of Powers.
- 1924. Powers introduced its alphabetic printing tabulator enlarged to ten sector units and accompanied by an alphabetic keyboard.

C.T.R. changed its name to the International Business Machines Corporation and introduced an electric duplicating key punch.
- 1925. Powers brought out its electric keyboard punch and the first synchromatic installation which allowed simultaneous typing of information on a typewriter and punching of the same information on cards.
- 1926. Powers opened their Brooklyn experimental laboratory while IBM introduced their motor driven gang punch.
- 1927. Powers and seven other companies merged to form Remington Rand.

1928. IBM introduced its first general purpose accounting machine featuring 80 column cards and equipment with an automatic bill feed on the tabulator.
1929. Remington Rand marketed its Model 2 Tabulator and IBM brought out an improved key punch with automatic feed and eject.

Structure of the Industry in 1930

The advent of the depression found the two main punched card competitors, IBM and Remington Rand, in much dissimilar circumstances.

IBM, the product of a merger in 1911, under Thomas Watson, had successfully been consolidated after its merger and had instituted a program of a major emphasis on engineering improvement of the products offered by IBM. IBM had successfully negotiated the surplus of used tabulating equipment after World War I by introducing the IBM version of the printing tabulator in 1920. Progressive and aggressive management through machine improvement and sales effort had capitalized on being the first company in the field of punched card equipment in order to build a solid conservative organization. The depression was far less distressing to IBM than the post World War I machinery surplus. The nationwide IBM Tabulating Service installations and their aggressive sales force had done much to establish IBM as the foremost company in tabulating equipment. Indeed, many discussions of punched card developments spoke only of the IBM systems. The development by IBM of a printing tabulator was felt to be a great step forward in the application of punched card systems to accounting, yet little recognition is found of the fact that Powers (Remington Rand) had introduced its printing tabulator seven years before. A similar situation existed with the development of the alphabetic printing tabulator.

Remington Rand was the product of the merger of Rand Kardex Bureau, Inc., Baker-Vawter Co., Dalton Adding Machine Co., Powers Accounting Machine Co., Safe-Cabinet Co., the Remington Typewriter Company, and various smaller

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firms. This merger was accomplished in 1927 with the concept in mind of providing a complete office equipment service for business.

The Powers accounting machine company lost its identity when the merger was consummated and attempts to find financial statistics on Powers proved fruitless since its securities were not on the New York Stock Exchange and were not reported in the financial services. An estimate of the size of the Powers Accounting Machine Company was, however, derived from the information available in Moody's Financial Service. The net profit was given for most of the other major companies involved in the merger as well as a total net profit figure for Remington Rand.¹⁴ By difference, the Powers net profit for 1925 is estimated to have been one to two million dollars compared with an IBM net profit of four and a half million dollars in the same year.

There is an old saying, "...it takes three years to digest a merger." The Remington Rand merger was hit in the midst of its digestion by the depression. The conglomeration of useful and useless properties, people, and policies simply could not be separated in time to get the company on a solid foundation to weather the depression. Remington Rand had, however, through its Powers Division, continually pioneered in new developments in punched card machines until IBM introduced its general purpose 80 column card system in 1928. The development of printing tabulators, punch synchronization with typewriter, and alphabetic and numeric interpreting machines was done by Remington Rand.

Although IBM was more than twice as large as the Powers Company, the truly progressive achievements of the Powers Company should be recognized

¹⁴ See Appendix 1 for data.

in the literature but such credit is generally absent from punched card dissertations because the writers limit their work to IBM equipment.

State of the Art of Tabulating Equipment in 1930

In January of 1930 there were two competing types of equipment available to industry, the Remington Rand and IBM machines. Both systems were designed to accomplish similar results but in the case of IBM machines, this was done electrically; in Remington Rand machines, mechanically.

The IBM equipment consisted of an electric key punch with automatic feeding and ejecting of cards, the type 80 horizontal sorter, and a general purpose numeric printing tabulator with automatic bill feed. The cards involved contained 80 columns but in older equipment the cards were of 34, 38, or 45 column capacity. Auxiliary equipment available included the manual electric duplicating key punch, automatic control of the tabulator, and a manual mechanical verifier. This system was highly flexible because all electric connections are made on plug boards and could be easily changed. The Remington Rand equipment consisted of an electric alphabetic and numerical key punch, a horizontal sorter and an alphabetic and numerical printing tabulator, which handled cards with a 45 column capacity. The auxiliary equipment available from Remington Rand included an electric punch synchronized with a typewriter and automatic control of the tabulation.

The equipment available had very definite limitations although there had been a continuous improvement of the machines. The advent of the printing tabulator opened a major segment of accounting to punched card installations. Possible applications of the machines were again increased tremendously when the alphabetic and numerical tabulating systems were inaugurated. However, there continued to be drawbacks which limited the scope of application of the systems. One major item was the expense of

the installations. Although no definite information is available, the necessary volume of data handled was estimated to be about 1,500 operations a day to make the equipment economically feasible.¹⁵ Another expensive item was the use of manual effort and the opportunity for errors occurring in the punching operation. Numerous other functional deficiencies were evident such as the inability to multiply, subtract, or divide through punched card control and the inability of the tabulation to automatically punch a summary card. Some of these deficiencies were to be corrected and others have never been fully solved.

Chronicle of Machine Developments and Business Applications

The available periodical references of business applications of punched card machine systems are used to derive a pattern of development of punched card systems in business. It is felt that the report given in each of those articles contains new information about the application of the punched card systems and consequently, each report is of value in deriving a pattern of development.

The equipment improvements and the reported business applications are given in chronological order to provide a continuity of development over time. Unfortunately most of the sources of information used are lacking, in one or more respects, as a complete report of the facts which would be conducive to a more rigorous analysis. Items such as costs, date installed, etc. are in many cases not reported. The available information is, however, in this writer's opinion, sufficient to enable trends and patterns of development to be deduced.

¹⁵R. V. Credit, "Punched Card Method in Accounting," Journal of Accountancy, 57: 272-285, 1934, p. 274.

The principal aim in each report of application is to show what the punched card methods accomplished and why they could do it. The how of each application is felt to be secondary since there are many different ways that the same job could have been done using different detailed techniques.

1930

Machine Developments

IBM introduced the numeric interpreter for the printing on the card of the numbers found in the punched holes.

Remington Rand introduced its Model 2 Interpreter and Standard Reproducer. Powers-Samas brought out a small 26 column card (4 11/16" x 2") and a complete line of machines to handle the cards. This was the first change from the standard card size of 7 3/8" x 3 1/4". In addition, Powers-Samas introduced automatic card verification by the offset hole method along with universal printing counting sorter.

Applications

No business applications were reported in the available literature of 1930.

1931

Equipment Developments

Remington Rand introduced its 90 column card and a complete line of equipment to handle the cards. The 45 column cards could also be used in these new machines.

IBM offered an automatic multiplying punch and a duplicating summary punch.

Applications

Kaufmann's Department Store¹⁵

The system which was tried at Kaufmann's Department Store did away with the need to hand punch and verify cards for department store control, because all transactions which were initiated by the sale of a piece of merchandise were handled by machines.

Inventory and merchandise cards were simultaneously punched when the merchandise was received. After a sale was made, the merchandise ticket, sales person identification and customer charge plate, if any, were placed in a machine. The information was electrically transmitted by the machine to a central records machine which punched all the information on a sales audit card and recorded the information on an adding machine tape and on a totalizer. The inventory cards were removed by drawing them off through sorting and tabulating machines. Sales cards were filed for each customer and were periodically run off on a Powers alphabetic tabulator to print the billings. Credits were entered by hand punched sales audit cards.

It was suggested that this method be used in production control since it did away with the checking and hand work which made savings doubtful on a conventional punched card installation.

Some features of this system were complete accuracy, no human intervention after merchandise and inventory cards on punched and instantaneous recording. This application was discussed in

¹⁵"Machine Made Records," Factory and Industrial Management, 82: 492-3, October, 1931.

1938 by L. F. Woodruff in much greater detail. It is interesting to note that no other mention was made in the literature of other applications of this system until it was described again by Woodruff.

East Bay Municipal Utility District of California¹⁶

The East Bay Municipal Utility District of California, which had used tabulating equipment since 1916, reported the applications afforded by the perfection of the printing tabulator and the interpreter. These two machine developments were cited as materially increasing the value of the system from the accounting standpoint.

The tabulating equipment was used to handle customer accounts, billing, and sales analysis. Generally the system involved the basic unit of a tabulating card per customer per month. All the necessary information was punched into each card from the original information shown by the meter reader's records and subsequently checked for accuracy. The cards were then processed to print individual billings on pre-addressograph bills. After the billing, the same cards were analysed under various categories for sales analysis purposes. Finally, the cards themselves constituted the ledger of accounts outstanding, with paid cards filed to give the history of the customer's account.

Cost figures were not available for comparison, but the author felt this system to be at least as economical and far more convenient than any other.

¹⁶J.H. Kimball, and R.M. Sedgwick, "Tabulating Machines in Customer Accounting," Journal of the American Water Works Association, 23: 1891-4, November, 1931.

1932

Machine Developments

IBM introduced its alphabetic printing tabulating machine system about eight years after Remington Rand. In addition, a verifier with an automatic feeding and ejecting mechanism was offered. Now the entire punched card industry offered alphabetic and numerical systems.

Remington Rand, meanwhile, brought out an automatic compensation feeding device for the tabulators and the company consolidated its engineering laboratories in Brooklyn.

Applications

No punched card applications were found for 1932 in the available literature.

1933

Machine Developments

IBM opened its new research laboratory and school in Endicott, New York and introduced its alphabetic key punch, type 3, a re-producing punch, a test scoring machine, and an alphabetic printing punch.

Remington Rand brought out a 90 column synchronomatic typewriter punch, a summary punch, and an electric hand punch.

Applications

Boston and Maine Railroad¹⁷

A study of the Boston and Maine Railroad in 1925 indicated that although information on variable costs was available, 90% of that information was not reported to management in intelligible form. Consequently, a Bureau of Statistics was formed to provide daily

¹⁷G.F. Glacy, "Improved Car Accounting and Statistics Lower Costs," Railway Age, 94:548-52, April 15, 1933.

operating and cost statistics. The original data processing system, one similar to prevailing industry practice, was a manual system which involved considerable duplication of effort that resulted in high costs.

In late 1932, a complete Powers system was installed. The machines involved included two automatic key punches, one summary card punch, one interpreter, two sorters non-counting, one sorter counting, one seven unit printing tabulator, one seven unit printing tabulator with direct subtraction, and one five unit printing tabulator.

Through the use of the Powers system, a multitude of statistics were available in an intelligible form derived from car accounting. This considerably eased the task of traffic analysis and also made possible, for the first time, the reporting of operating statistics by states required for Public Service Commissions.

The installation resulted in a saving of \$10,000 a year after machine costs were deducted, while making available material of immediate value. The interpreter was of the highest utility since it greatly facilitated card reading and performance of the work. Some achievements of the system were:

1. Less clerical work for conductors and clerks.
2. No small slips of easily misplaced papers in case.
3. More accurate and neater records.
4. Manual car count eliminated, done by cards.
5. Tabulation of home routes of foreign cars was made available.
6. Work load evened out by high daily capacity.
7. Data carry over from month to month more easily done by transferring cards.

8. Considerable time saving illustrated by the fact that per diem car reports now took only twenty hours of machine time per month compared with fourteen days clerical work under the old system.

Polish National Alliance of the United State of North America¹⁸

The Polish National Alliance of the United States of North America insurance company, by the use of one primary control punched card, a small number of loose leaf sheets, and permanently bound books for recording totals of vital statistics, drastically simplified its entire statistical requirements. This punched card system required only one file of cards, the membership list. All data were computed with that file.

The savings cited were the release of seven clerks who had been continuously employed in the compilation of statistics, and a decrease of ten clerks from the sixteen needed for the peak work load.

Model Laundry Company¹⁹

This novel application at the Model Laundry Company used a punched card system for laundry production control, market analysis, sales analysis and personnel statistics.

A card per customer contained all the pertinent data such as the number of the plant, type of service, day of pick-up and delivery, driver, route number and charge or C.O.D. Production control was maintained through punched holes indicating lot number, employee responsible for finished work, total number of pieces, and the total weight.

¹⁸"Accurate Statistics," Systems and Management Methods 62: 305-6, July, 1933.

¹⁹"Cards Tell Facts," Systems and Management Methods 62:357, August, August, 1933.

Tabulation of these cards yielded all the analyses necessary for management control.

Frank H. Fleer Corporation²⁰

This punched card system provided the Frank H. Fleer Corporation with control of stocks in twenty-eight public warehouses. The accounting was done at the main office and included fiscal accounting, sales analysis and stock control.

The warehouses reported deliveries to the main office which made up punched cards for accounts receivable. Accounts paid were entered on the same card to complete the transaction. The warehouse's monthly tabulation of receipts and deliveries was checked by a machine tabulation of the inventory and sales cards. Using the same cards, monthly sales analyses were prepared.

1934

Machine Developments

IBM introduced an automatic carriage for its printing tabulating machines as well as an alphabetic direct subtraction accounting machine.

Another small card system was introduced by Powers-Samas. This system used a 21 column card (2" x 2 3/4") with a round hole 3/32" in diameter instead of the standard 1/8" diameter hole. These small card systems were designed to save space and expense. Unfortunately, in the survey of applications, no report of the use of these systems was found.

Applications

No applications were found in the available literature.

1935

Machine Developments

Remington Rand offered a printing multiplying punch and Power Samas

²⁰"Mechanical Method Provides Accurate Control of Warehouse Stocks," Systems 62:560-1, December, 1933.

brought out a summary card punch.

Applications

No applications were found in the available literature for the year 1935.

1936

Machine Developments

IBM standardized on the name of "electric accounting machines" as properly descriptive of its products. The alphabetic verifier, alphabetic interpreter, and the collator were introduced. The introduction of the collator marked another milestone in punched card development. This device which was capable of merging and separating cards greatly increased the flexibility and versatility of the machine system.

Remington Rand probed the possibility of direct sale of their equipment. Heretofore all machines had been leased, and Remington Rand believed this might have been a disadvantage from the point of view of the customer. Power-Samas used the smaller 3/32" diameter hole to increase the capacity of the 26 column card to 36 columns and offered a complete line of machines.

W. W. Lasker, a pioneer in Powers machine developments died during 1936.

Applications

Old Colony Trust Company and the First National Bank of Boston²¹

It was recognized that company operations in the trust accounting

²¹A.W. Bosworth, "Advance in Trust Accounting and Control," Trust Companies 62:25-32, January, 1936.

departments of the Old Colony Trust Company and the First National Bank of Boston were 50% devoted to reproducing existing facts which entailed a naturally associated high cost.

The punched card installations installed made no departures from the accepted methods of bookkeeping for journals and ledgers were still maintained. Daily proofs and trial balances of accounts were made possible by the Powers system installation. The running trial balances of all accounts formerly took 1,000 man hours; this was reduced to 60 man hours by the machine installation.

The installation included punch machines, reproducers, interpreters, sorters and alphabetic and numeric tabulators. The service provided by the installation was complete accurate control and reporting of trust accounts. The accuracy of the system was highly satisfactory for in a trial run only three errors were detected out of 120,000 cards processed. Through the use of this system, error detection was concentrated at the card punching and verifying stage which consequently removed the hazard of possible posting errors by a number of clerks. The system resulted in increased efficiency of trust accounting, reduced the cost, and removed the drudgery formerly found in trust accounting. Additional uses planned for the system included payroll and expense distribution applications.

Merchants National Bank of Boston²²

The system of trust accounting installed in the Merchant's National Bank of Boston was practically identical to the one previously reported.

²²F.A. Waite, "The Electrographic System of Trust Accounting," Trust Companies 63:187-94, August 1936 and 439-43, October, 1936.

This was the only source uncovered which gave actual rental figures for the machine installation. The IBM equipment involved consisted of two duplicating printing punches, one horizontal sorter with group selector and card matching devices, and one electric tabulator with a summary punch attachment. The annual rental of this installation was \$6,500. If the weekly wage of a clerk were about \$40., the release of three or four clerks by this installation would just about compensate for the annual rental. Obviously such a monetary saving in addition to greater accuracy, speed, and versatility served as a powerful force for the installation of punched card equipment.

Bureau of Water Works and Supply, Los Angeles, California²³

The first application of tabulating equipment in the Bureau of Water Works and Supply was to consumers' billing and bookkeeping operations and the associated sales analysis. A later application to payroll problems was planned.

It was felt that the fundamental reason for the application of the tabulating machines to bookkeeping and billing operations was the use that could be made of the sorting and gang punch equipment. It was unnecessary to compile each bill from the meter book at the time of original transcription to the addressographed tabulating card because the sorter accumulated all like units of consumption in one group so that the amounts could be gang punched to the entire group in one operation. The tabulating machine was utilized to furnish a statistical report of great value in determining unit of consumption use by consumers, which at the same time offered an audited report proving conclusively that all consumption was billed in accordance

²³Frank Twohy, "Application of Tabulating Equipment in Accounting Procedures," Journal of the American Water Works Association, 28: 1704-11, November, 1936.

with the rate schedule.

The use of punched card equipment resulted in a method of guaranteed accuracy, a speed which enabled bills to be mailed on the third day following the meter reading, and a ledger record most easily kept in balance.

Luden Corporation²⁴

This punched card system at the Luden Corporation was used to coordinate perpetual inventory and stock control with fiscal and production accounting. The basic unit was one card per commodity and the machines used to process the cards included a sorter and a printing tabulator.

1937

Machine Developments

The Powers-Samas use of the 3/32" diameter hole increased the standard 45 column card capacity to 60 columns. The full line of machines using this was the only equipment development introduced in 1937.

Applications

Guaranty Trust Company of New York²⁵

Unlike stocks and bonds, no statistical services were available on mortgages. Each bank maintained its own file. The use of a punched card system at the Guaranty Trust Company of New York cut the work

²⁴R.H. Butz, "Punched Cards Speed Stock Control," Food Industries 8:631, December, 1936.

²⁵W.J. Weig, "Punched Card Accounting for Mortgages," Banking 29:28, January, 1937.

load and offered good control of the mortgage statistics.

A control card was prepared which contained such information as location, mortgagee, etc. and a lead card was also prepared for the dollar statistics. Billing for interest and amortization were handled completely by the machine system using the two basic cards, the lead card and the control card. Periodically, mortgage ledger sheets were prepared for a permanent historical record from the cards by running them through the printing tabulator.

Gates Rubber Company²⁶

The executives of the Gates Rubber Company wanted data to compare with budget estimates. The installation of a punched card system solved this problem by providing detailed sales analysis.

The information had to be analyzed for a dozen or more brands and a size assortment of product which ran into the hundreds. All types of sales terms were used to further complicate the analysis.

The large variety of analyses facilitated by the card system, together with cost data told management where the profit lay. Coupled with inventory and production statistics, this formed the backbone of all budget estimates.

The Union Switch and Signal Company²⁷

This application at the Union Switch and Signal Company arose out of the recognition that the information contained in the standard route sheet, tool lists, parts lists and other standard instructions

²⁶ C.W. Dean, "Gates Rubber Company's New Budgetary Control System," American Business, 7:34-5 et. seq., May, 1937.

²⁷ Kenneth Porteous, "Factory Orders and Inventory Records," Factory Management and Maintenance 95:70-80, September, 1937.

in production work was copied again and again. Every copying involved not only clerical costs, but also delays and chances for cumulative errors in transcription.

After extensive investigation, an IBM punched card system was installed. All data concerning routing, tooling, material required, and the like, after having once been worked out, were recorded permanently on master cards. Each time an order was to be issued, a temporary master card was made up which embodied all the variable information such as order number and quantity applicable to one order. The combination of the temporary master card and a permanent master card in the machine resulted in a complete requisition being produced by the printing tabulating machine which also performed the extension of unit quantities. Time cards, production chasers, etc. were similarly prepared.

The machines used in this application included: printing punch, re-producing punch, numerical interpreter, alphabetical printer, sorter, multiplying punch, and a tabulator. The system capacity was 400 shop orders daily and the machines were also used for inventory record control.

The advantages encountered included the elimination of backlogs, two hour service on rush orders, uniform size of all shop records, unusual capacity for peak loads, and flexibility of the system which tied together the accounting and the shop departments.

New England Gas and Electric Association²⁸

The New England Gas and Electric Association conducted a market survey

²⁸D.H. Linton, "How We Make a Market Survey," American Gas Journal 146:18-20 March, 1932.

by using their meter readers to obtain information on the various appliances and heating systems in use by their customers. The collected data was analyzed by an IBM tabulating service bureau. The results were satisfactory and a total cost of 3 to 5 cents per customer was felt to be very good.

A Food Wholesaler²⁹

This application of punched cards by a food wholesaler was used to maintain inventory and stock control while simultaneously providing billings and sales analysis.

Before the installation of the punched card system, ten warehousemen and eight office people were needed to accomplish the work outlined above. The use of a printing punch, a sorter, and a printing tabulator made possible considerable savings. Cards were prepunched for all food items and when placed in an inventory file, served as the on-hand file. Standard inventory control procedures were used in conjunction with the card file.

Customer order blanks listed all the food items in a coded sequence and the warehouse was rearranged in that sequence. The use of these systems improvements coupled with the installation of the punched card system resulted in cutting in half the personnel necessary. Operating costs were cut 31.9% and price errors were eliminated in billing by the use of the printing tabulator.

²⁹W.V. Davidson, Jr., "How a Wholesaler Became Efficient," Food Industries 9:120-3, March, 1937.

1938

Machine Developments

IBM opened their headquarters in New York, and introduced a transfer posting machine and the type 513 Reproducing Gang Summary Punch.

Remington Rand brought out its multi-control Reproducing Punch and Power-Samas introduced a 130 column capacity card by using the split column method on the 65 column card.

Applications

Excelsior Insurance Company³⁰

The Excelsior Insurance Company, a fire insurance company, needed data on the premium totals written by various agencies to compare with the cumulative quotas of the agencies.

The use of a tabulating service in conjunction with a photostating feature served to fulfill the needs of the firm. Data, on the basis of a card per agent, was entered on the punched cards to indicate territory, cumulative quota, etc. The cards were then tabulated by the tabulation service to provide a sales analysis and a breakdown of the data into various categories. The actual printed data were entered on the card by an interpreter below the prepunched and printed quotas. The cards were distributed as the sales record. Differences were adjusted annually.

Savings in errors decrease and amount of transportation of data plus compact summaries of figures were felt to be the virtues of the system.

³⁰H.C. Little, "Time Saving Sales and Quota Record," American Business, 8:32 et. seq., January, 1938.

Cleveland Trust Company³¹

The Cleveland Trust Company found punched cards highly suitable because large amounts of figures had to be accounted for with absolute accuracy, numerous reports had to be compiled frequently, and the information had to be quickly available.

Other departments in the bank were also using the punched card system. Real estate loan, business development, rental, banking, and others found the equipment helpful.

The machines were useful in preparing statements of trust accounts, lists of securities for customers, income and analysis sheets, etc. One prime benefit of the system was the reduction of the drudgery formerly involved in compiling the data.

Kaufmann's Department Store³²

The Kaufmann Department Store installed an experimental system of remote-control accounting utilizing specially adapted Powers machines. It is interesting to note that, although this system was mentioned in the literature in 1931, no reference has been found of a similar system being installed despite the fact that it aroused interest in many quarters as reported by Graham in 1932.³³

The need for a remote control accounting system was recognized because, although punched card installations were usually highly effective when large masses of data had to be tabulated, many areas

³¹I.I. Sperling, "Reducing Routines to Minutes," Banking 30: 66-8 May, 1938.

³²L.F. Woodruff, "A System of Electric Remote-Control Accounting," Electrical Engineering 57: Transactions 78-87 February, 1938.

³³W.J. Graham op. cit. p. 185.

existed, department stores for one, in which their effectiveness was debatable or limited by cost considerations. Many attempts to introduce punched card systems in department stores failed after thorough trials. The basic reason for this failure lay in the cost of human operated punching and verifying machines and the inevitable errors which resulted. In some instances, speed and availability of information considerations overrode normal cost considerations, but this was not the case in the majority of installations.

This remote control system was actually an auxiliary to the punched card system and was designed to eliminate some of the very definite drawbacks of punched card systems.

Inventory control and sales analyses are of the utmost importance in department store operations. The proper information must be available for the efficient planning of purchasing and merchandising the stock. The sales slip and cash register method of sales reporting did not lend themselves to economical statistic collection and tabulation due to expense, errors and plain lack of information.

Generally, the factors involved in a sale are: (1) the customer, (2) the merchandise and its selling price (3) the sales person, and (4) the cashier. In the system described, each of these factors was identified by a small punched tag. In a charge transaction, identification of the cashier was unnecessary and, similarly, in a cash transaction, customer identification was unnecessary. In any one sale, therefore, it was necessary to identify only three of the four factors.

The punched tags controlled reproduction, by mechanized and electrical means of the information thereon on a standard punched card.

Then the usual methods of sorting and tabulating could be automatically accomplished to perform the various accounting and statistical operations necessary to derive the required analyses.

The Powers machines used in this installation included: a duplex marking punch specially designed to simultaneously print and punch a standard card and the price tags for the item, a recorder which was an adaptation of a punch for remote control operation, an alphabetic and numerical tabulator, and various pieces of standard equipment.

The electrical remote control portion of the system consisted of plug-in transmitters with suitable error preventative devices, a machine selector, relay and a credit authorization unit. The usage of these items will provide an ample description of their characteristics.

When merchandise was received, the duplex marking punch provided an inventory card and a price ticket for each item. A cash sale resulted in the placing of the merchandise tag, the sales person's identification, and the cashier's identification in the electrical transmitter. The signal from the transmitter went to the selector relay which selected an idle automatic recorder. The recorder then punched out a sales card and simultaneously kept a running record of its transactions. The charge sale procedure was similar except that it involved the substitution of the customer's identification for the cashier's and the selector relay consequently went through another step, picking a credit authorization machine, before the final recording of the information took place. An operator at the credit authorization machine received from the machine, printed on

a paper tape, the customer's name and the amount of the sale. A relay in the credit authorization machine allowed the sales person to be informed of the customer's credit status. If the credit was granted, the system proceeded as before.

Daily sales analysis and inventory control were accomplished by tabulating the sales cards while automatic billing of the charge purchases was accomplished by the alphabetic and numerical printing tabulators.

The system offered a highly efficient means of eliminating much of the labor and error involved in sales accounting. In addition, problems of "in line" accounting and work load probability were brought out. This spotlight on punched card system faults was a beginning of investigation into more efficient data processing systems.

1939

Machine Developments

The IBM introduction of mark sensing equipment with electronic tubes was the beginning of electronic research useful in the punched card industry and electronic computer industry.

Remington Rand presented its Model 3 Tabulator while Powers-Samas introduced an alpha-numerical interpreter and a combination automatic and visible key punch for their 130 column cards.

Applications

Schenley Distilling Corporation³⁴

The repeal of prohibition caught the Schenley Distillery Corporation unprepared for the magnitude of accounting entries which resulted from

³⁴G.A. Gardner, "Improving the Operation of Tabulating Machine Installations," N.A.C.A Bulletin 21: 481-90 December 15, 1939.

the greatly increased sales. At first, punched card equipment was used on a hit and miss basis.

A thorough systems analysis was later made to cope with the large volume of data and possible shifting of management emphasis in order that the proper information could be available at all times. Content of report analysis coding and integration of tabulating equipment with the existing data processing were found to be necessary to provide pertinent information at all times.

American Rolling Mill Company³⁵

A punched card installation was adopted at the American Rolling Mill Company because the increased volume of invoices made manual operation of the accounting system impossible because more exhaustive production and sales analysis were needed.

The speed, accuracy and low cost of the system saved half the former processing cost and made the desired information quickly available.

McKesson and Robbins, Inc.³⁶

This system involved the establishment of a central tabulating center at McKesson and Robbins, Inc., to provide at one operation: factory picking order, shipping weight of order, perpetual inventory, customer's invoice and inventory control.

The installation of electric key punching machines allowed the centralization of all card punching with considerable savings over the manual punching in prior use. Speeds of all operations were

³⁵E.V. Denton, "Sales and Statistical Analysis For a Metal Manufacturer," N.A.C.A. Bulletin 21: 491-9 December 15, 1939.

³⁶H. Van Drooge, "Orders, Inventory, Billings Under Automatic Control," Factory Management 97:56-9 June, 1939.

increased, needless overlapping of the functions of several departments was eliminated, and errors were considerably reduced. While running a parallel manual system, 96% fewer errors were detected in the punched card installations.

Even if no monetary savings had been possible, the firm felt the system well worthwhile because of its speed and accuracy. The tabulating department posted the ledgers also prepared labor distribution, payroll, social security reports, expense and advertising analyses.

Rock Island and Pacific Railroad³⁷

Since 1937, the Rock Island Railroad had been applying modern machine methods to its accounting and statistical work. In January, 1939, tabulating machines usage was extended to material accounting which made a total of forty different classes of work being done by the punched card machines.

The installation was claimed to be the largest railroad installation of accounting machines. A total of sixty-six IBM machines of all types were in use.

Brooklyn Union Gas Company³⁸

550,000 accounts were handled by the Powers installation at the Brooklyn Union Gas Company. The machinery involved included thirty-two billing machines synchronized with punching machines, three electric hand punches, four sorting machines, three tabulating machines and various addressograph equipment.

³⁷"Rock Island Goes Modern in Material Accounting", Railway Age 106:976-84 June 10, 1939.

³⁸"Billing Procedure of the Brooklyn Union Gas Company," American Gas Journal 151:15-17 December, 1939.

The data were extracted from the meter book, the bills made out and checked on the billing machines and the cards were punched with the identical information. Sorting and tabulating of the cards gave the sales analyses and a tabulation sheet with all the billing data.

Evaluation of the Reports of Applications

It must be pointed out that many successful applications have obviously not been reported in the literature, and in addition, failures of applications are not reported although they must surely have existed. The information available in the literature has undergone a number of filtering processes such as the author's impression of the important aspects of the application, any editing by the editors of the periodical, the change of the significance of certain aspects with time and, finally, the editing by this writer. These limitations on the content on reported applications, however, certainly were anticipated due to the variety of sources investigated and the varied purposes of the reports.

Bearing in mind the limitations already mentioned in drawing case histories from the literature, a list of desirable information that an ideal report of an application might contain would at least include: the company involved; the date of the application; the purpose and a general description of the new application the machines used; and the costs, savings, and benefits associated with the new system. Only one source uncovered in this investigation, "The Electrographic System of Trust Accounting" by F. A. Waite, included all the desirable information. Others omitted one or more bits of useful information.

Still, the flavor of the times and the basic trends of development can be discerned from this sample of applications when one is mindful of the contemporary social and economic conditions. The influence of these

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social and economic conditions could well be the subject of an entire thesis. They will only be touched upon in this work.

SUMMARY OF PUNCHED CARD DEVELOPMENTS 1930-1940

The decade, 1930-1940 saw the growth of IBM, the foremost firm in the industry, due to its engineering development and sales leadership, the continued development of punched card machine equipment and a broadening of their applications in the business world.

Structure of the Industry

Prior to this decade, Remington Rand(Powers) had been the leading company in equipment development by virtue of its early introduction of the printing tabulator and other auxiliary machines. During the 1930's IBM's emphasis on engineering development work began to produce results for the company took over the leadership in equipment improvements by introducing its complete line of alphabetic and numeric equipment, the collator and mark sensing test scoring equipment.

The effects of the depression and the subsequent growth of the two primary firms in the punched card industry can be seen by comparing the net profits of IBM and Remington Rand from 1930-1940 as shown in Appendix II. In 1930, Remington Rand's net profits were \$9.7 million and IBM's were \$10.9 million, while in 1940 they were \$4.9 million and \$21.7 million respectively. This great change in relative industry position of IBM's growth from 50% to 80% of the industry can be partially attributed to the troubles of the Remington Rand merger in a depressed economy but it was largely due to the success of IBM's aggressive sales and engineering management.

Machine Developments

With the introduction by IBM years after Remington Rand of its alphabetic and numerical tabulating system, the entire industry was offering equipment readily applicable to many areas of accounting. The automatic carriage enabled even more convenient use of the printing tabulator because

data could be printed on a continuous manifold paper instead of requiring manual insertion of tabulation forms. The IBM collator, greatly facilitated the handling of cards for it could merge or separate series of cards instead of merely running and sorting cards. The wide use of interpreter which printed on the card the information represented by its holes also greatly facilitated card handling and enabled cards to be filed as permanent records. By means of these and other developments the punched card systems were capable of handling many accounting operations.

The continuing effort of engineering improvement applied to electrical punched card systems by IBM led to the development of mark sensing equipment. Although reports of its use were not uncovered in the 1930's, this led to a continued investigation of electronic circuits which have been useful in the introduction of electronic data processing equipment.

Applications

As the size of business continued to increase past the stage where one or two men could keep themselves informed by personal observation and could control by personal suggestion the operation of all phases of their business, more records and more work became necessary because of the more complex organizations required and because of governmental regulations. A quantity of detail alone which precluded personal familiarity with all parts of the business was consequently generated. It was necessary to keep more records in order to provide for purchases, payments, collections, expansion, and other financial and operational needs.

Records as they developed had always included accounting procedures among the first of the operative processes. Because of the universal need for such records and the long period over which they had been universally used, accounting techniques had been developed more thoroughly than statistical methods. Systems for simplifying accounting records and reducing

the number necessary and increasing the ease of handling them were applicable, while in statistical analyses the very nature of the process required great quantities of detail that became increasingly impossible of collection and organization by hand methods. Double entry methods and highly standardized report forms for accounting purposes were in use long before systematic utilization of statistical facts for formal control was recognized in any appreciable degree. While this development was occurring, all kinds of paper work were increasing in volume.

With first consideration of the use of statistical measures for control and policy making, the need for great quantities of data was evident. Emphasis was turning to detail on individual statistics rather than totals. Businessmen, recognizing these facts, necessarily continued to look for efficient means of acquiring, organizing and analyzing the data. Both in the production of accounting records and relevant reports and in the production of purely statistical series for analysis the punched card method proved the best solution when the quantity of work was great. Punched cards eliminated the need for clerical performance of great quantities of irksome routine work incident to the performance of many modern businesses. Examples of the business areas of continued and broadening application of punched cards included utilities, insurance companies, laundries, railroads, banks, industrial manufacturers, department stores, distillers and many others.

To warrant the use of punched card methods the work had to be of sufficient quantity to justify paying the charges for a complete installation of machines or paying for the services of a service bureau which charged by the hour or by the hundred cards.

One of the outstanding features of the punched card method was the variety of useful reports that could be produced from one basic record.

Quite extensive analysis of sales were useful to management in forming business judgements and regulating activities, yet the entire analysis could be made from one record, the sales ticket. The same characteristic was true of distribution of expenses and production control and factory orders. A type of business needing such analysis profited perhaps more than any other from the use of punched card methods.

Many routine office tasks such as writing checks, filling out drivers' licenses and writing notices of insurance premium or notes due were done by means of punched cards at the same time as making other records on tabulating machine or at least from the cards prepared for making other records. Payroll, with an increasing number of deductions, both voluntary and statutory, had presented a mass of detail almost insurmountable by hand methods and had therefore become one of the most universal problems solved by punched cards. Cost analyses too costly to be done by hand, detail records of, for example, automobile parts, sales and engineering records too expensive to be profitable and too open to human error to be usable by hand methods could be made regularly by punched card methods in little time. Engineering specifications, inventory, controls, production schedules, medical and personnel records, daily reports on shipments, daily sales analysis, immediate location of any required number of any classification of product or personnel from a mass, or reports needed immediately at the end of a manufacturing process were a matter of minutes if cards were already punched or hours if they had to be punched for that purpose. Accuracy was assured by verifying the punching and by listing or tabulating for checking. Audit by means of cards was growing in popularity because there was little chance for human error and very small percentage chance of machine error if proper checking was done. Many kinds of business requiring large quantities of paperwork used the

punched card method profitably.

Although punched card systems were used profitably by many kinds of businesses, the systems possessed definite limitations which included inefficient use of card space for information storage, speed limitations, the cost of verification, and cost human intervention in punching and handling of cards. The Kaufmann Department Store experimental application was evidence that at least some of these limitations were recognized and attempts were being made to overcome them which brought about the first examples of automatic "in line" data processing and work load probability considerations in designing information systems.

Chronology of Machine and Industry Developments 1940-1950

Before presenting the pattern of development of punched cards, the events of the decade 1940-1950 will be described in order to present the complete picture of punched card development. The decade 1940-1950 saw the punched card industry pass through a major World War and progress into electronic data processing systems.

1940 Remington Rand brought out a Model 3 Interpreter while Powers-Samas introduced an interpolator and a multiple counting machine.

1941 While Remington Rand was converting to war production, IBM introduced its type 416 accounting machine, a tape controlled punch, its type 404 alphabetic accounting machine with multiple line printing from a single card.

1942 Remington Rand inaugurated the first direct sales program for tabulating machines.

1943 Powers-Samas introduced a cross-adding punch and all members of the industry were highly involved with war work.

1946 IBM introduced its type 55 alphabetic verifier, the type 602 calculating punch, the type 603 electronic multiplier, cardatype equipment, and the type 519 document originating machine.

Samas of France introduced its "Calculatrice Samas," a direct multiplying, adding, subtracting and dividing machine.

1948. The type 82 sorter, type 602A calculating punch, types

402 and 403 accounting machines, type 604 electronic calculator, and the tape controlled automatic carriage were introduced by IBM.

The Powers-Samas organization formerly privately controlled became a public corporation controlled by Vickers, Limited.

1949 Powers-Samas presented its model 3 tabulator, a posting interpreter, a reproducing feature on the Universal Automatic Keypunch, and a new non-listing high speed punched card adding machine.

IBM brought out its type 24 and 26 card punches, type 407 accounting machine, type 89 alphabetic collator, the card programmed electronic calculator, type 101 electronic statistical machine, the type 856 cardatype and the types 514, 523 and 524 summary punches.

1950 IBM presented the dual feed tape controlled carriage and its type 56 alphabetic verifier.

Powers-Samas introduced a new 40 column (4 1/16"x2") card together with a complete line of punched card equipment.

CHAPTER V

THE PATTERN OF DEVELOPMENT OF PUNCHED CARDS

During the decade 1880-1890, one of the early periods in the gradual transformation of American business from small individual enterprises into large complex organizations, the emergence of such giants as the Standard Oil Company and the New York Central Railroad was observed. With this growth of business and a similar growth in the population of the country, the need for the development of methods to handle the information generated became an increasingly important problem.

The Bureau of the Census was greatly affected by this growth for the problem of information handling had reached a crisis. Existing hand methods could not analyse the census of 1890 before the information derived would be over ten years old. This urgent necessity and the presence of an extremely capable statistician and inventor in the person of Dr. Hollerith resulted in invention of the Hollerith Tabulating System which successfully tabulated the Census of 1890 in two and a half years.

The Hollerith System, as first invented, was only capable of tabulating purely statistical information such as seen in its early applications to railroad freight and commodity statistics and vital statistic tabulation for insurance companies.

As the advantages of the tabulating system became evident, a growing demand was felt for the development of tabulating equipment to simplify industrial accounting techniques which had been universally used for a long time and had been much more thoroughly developed than statistical methods. Double entry bookkeeping methods and highly standardized report forms for accounting purposes had been in use a long time before systematic utilization by management of statistical facts in the control

of business became important.

Businessmen, recognising the utility of statistical analyses in control and policy making, continued to press for efficient means of recording, organizing and analysing data. This demand for better tabulating equipment brought about improvements in the Hollerith machines. This desire for better tabulating equipment also existed in the Census Bureau which resulted in Powers being summoned to develop a better tabulating system. The Powers mechanical equipment which was developed for the census of 1910 was an improved system of tabulation. Commercial application of this system in conjunction with the introduction by Powers of a printing tabulating machine constituted the first major step toward the application of tabulating systems to accounting. The completely automatic Peirce system was also available at this time.

The advent of World War I brought about a tremendous demand for tabulating equipment to handle the volume of statistics involved in waging a war. The tabulating machine industry expanded during the war and later was faced by a surplus of used tabulating equipment. This surplus plus the existence of a technically more advanced competitor in the Powers Company led to the emphasis in IBM upon engineering development and research.

Continued improvements of equipment and the development of alphabetic printing tabulators by IBM and Powers during the 1920's and early 1930's led to expanded use by industry of punched card systems in accounting systems. One of the outstanding features of the punched card method was the variety of useful reports that could be produced from one basic record. Quite extensive analyses were made available to management for forming business judgments and regulating operations.

The availability of such efficient tabulating information processing systems brought about a recognition of the inefficiencies of other segments of the management informational procedures and resulted in the concept of integrated management information systems study. Audit by means of punched cards also grew in popularity because of the small chance of error and the facile reproducibility of the data and analyses.

Although punched card machine systems were highly efficient methods of data processing, definite limitations of the systems were observed during their development. Efforts were expended to overcome the necessity for manual punching and verifying of cards which pointed towards completely automatic systems of data processing.

The continued engineering efforts of IBM in improving the electric punched card tabulating system which in addition to aggressive sales management, elevated IBM to a dominating position in the industry by 1940, also began IBM's investigations into electronic calculators because of the research in electronic circuits which went into the development of IBM's mark sensing equipment.

The transition of data processing techniques from punched card systems into electronic calculators, however, may be covered by more work in this field of the development of data processing techniques.

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APPENDIX I
POWERS NET PROFIT DEDUCTION

The statistics offered by the 1927 Moody's for the major components of the Remington Rand, Inc. merger are the only available statistics which allow an estimate of the size of the Powers Accounting Machine Company.

The approximate net profit data of the other major companies are:

Rand Kardex, Inc.	\$1,770,000
Baker Vawter Co.	290,000
Remington Rand Typewriter	2,795,000
Dalton Adding Machine Co.	290,000
Safe-Cabinet Co.	- 560,000 (deficit)
	<u>\$4,585,000</u>

The total net profit of the firms later comprising Remington Rand, Inc. for 1925 was \$6,382,000 as reported in Moody's 1930.

By difference, the net profit of the Powers Accounting Machine Company was approximately \$1,797,000.

APPENDIX II

COMPARISON OF IBM AND REMINGTON RAND NET PROFITS 1930-1940

The net profit figures, listed below in millions of dollars, were taken from their respective annual reports and represent net profit before depreciation, interest and taxes.

	<u>Remington Rand</u>	<u>IBM</u>
1930	\$9.72	\$10.97
1931	4.04	11.39
1932	- 0.82 (deficit)	10.63
1933	-0.81 (deficit)	10.07
1934	3.18	10.99
1935	3.70	12.25
1936	5.29	13.73
1937	5.92	15.73
1938	7.03	16.97
1939	3.91	18.52
1940	4.93	21.66

BIBLIOGRAPHY

Books

1. Alden, William and others, The Automatic Office, Westboro, Mass.: William Alden Company, 1953.
2. American Office Machines Research Service, New York: Office Machine Research, Inc., 1937.
3. Baehne, G. W., Practical Applications of Punched Card Method in Colleges and Universities, New York: Columbia University Press, 1935.
4. Berkeley, Edmund C., Giant Brains, New York: John Wiley and Sons, Inc., 1949.
5. Bowden, B. V. ed., Faster Than Thought, London: Sir Isaac Pitman, 1953.
6. Casey, Robert and Perry, James W. ed., Punched Cards, New York: Reinhold Publishing Corp., 1953.
7. Doss, Milburn P., Information Processing Equipment, New York: Reinhold Publishing Corp., 1955.
8. Eckert, Wallace J., Punched Card Methods in Scientific Computation, New York: Columbia University, 1940.
9. Franklin Institute, Report on the Hollerith Electric Tabulating System, Philadelphia, Pa.: Franklin Institute, 1890.
10. Freeman, W. E. ed. Automatic, Mechanical Punching, Counting, Sorting, Tabulating, and Printing Machines. New York: National Electric Light Association, 1915.
11. Geier, George J. and Mantner, Oscar. Systems Installation In Accounting, New York: Burrel-Snow Inc., 1932.
12. Gillespie, Cecil, Accounting Systems: Procedures and Methods, New York: Prentice-Hall, Inc., 1951.
13. Hartkemeier, Harry P. Principles of Punch-Card Machine Operation: How to Operate Punch Card Tabulating and Alphabetic Accounting Machines. New York: Thomas Y. Crowell Co., 1942.
14. Hartree, Douglas R. Calculating Instruments and Machines, Urbana, Illinois: University of Illinois Press, 1949.
15. Heckert, J. B. Accounting Systems: Design and Installation, New York: Ronald Press, 1936.
16. International Business Machines Corporation, Annual Reports, Endicott, New York: International Business Machines Corporation, 1924-1950.

- 60
17. International Business Machines Corporation, Machine Methods of Accounting, Endicott, New York, International Business Machines Corporation, 1936.
 18. International Business Machines Corporation, Managerial Accounting by Machine Method, Endicott, New York: International Business Machines Corporation, 1939.
 19. International Business Machines Corporation, Pre-Punched Cards, Endicott, New York: International Business Machines Corporation, 1934.
 20. International Business Machines Corporation, The Control of Material, Endicott, New York: International Business Machines Corporation, 1924.
 21. International Business Machines Corporation, The Electric Tabulating and Accounting Machine Method, Endicott, New York: International Business Machines Corporation, 1925.
 22. Lasser, J. K., Handbook of Accounting Methods, New York: D. Van Nostrand Co., 1943.
 23. Neuner, J. W. and Neuner, V. J., Accounting Systems: Installations and Procedures, Scranton, Pa.: International Text Book Co., 1949.
 24. Parsons, Carl C. Machinery of the Office, Chicago: La Salle Extension University Press, 1921.
 25. Remington Rand, Inc., Annual Reports, Buffalo, New York: Remington Rand, Inc., 1927.- 1950
 26. Remington Rand, Inc., "Know-How" Makes Them Great, Buffalo, New York: Remington Rand, Inc., 1941.
 27. Remington Rand, Inc., Powers Reference Manual, Buffalo, New York: Remington Rand, Inc., 1935.
 28. Thompson, William R., Accounting Systems, Chicago: La Salle Extension University Press, 1921.
 29. Traweek, Stella, Case Studies of Texas Business, Austin, Texas: Bureau of Business Research, Texas University, 1953.
 30. Turck, J. A. V., Origin of Modern Calculating Machines, Chicago: 1921
 31. United States Census Bureau, 16th Census of the United States, Population, Comparative Statistics, Washington, D.C.: United States Government Printing Office, 1943.
 32. Watson Scientific Computing Laboratory, Bibliography on Use of IBM Machines in Science, Statistics, and Education, New York: Columbia University Press, 1954.

BIBLIOGRAPHY

Articles

1. "Accurate Statistics," System and Management Methods 62: 305-6, July, 1933.
2. "Billing Procedures of the Brooklyn Union Gas Company," American Gas Journal, 151: 15-17, December, 1939.
3. Bosworth, A. W., "Advances in Trust Accounting and Control", Trust Companies 62: 25-32, January, 1936.
4. Briggs, G. B., "Economies In Trust Accounting ,", Trust Companies 64: 551-3, May, 1937.
5. Butz, R. H., "Punched Cards Speed Stock Control," Food Industries 8:631, December, 1936.
6. "Cards For Customers: Making and Printing Tabulating Machine Cards," American Machinist 81:556-8, June 16, 1937.
7. "Cards Tell Facts", System and Management Methods 62:357, August, 1933.
8. Cradit, R.Y., "Punched Cards Method In Accounting," Journal of Accountancy, 57: 272-85, April, 1934.
9. Cragg, W. B., "How Census Data Is Tabulated," Credit Monthly 32: 48-9, August, 1930.
10. Curtis, C. R., "Mechanizatinn In Gas Offices," Gas Journal 202: 807-9, June 14, 1933.
11. Davidson, W. V., Jr., "How A Wholesaler Became Efficient," Food Industries, 9: 120-3, March, 1937.
12. Dean, C. W., " Gates Rubber Company's New Budgetary Control System", American Business 7: 34-5 et. seq., May, 1937.
13. Denton, Elwood V., "Sales and Statistical Analysis For a Metal Manufacturer," N.A.C.A. Bulletin , 21: 481-90, December 15, 1939.
14. Gardner, G. A. "Improving the Operation of Tabulating Machine Installations," N.A.C.A. Bulletin 21: 481-90, December 15, 1939.
15. "Gas Accounts and Records by Punched Cards," Gas Journal 227: 395-6 April 16, 1939.
16. Glacy, G. F., "Improved Car Accounting and Statistics at Lower Cost," Railway Age 94:548-52, April 15, 1933.
17. Graham, W. J., "Distribution Methods by Hand and Machine," Journal of Accountancy, 53: 171-85 March, 1932.

18. Hollerith, Herman, "An Electric Tabulating System," The Quarterly; Columbia School of Mines, p. 238-255, April, 1889.
19. Kimball, J. H. and Sedgwick, R.M. "Tabulating Machines in Customer Accounting," Journal of the American Water Works Association
20. Linton, D. H., "How We Make A Market Survey," American Gas Journal 146: 18-20, March, 1937.
21. Little, H. C., "Time Saving Sales and Quota Record," American Business, 8:32 et. seq., January, 1938.
22. "Machine-Made Records," Factory and Industrial Management, 82: 492-3, October, 1931.
23. "Mechanical Method.Provides Accurate Control of Warehouse Stocks," System 62: 560-1, December, 1933.
24. Porteous, Kenneth, "Factory Orders and Inventory Records: Case History of Their Mechanical Preparation," Factory Management 95:70-80, September, 1937.
25. "Rock Island Goes Modern In Material Accounting," Railway Age, 106: 976-84, June 10, 1939.
26. Sperling, I.I., "Reducing Routine to Minutes," Banking 30:66-8, May, 1938.
27. "Tabulating Machines," Encyclopedia Britannica 21:733, 1954.
28. "Tabulating Machines Target of Trust Suit," Business Week, 129:16, April 6, 1932.
29. Twohy, Frank, "Application of Tabulating Equipment in Accounting Procedures," Journal of the American Water Works Association, 28:1704-11, November, 1936.
30. Van Drooge, H. "Orders, Inventory, Billings Under Automatic Control," Factory Management 97:56-9, June, 1939.
31. Vannais, L. E., "Punched Card Accounting From the Audit Viewpoint," Journal of Accountancy 70:200-17, September, 1940.
32. Vannais, L. E., "Punched Card Accounting From the Audit Viewpoint," Journal of Accountancy, 70:339-56, October, 1940.
33. Waite, Fredrick A., "The Electrographic System of Trust Accounting", Trust Companies, 63:187-94, August, 1936.
34. Waite, Fredrick A., "The Electrographic System of Trust Accounting", Trust Companies, 63: 439-43.
35. Weig, W. J., "Punched Card Accounting For Mortgages," Banking 29:28 January, 1937.
36. Woodruff, L. F., "Systems of Electric Remote Control Accounting ," Electrical Engineering, 57: Transactions 78-87, February, 1938.

SUPPLEMENTARY BIBLIOGRAPHY

PART I 1919 - 1930

1. "A.B.&A. Introduces Tabulating Machine Checks," Railway Age 75: 76-7, July 14, 1923.
2. Angstadt, L.H. "Mechanical Accounting For Store Inventories," Management Engineering 4:267-8, August, 1923.
3. Atkins, P.M., "Industrial Cost Accounting For Executives," American Machinist 59:591-4, October 18, 1923.
4. "Austin Works System," Automobile Engineering, 17:380-4, October, 1927.
5. "Census Tabulating Machine," Engineer 131:532-3, May, 20, 1921.
6. "Compiling Operating Statistics by Punched Cards," Railway Review 79: 647-8, October 30, 1926.
7. Conover, J.L. "Report of Committee on Office Labor Saving Devices," American Gas Association, Accounting Section, 1:15-34, May, 1927.
8. Davidson, W.V., "Punched Card Systems of Inventory Control", N.A.C.A. Bulletin 4:23, 1923.
9. Eisertola, F., "Mechanical Devices in Accounting Department of San Antonio and Arkansas Railway," Railway Review 68: 44-8, January 8, 1921.
10. Eisertola, F., "Mechanical Devices in Accounting Department of San Antonio and Arkansas Railway," Railway Review 68: 80-5, January 15, 1921.
11. Ford, C.M., "Alphabetical and Mneomonic Symbols on Tabulating Machine Cards," Industrial Management, 61:347-50, May 1, 1921.
12. "Fuel Accounting with Punched Cards," Railway Review, 79:719-21, November 31, 1926.
13. Howell, M.J., "Punch Cards For Bills Receivable," Railway Age 79: 321-2, August 15, 1925.
14. Ingram, F.C., "Mechanical Bookkeeping of Consumers' Accounts," American Gas Journal, 115:349-51, October 15, 1921.
15. International Business Machines, "Punched Hole Accounting,": International Business Machines: New York, 1924.
16. Jacobson, C.A., "Universal Calculating Machine for Chemical Calculations," Chemical Age 30: 51-2, February, 1922.
17. "Mechanical Aids In Preparing The Railroad Payroll," Railway Review, 66:423-4, March 13, 1920.

- 69
18. "Mechanical Aids to Merchandise Control in Department Stores," Harvard Business Review, 6:330-42, April, 1928.
 19. "New Methods To Order and Inventory Control in Rubber Footwear," Rubber Age, 25:671-2, September 25, 1929.
 20. Paetzold, F.L., "Use of Mechanical Devices in Treasury Department," Railway Age, 73:839, November 4, 1922.
 21. "Payroll Machine," Management and Administration, 8:312-13, September, 1924.
 22. Perry, R.P., "General Accounting With Bookkeeping Machines," Electric Railway Journal, 61: 413-14, March 10, 1923.
 23. Price, C.O., "Calculating Machine in Railroad Accounting," Railway Review, 64: 972-6, June 28, 1919.
 24. Price, S.O., "Mechanical Devices in Railroad Accounting," Railway Review, 65: 600-1, October 25, 1919.
 25. "Railroad Accounting by Use of Perforated Cards," Railway Review, 76: 980-5, May 30, 1925.
 26. "Railway Accounting With Punched Cards," Railway Review, 79:353-4, September 4, 1926.
 27. Rowland, F.H., "Textile Accounting and Punched Cards," Textile World 69: 3025-6, May 1, 1926.
 28. Scheyer, C. "Control of Machines by Perforated Records," American Machinist, 55: 743-7, November 10, 1921.
 29. Scheyer, C. "When Perforated Paper Goes To Work," Scientific American, 127:394-5, December, 1922.
 30. "Sorting and Tabulating Machines in Disbursement Work," Railway Review, 67:51-2, July 10, 1920.
 31. "Station Accounting by Punched Card Systems," Railway Review, 79: 575-8, October 16, 1926.
 32. "Statistical Bureau of Freight Auditor's Office," Railway Review 77: 41-7, July 11, 1925.
 33. Stewart, J.A., "Electricity and the Census," Scientific American, 122:109, January 31, 1920.
 34. Van Bibber, A.E., "Using Punched Cards for Controlling Materials," American Machinist, 51: 295-300, August 14, 1919.
 35. Workman, E.W., "Cost Accounting by Machinery, The Hollerith System," Engineering and Industrial Management 6:314-18, September, 1921.

SUPPLEMENTARY BIBLIOGRAPHY

PART II 1940-1950

(Partially Annotated)

1. Adamson, J.R., "Punched Card System Speeds Accounting at Trion Division, Riegel Textile Corporation," Textile World, 99:114-115 et. seq., June, 1949.
2. Aldous, J.G., "Simple Method of Cross Indexing a Reference File," Science, 106:109, August 1, 1947.
3. Albach, O.H., "Economy in Interline Accounting," Railway Age, 128: 224-7, January 28, 1950.
4. "Automatic Calculator: Remington Rand," Business Week, 657: 69, April 4, 1942.

Automatic multiplication of constants is found on the new model of the Remington Rand 10 key printing calculator which was introduced in 1939.

5. Baird, D. G., "Buick Speeds Orders With Punched Cards", American Business, 20: 20 et. seq., September, 1950.
6. Baird, D.G., "Speed Order Handling With New System at Chrysler Corporation," American Business, 19:10-11, April, 1949.
7. Baird, D.G., "Hudson Parts Control Method," American Business, 17: 12-13, October, 1947.
8. Benjamin, K., "Problems of Multiple Punching With Hollerith Machines," Journal of the American Statistical Association, 42: 46-71, March, 1947.
9. Beswick, G.J. and Littlewort, H.G., "Use of the Multiplying Punch," American Gas Association Monthly, 29:401-4, September, 1947.
10. Block, B.J., and Olds, E.B., "Punched Card Method for Presenting Analyzing and Comparing Many Series of Statistics for Areas," Journal of the American Statistical Association, 41:347-55, September, 1946.
11. Bolger, L.T., "California Fruit Growers Exchange Cooperates on Low Cost Methods," American Business 19:32 et. seq., July, 1949.
12. Bond, G.D., "Continuous Meter Reading," Electrician, 125:335-6, December 27, 1940.
13. Brown, J.K., "Punched Card Payroll Accounting," American Gas Association Proceedings, 1947: 273-5.

- 14. Bruce, H.W., "Keeping Meter Records With Business Machines," Electrical West, 94:58-9, December, 1946.
- 15. Bryan, R.N., "Mechanical Brain Aids Canadian Census Takers," Compressed Air Magazine, 47:6793-4, July, 1942.
- 16. Cady, G.H. and Boley, C.C., "Methods of Recording Coal Data," Economic Geology, 35:876-82, November, 1940.
- 17. "Canadian Pacific Speeds Car Tracing," Railway Age, 128: 311-12, February 11, 1950.
- 18. "Census Machine Does Work of 500 People," American Business 19:24, December, 1949.
- 19. Chapin, T.A., Jr., "Some Problems of Installing a Punched Card System," N.A.C.A. Bulletin, 27:99-116, October, 1945.
- 20. Cochran, J.W., "Recent Progress in Patent Classification," Industrial and Engineering Chemistry, 40:721-3, April, 1948.
- 21. Conley, R., "Check Handling Made Easier," American Business 16:14-15, January, 1946.
- 22. "Conventional and Mechanical Search Methods", Industrial and Engineering Chemistry, 42:1456-7, August, 1950.
- 23. Collins, L.S., "Mechanical Labor Distribution for Job Cost Accounting," Ceramic Industry, 36:45 et. seq., March, 1941.
- 24. Cox, G.J., "Punched Cards for a Chemical Bibliography," Chemical and Engineering News, 23:1623-6, September 25, 1945.
- 25. Crandall, G. and Brown, B., "Information Service Using Both Hand and Machine Sorted Cards," Journal of Chemical Education, 25: 195-6, April, 1948.

The application of both machine and hand punched card systems to lists of references at the Socony Vacuum Laboratories. The advantages of each system are discussed and a combination of both systems is found to be a fairly satisfactory information system.

- 26. Critchlow, E.F., "Measurement and Prediction of Aircraft Vibration by Punched Card Systems," S.A.E. Journal, 52: 368-79, August, 1944.
- 27. "Customer Inquiries are Handled by Machine," American Business, 19:30 May, 1949.
- 28. "Daily Production Material Control Cuts Inventory and Speeds Planning." American Machinist. 88:94-6, August 3, 1944.
- 29. "Data Detector: I.B.M. System for Correlation of Large Numbers of Chemicals," Chemical Industries 67:183, August, 1950.

- 67
30. Deemer, W.L., "Use of Mark Sensing in Large Scale Testing," Journal of the American Statistical Association, 43:40-52, March, 1948.
 31. DeLong, F.G., "Punched Card Method of Trust Accounting," Trusts and Estates, 72:407-10, April, 1941.
 32. DeLong, F.G., "Punched Card Method of Trust Accounting," Trusts and Estates, 72:79-82, June, 1941.
 33. Demming, W.E., "Errors in Card Punching," Journal of the American Statistical Association, 37:525-36, December, 1942.

An exhaustive study of punching errors. Samples of card verification showed errors varied from 0.5% to 5.0%. It is pointed out that considerable expense is involved in verifying cards. Therefore, a statistical quality control type of verification procedure is suggested.

34. "Description of Machine Accounting for Insurance General Agency," Pathfinder Service Bulletin. 186, April, 1949.
35. Donaldson, R.W., "Control of Accounts Payable by Punched Card Methods," N.A.C.A. Bulletin, 30:257-63, November 1, 1948.
36. Dunstan, L.A., "Machine Computation of Power Network Performance," Electrical Engineering, 66:901-6, September, 1947.

This is a general outline of the system used in computing power network performance with a list of the advantages and disadvantages of the method included.

37. Eckert, W.J., "Punched Card Techniques and Their Applications to Scientific Problems," Journal of Chemical Education 24: 54-7, February, 1947.

Author describes industrial applications such as quality control and structural vibration, stress, and strain analyses. IBM equipment of the day is described and the card operated typewriter is commented upon.

38. Egan, D.J., "It's All in the Cards," Bus Transportation, 23: 48-51, November, 1944.
39. Elliot, J.D., "Customer Billing in a Electric Utility," Edison Electric Institute Bulletin, 13:354-6, December, 1945.
40. Epstein, A.P., "Practical Uses of Trade Union Records," Monthly Labor Review, 68: 300-1, March, 1949.

- 41. Fairbanks, E.E., "Punched Card Identification of Ore Minerals," Economic Geology, 41:761-8, November, 1946.
- 42. "Figures That Help Top Management Decide," American Business, 19: 18-19, July, 1949.
- 43. Forest, J.H., "Liberty Mutual Develops Machine Writing of Automobile Policies by Punched Cards," National Underwriters, 52:2 et. seq., October, 28, 1948.
- 44. French, R. G., "Quick Figures Cut Shipping Delays at Chrysler Plant," American Business, 11:30-1, June, 1941.

The investment of \$100,000 by Chrysler for a Remington Rand system is described. The makeup of the system (machines, etc.) and the different types of reports now available are brought out by the author.

- 45. French, R.G., "This Record Reveals Extra Skills of Workers," American Business, 15: 12-13, December, 1945.
- 46. "From Hand to Electric Accounting Methods for Sorting and Billing Operations," American Business, 18:12-13, July, 1948.
- 47. Gallagher, A.M., "Wholesale Figures for the Millions," American Business, 19: 18-19, January, 1949.
- 48. Gallagher, A.M., "Week's Work Done in 8 Hours," American Business 18: 22 et. seq. November, 1948.
- 49. "Government Moves to Stabilize Office Salaries", American Business, 13: 17-18, July, 1943.

It is reported that the Wage Labor Board was set up June 8, 1943, to stabilize salaries. A considerable portion of the results, maximum weekly salaries for office workers, is quoted.

- 50. "Handling Partial Payments on Cash Splits With Mark Sensing Tabulating Cards," American Gas Association Monthly, 26: 418-19, October, 1944.

This is a description of the punched card method applied to cash splits at Consolidated Edison of New York which made use of the IBM mark sensing developments.

- 51. Harper, W.F. and McGinnity, W.J., "Completely Mechanized Material Control System," N.A.C.A. Bulletin, 31:1371-7, July, 1950.
- 52. Hartkemeier, H.P. and Miller, H.E., "Obtaining Differences from Punched Cards," Journal of the American Statistical Association, 37:285-7 June, 1942.

53. Hayward, R.J., "Street Lighting Record Control Modernized," Electrical World, 123:104 et. seq. , January 6, 1945.
54. Hood, T.A., "Punched Cards for Field of Metal Finishing," Metal Progress, 56:75-8, July, 1949.
55. "How Lightolier's Punched Card Installation Produces Statements in 6 Instead of 20 Days, " Journal of Accounting, 90:136-40 August, 1950.
56. "How to Set Up Property Records on Punched Cards to Facilitate Depreciation Accounting," Journal of Accounting, 90:341-2 October, 1950.
57. International Business Machines Corporation, "War Accounting Service." Endicott, New York: International Business Machines Corporation, 1943.
58. "Insurance Accounting Urged to Use Card Systems," National Underwriters (Life Edition), 50:7, May 17, 1946.
59. "Inventory Records Kept 99% Accurate," American Business, 20:10-11, June, 1950.
60. Israel, W.C., "Sensing Marks on Tabulating Cards," American Gas Association Proceedings, 1941:198-205, 1941.
61. "It's All in the Cards," Bus Transportation 27:66-8, April, 1948.
62. Jacobs, N.B., "Coordinating Operating System Records With Accounting Records," Journal of the American Water Works Association, 32:225-41, February, 1940.
63. Johnson, R.I., "Post Sales Record for Manufacturing Equipment," N.A.C.A. Bulletin, 29:955-60, April 1, 1948.
64. Kassenhohen, W., "Preventing Press Work Problems," American Machinist, 84: 162-3, March, 1940.
65. King, G.W., "Some Applications of Punched Card Methods in Research Problems in Chemistry and Physics," Journal of Chemical Education, 24:61-4, February, 1947.

Author states capabilities of presently available machines to be confined to addition, subtraction and multiplication and comments that machines which can divide are forthcoming. A list of the areas where punched cards can be useful in research is given.

- 71. "Machine Sorts Information Fast," Business Week, :1055, 41-2, November 19, 1949.
- 72. "Mark Sensing Aids in Taking Inventory," Railway Age, 129:16-17 July 29, 1950
- 73. McGann, H., "Combination Billing Service," American Gas Association Monthly, 31:25-6, July, 1949.
- 74. McGann, H., "Combination Billing Service," American Gas Association Monthly, 31:50, August, 1949.
- 75. McNeill, J.C., "Machine Methods Promote Efficiency in Mine Accounting," Coal Age, 50:109-14, November, 1945.
- 76. McNeill, J.C., "Payroll Work Speeded up by Modern Machine Equipment," Coal Age 51:92-6, August, 1946.
- 77. McPherson, J.C., "Mathematical Operations with Punched Cards," Journal of the American Statistical Association, 37:275-81, June, 1942.

The author gives an excellent description of the available machines, including card capacities and functional capabilities.

- 78. "Mechanized Accounting," Mass Transportation 37:141 et. seq., October, 1941.
- 79. "Management Reports Reveal Trends," American Business 18:18-19, September, 1948.
- 80. "Milwaukee's Street Inventory Record Will Facilitate Prediction of Future Pavement Requirements," Engineering News, 136:63-7, January 10, 1946.
- 81. "Modern Machines for Trust Operating Economy," Trusts and Estates, 89:470-2, July, 1950.
- 82. Moore, E.L., "Paperwork for Smooth Flow and Close Control," Factory Management 103:134-8, October, 1945.

The use of and IBM system for parts and material control, payroll and other accounting jobs is described. A list of the equipment used and the capacities of the equipment are given.

- 83. "Moraine Products Improves Payroll with New Check," American Business, 16: 36 et. seq., September, 1946.
- 84. Muncy, W.G., "Accounting Control with Punched Card Procedures," Bus Transportation, 28:62-4, April, 1949.

- 171
85. "New Billing System Cuts Time and Errors for Commonwealth Edison," American Business, 18:12-13, June, 1948.
 86. "New Electronic Statistical Machine to be Used in Census," Electrical Engineering, 69:147 et. seq., February, 1950.
 87. "New Payroll Procedures in Canadian National," Railway Age, 129:18-20, July 29, 1950.
 88. "New Pre-Billing System Ups Office Output for Service Parts," American Business, 18:14-15, May, 1948.
 89. Nilson, C.J., "Putting the Factory Ledger on Punched Cards," N.A.C.A. Bulletin, 31:67-76, September, 1949.
 90. Noah, S., Jr., "Payroll Accounting by Punched Card Methods," N.A.C.A. Bulletin, 28:1512-31, August 15, 1947.
 91. "No More Cut-Ups, New Haven Has Mechanized Entire Car Service Procedures," Railway Age, 128:356-7, February 18, 1950.
 92. Norris, W., "Better Methods Shatter Glass Company's Costs," American Business, 19:8-9, March, 1949.
 93. Notaro, M.R., "Punched Card Service Equally Applicable to Small Agency," National Underwriter, 53:6 et. seq., June 16, 1949.
 94. "Novel System Mechanizes All Car Records," Railway Age, 120:394-8, February 23, 1946.
 95. Otcasek, C.D., "Tabulating Cards Control of Meters," American Gas Association Monthly, 28:173-6, April, 1946.
 96. "Paramount Studio Saves \$36,000 per year: Uses Punched Card Accounting," American Business, 20:10-11, March, 1950.
 97. Patton, W.G., "Pontiac Using Punched Card System for Distributing Available Cars," Iron Age, 159:74 et. seq., March 27, 1947.
 98. "Payroll System Saves \$10,000 per Year," American Business, 20:12-13, February, 1950.
 99. Peakes, G.L., "Report Indexing by Punched Card," Journal of Chemical Education, 26:139-46, March, 1949.
 100. "Pencil Entries Now Recorded Automatically on Punched Cards," Journal of Accountancy, 81:332 et. seq., April, 1946.
 101. Pennington, P.R., "Sales and Production Outran Office Methods," American Business 17:10-16, November, 1947.

102. Perry, J.W. and others, "Round Table Discussion: Indexing and Classifying Results of Chemical Research in Relation to Punched Card Investigations", Journal of Chemical Education, 24:71-4, February, 1947.

The presentation of different opinions of the value of punched cards. Other techniques will be completely replaced since this new tool has saved money for some.

103. Perry, J.W., "A.C.S. Punched Card Committee: Interim Report," Chemistry and Engineering News, 27:754-6, March 14, 1949.

Machine punched cards have too much waste space for filing scientific chemical information. Existing machines restrict the use of the cards to only a small number of the possible permutations of combinations. Changes are said to be on the way.

104. "Price Tag Accounting Automatically," Business Week, 1034:84, June 25, 1949.

105. "Punched Card Accounting System at Sun Shipyard," Marine Engineering, 54:71-2, March, 1949.

106. "Punched Card Installations Must Be Planned," N.A.C.A. Bulletin, 32:27-38, September, 1950.

107. "Punched Card Machines and Studies of Flutter and Vibration in Planes," Journal of the Civil Aeronautics Administration, 7: 2 et. seq., January 15, 1946.

108. "Punched Card Method Offers Agencies Real Cost Control," National Underwriters, 53:6 et. seq., June 2, 1949.

109. "Punched Card System for Information Data," Petroleum Processing, 3:527-8, June, 1948.

110. Raywind, J., "Punched Card System for My Agency?," Spectator (Property Edition) 14:16, June, 1949.

111. "Restoring Lost Baggage," Bus Transportation, 23:28-30, October, 1944.

112. Riddle, L.P., "Analytical and Accounting Control of Sales and Gross Profit by Punched Cards," N.A.C.A. Bulletin 29:323-34, November 15, 1947.

113. Root, W.J., "Block Rate Computations," American Gas Association Monthly 25:75-7, February, 1943.

114. Rostler, K.S., "Applications of Punched Cards to Indexing Rubber Compounds," India Rubber World, 120:698-701, September, 1949.
115. "Sales Management Survey of Buying Power: Data Available on IBM Punched Cards," Sales Management 62:66 May 1, 1949.
116. Sargent, A.M., "Accurate Personnel Selection by Punched Card Systems," Factory Management 106:124-5, November, 1948.
117. Selgoie, T.A., "Case Study of Accounting For Fixed Assets," N.A.C.A. Bulletin 23:221-32, October 15, 1941.
118. Sherman, C.W., "Personnel Accounting," Electrical World 132:112-3, October 8, 1949.
119. Sidak, J.G., "Property Records and Depreciation Accounting on Punched Cards," N.A.C.A. Bulletin 28:1352-8 July 1, 1947.
120. "Slash Order Handling Errors and Costs," American Business 19: 26 et. seq. February, 1949.
121. "Some Precautionary Notes on Audit of Sales Accounts and Receivables When Accounts are Kept on Punched Cards," Journal of Accounting 89:522-3, June, 1950.
122. Sparks, C.C., "Fitting the Audit Program to Punched Card Accounting Systems," Journal of Accounting 86:196-200 September, 1948.
123. Spowart, D.J., "Car Records on Tabulating Equipment," Railway Age 126:946-8 May 14, 1949.
124. "Stock Control System Uses Punched Cards," American Business 20: 12-13 May, 1950.
125. "Taking a Big Bite Out of Costs," American Business 16: 18-19 September, 1946.
126. Tanner, Cyrus "Talent Tabulator", Personnel Journal 23:375-7, April, 1945.

A description of how the National Roster of Scientific and Specialized Personnel performed prodigious feats of locating people with certain combinations of specialties. The manner in which this was done included the use of punched cards.

127. Tassie, J.M., "Three Way Control for Low Cost Operation," Factory Management 104:110-12 December, 1946.
128. "Taxpayers Refunds Are Speeded by Machine," American Business, 19:18-19 March, 1949.

129. "Teletyped Bills Save A Million a Year", American Business, 19:18-19 August, 1949.
130. Thomas, J.D., "Mechanized Accountancy and Statistical Work As Applied to Middlesex Gas Company," Gas Journal 250: 336-8, May 14, 1947.
131. Turner, J., "Stock Control Plans to Increase Profits," American Business 17:12-13 January, 1947.
132. Turner, J., "Payroll, Costs, and Personnel Figures From One Machine," American Business, 16:16-17 December, 1946.
133. Turner, J., "Top Management Gets the Figures," American Business 16:8-9 November, 1946.
134. Turner, J., "Four Major Departments Profit From Mechanized Sales and Accounting Reports," American Business 18:10-11 January, 1948
135. "Two Clerks Do the Bookkeeping for 26,600 Consumer Loans," Bankers Monthly 66:5-7 November, 1949.
136. Unton, R.W., "Mechanization Cuts Time for Rewriting Meter Sheets," Electrical World 133:108 et. seq. March 27, 1950.
137. Vannais, L.E., "The Accountant's Responsibility for Making Punched Card Installations Successful," Journal of Accountancy 88:282-98 October, 1949.
138. "Volume Up 50%, Few Workers Added," American Business 19:12-13 October, 1949.
139. "Walkie-Talkie Inventory Cuts Shut Down Time," Modern Industry, 15:83-4 March, 1948.
140. Wall, S.G., "Detail Posted General Ledger Through Use of Tabulatory Equipment", N.A.C.A. Bulletin 31:59-66 September, 1949.
141. Weibenson, H.C., "Expense Accounting Simplified by Electrical Accounting Machine," Bankers Monthly 59:552-3 December, 1942.
142. Wornick, J.G., "Machine Prorates Freight Revenues," Railway Age, 126:950-2 May 14, 1949.