Do Not Fold, Spindle or Mutilate

THE ‘HOLE’ STORY OF PUNCHED CARDS

George A. Fierheller

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Updated edition.

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Dedication

Everyone feels they should dedicate a book to someone. The most logical group for this project is the Punchcard Preservation Society. (www.punchcardsociety.org)

This is a collection of several hundred survivors who were with IBM Canada during the 1950's and 60's. The group still gets together at least annually for a ski weekend, golf game or just a social event.

Hopefully these reminiscences will help revive a few memories of the Punched Card era.

Punchcard Preservation Society meeting at Woodbine Racetrack, Toronto

Acknowledgements

Updated Edition, February, 2014

The original book was published in 2006. Since then, a number of suggestions have been gratefully received. These have been incorporated into the Web edition. They do not however obsolete the print version. I am particularly indebted to several volunteer docents and their colleagues at the Computer History Museum, Mountain View, California including Robert Garner, Jim Strickland, Ed Thelen, Richard Weaver and Bill Worthington.

I was encouraged to do this book by many former IBM'ers and I am sure that if I had time to track down the many stories and thoughts that my peers have of the Punched Card Era, I could have come up with volumes of material. Perhaps my attempt to chronicle this era will encourage others to do the same.

I particularly want to thank Bob Beggs who is referenced on several occasions in the text as my instructor in the first formal class on punched card machines held at IBM Canada. Jack Kyle has been a long time associate both during his career at IBM and later as an executive at Systems Dimensions Limited and provided many recollections. Ron Fawcett has been particularly helpful as a member of the Executive of the Punchcard Preservation Society. He also provided some fascinating early IBM publications.

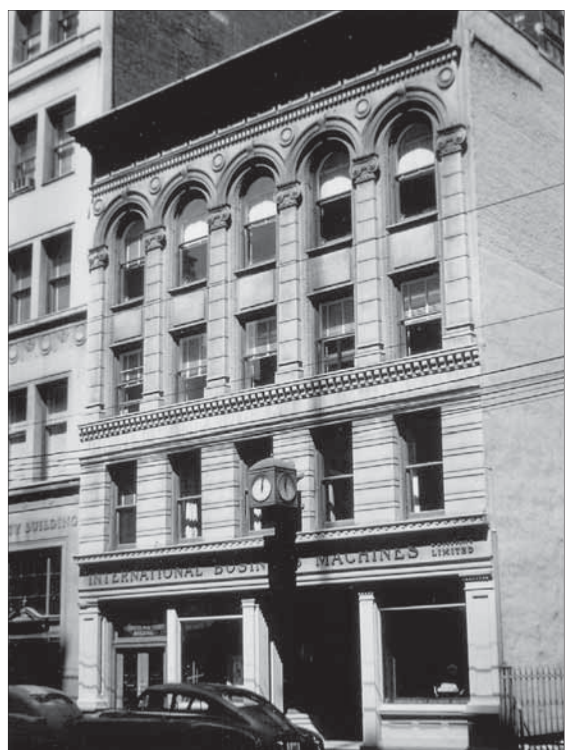
Ike Goodfellow was the founding director of the IBM Toronto Lab and is another pack rat like me. He supplied numerous useful photos and other material.

I should add however that none of the above take any responsibility for my text or opinions!

I am particularly indebted to Heather Baczewski of the WrightLine, Worcester, Massachusetts for providing some catalogues showing the early punched card accessory equipment for which they had developed a very complete line.

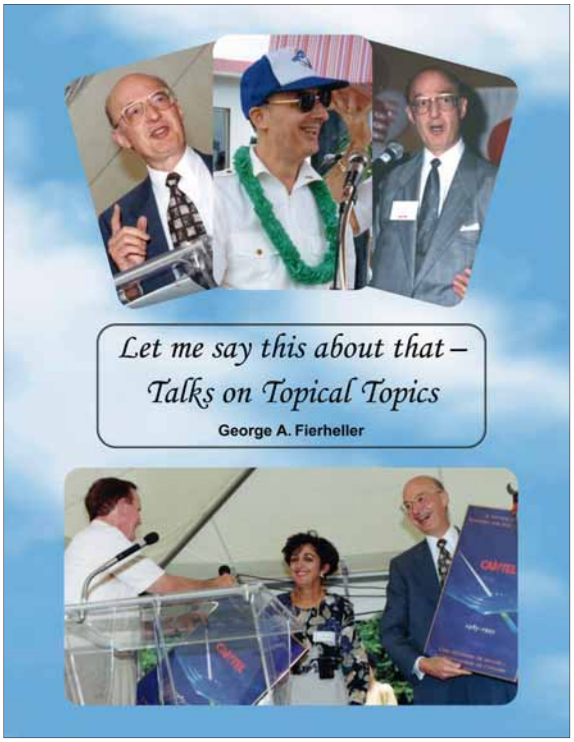
My thanks also to Jennifer Lopez (not that one!), my assistant for her typing and re-typing of the sometimes complicated text.

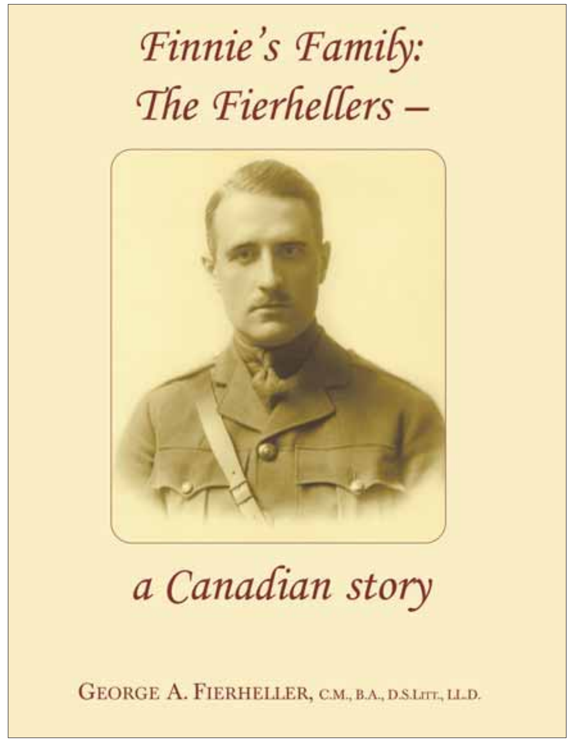
Also my warm appreciation to my ever-imaginative publisher, Robert Stewart, who pieced together the text and photos.



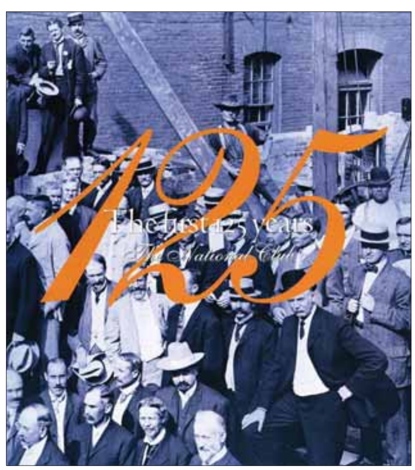
IBM office, 36 King Street East, Toronto, December 1955

OTHER PUBLICATIONS
by GEORGE FIERHELLER





The SDL STORY



The First 125 Years: The National Club

The Toronto Adventurer's Club - 25th Anniversary

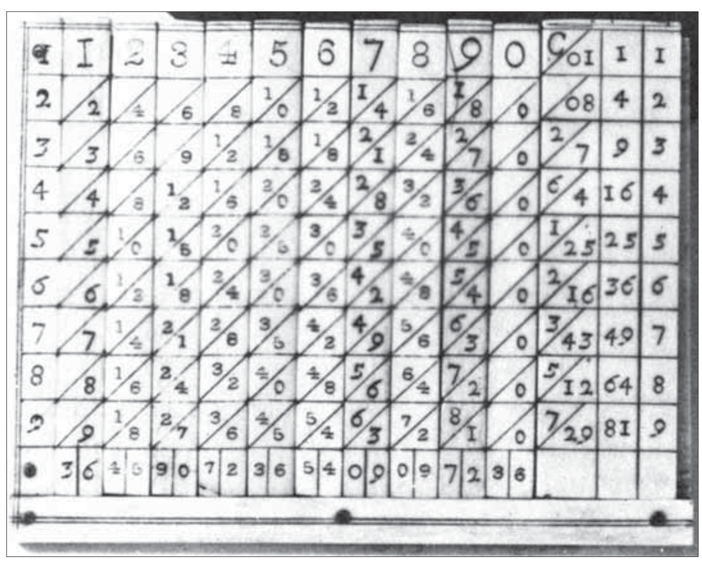
Introduction

Quote from Thomas J. Watson Sr.
"Men are known by the company they keep and companies are known by the men they keep."

Thomas J. Watson Sr. at age 40 when he joined C-T-R, later called IBM, the business he would lead for 42 years.

This observation by the founder of IBM might be considered a bit sexist these days. There were certainly many women in the field of Punched Card Data Processing in the 1950's and 60's and as would be expected they were extremely capable. However in IBM Sales at the time when I joined the company on July 1, 1955, the sales force was predominantly male.

I therefore could reasonably say that this book is about Men and Machines. It does not attempt to be a comprehensive history of data processing. There are many good accounts of the contribution of Leibniz, Napier with his bones, Babbage and Lovelace. There are also some excellent overviews of the development of computers. I have referenced a few good books in the bibliography covering both the earlier and later stages.



Napier's Bones

Instead this book is based on my personal recollections and experience with what were the most extraordinary electro-mechanical machines ever developed.

Strangely enough, I could find very little written on the obvious links between how data was handled during the time of the dominance of Punched Card machines and the early approaches to using electronic computers for the same tasks.

It is not surprising that data processing professionals at the time simply took that with which they were familiar, e.g. the way they handled large files on Punched Cards and transferred this approach to the new, faster medium of computers.

I thought it was worth trying to document a bit of this while there are still a number of us around who lived through that fascinating transitional time.

I have concentrated on electronic data processing as opposed to scientific computing. During my thirteen years at IBM, I did have some experience in the latter area, e.g. Avro Aircraft, The National Research Council and the Defence Research Board but the applications in these areas were not really dependent in any major way on the Punched Card.

While I have said that this is not intended to be a comprehensive history of computing, I have assumed that this book might be read by some who did not 'live' with these pioneering machines and have therefore tried to include enough background that the reasons for the approaches used would at least be understandable. My apologies to those remaining experts who may find this a bit basic.

But enough about what my intentions are – let's get on with the story and explore the world of

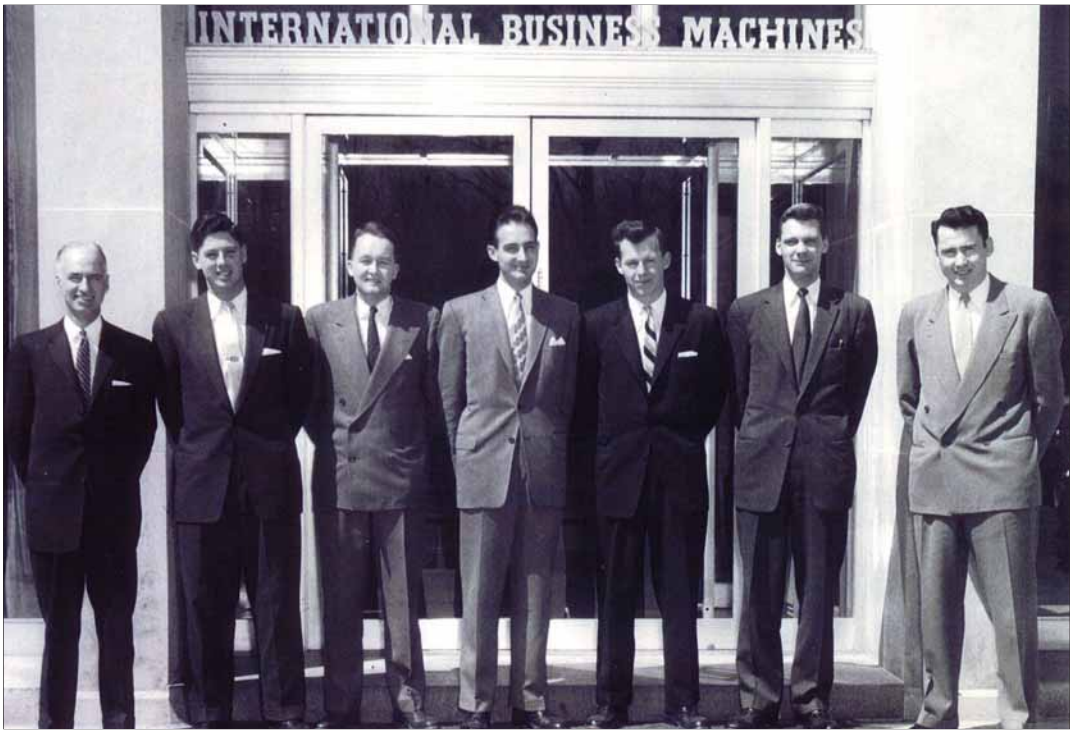
Speed,
Accuracy, and
Flexibility
(the IBM signature for punched card systems)

as practiced in the data processing world in the middle of the 20th century.

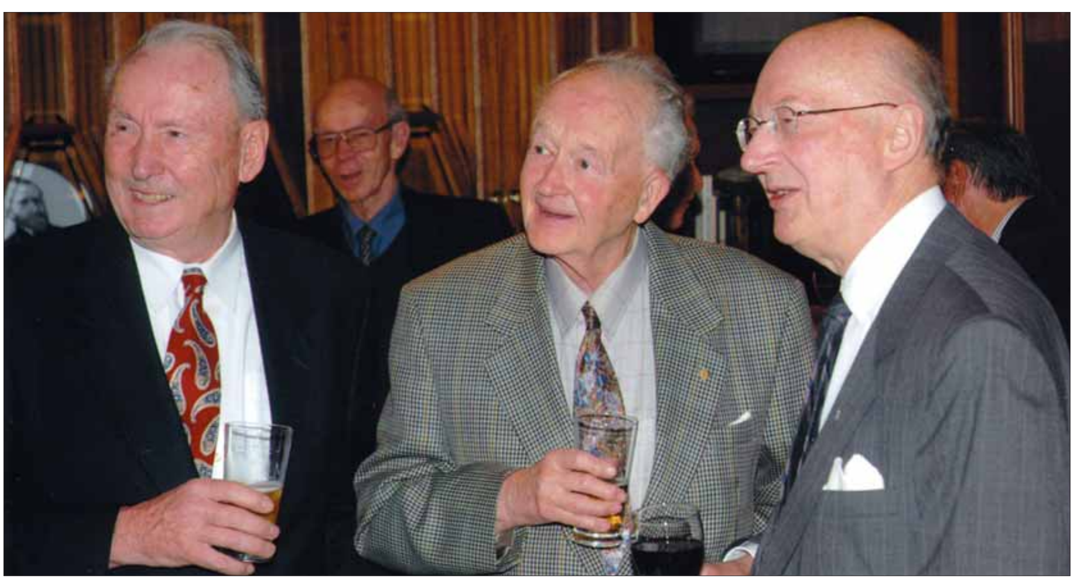
Enjoy!

The cover of Time Magazine, March 28, 1955. It was this article that encouraged me to join the company.

On May 12th 2006 a luncheon was held at the Albany Club in Toronto commemorating the 50th anniversary of the first IBM basic training session.



The photo above shows the graduates of the very first session in 1956.
From left: Reg Bull, Manager Sales Administration, Ike Goodfellow, Lorne Cox, George Fierheller, Don ‘Dek’ Avery, Byron Borden and Bob Beggs (Instructor)

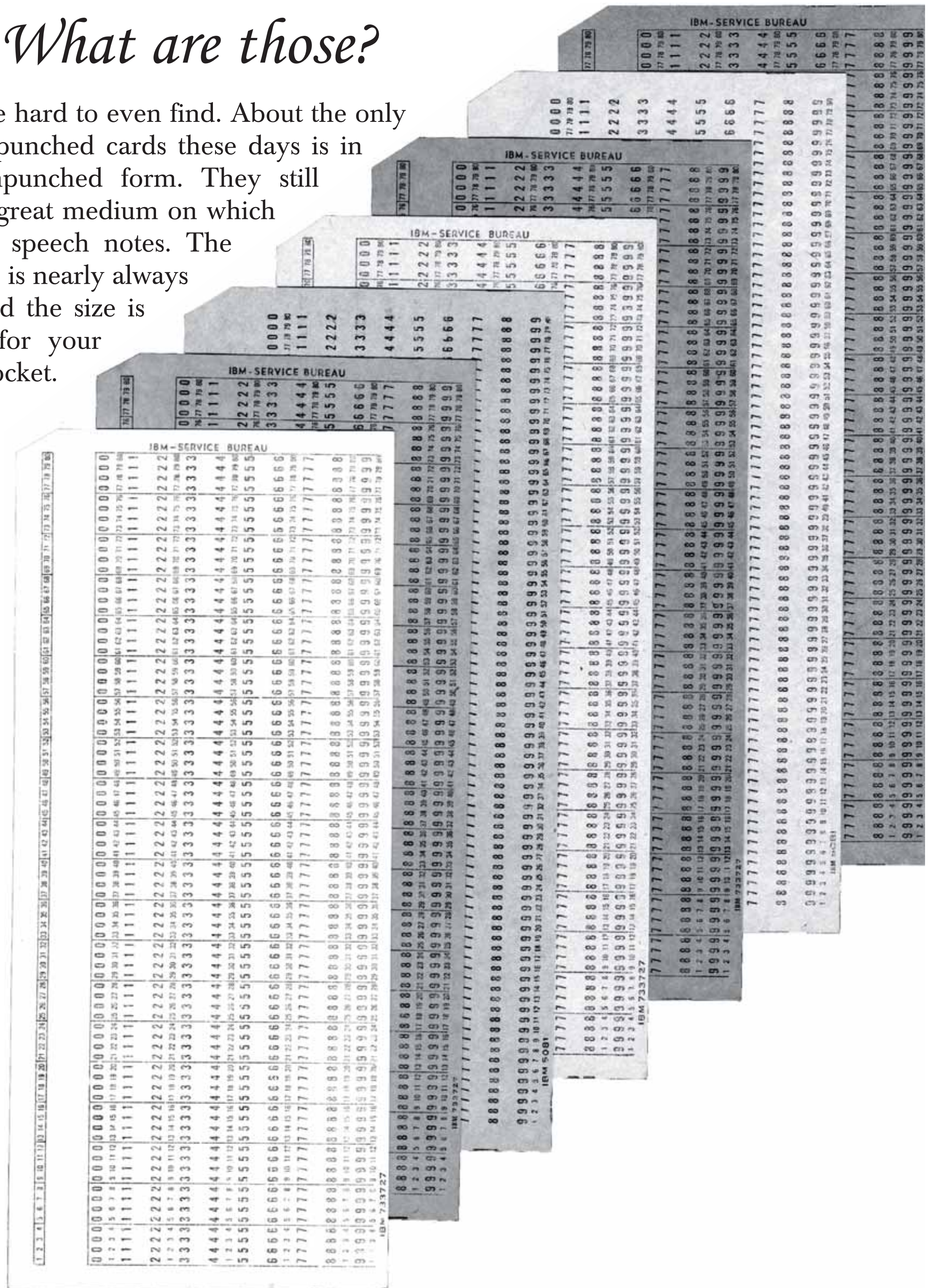


The 50th anniversary at the Albany Club in 2006:
From left: Bob Beggs, Lorne Cox and George Fierheller

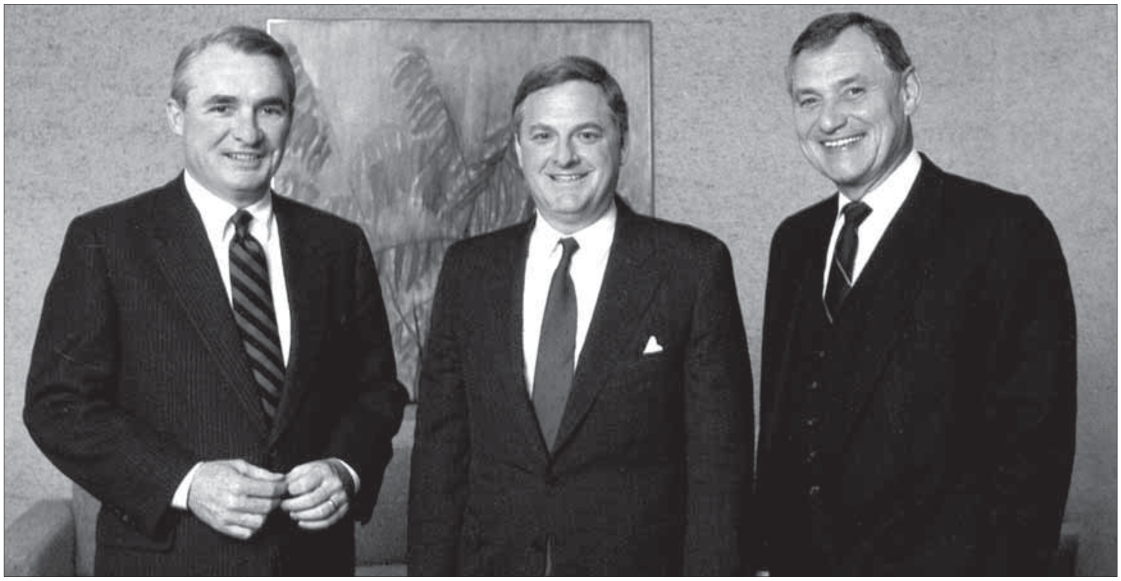
I. **Punch Card Prologue**

What are those?

They are hard to even find. About the only use for punched cards these days is in their unpunched form. They still make a great medium on which to write speech notes. The backside is nearly always plain and the size is perfect for your jacket pocket.



Lorne Lodge, a former President of IBM Canada, was using some cards for that purpose recently. He recalled that a young computer professional asked him “what are those?” Perhaps we should not be surprised that the current generation would not even recognize them. It has been at least a full generation since new data processing techniques totally supplanted the use of punched cards.



John F. Akers, IBM Board Chair, John Thompson, President & CEO, IBM Canada and Lorne Lodge, Chairman, IBM Canada

In fact their only recent revival in a public view was in the 2000 Florida election where improperly punched ‘chads’ led to hundreds of ballots being disqualified. We used to call chads ‘chips’ but whatever their name, this was certainly a knockout punch (no pun intended) for punched cards.

So who really cares about this electro-mechanical Disruptive Technology? Clayton Christensen in his 1997 book the *Innovator’s Dilemma* coined the term to describe revolutionary technological innovation. It is one that completely overturns a marketplace. There is no question that punched card technology did this. This alone makes it worth examining.

Punched card accounting was the first serious attempt to convert data into useful information for both industry and government.

It is probably correct to say that the huge growth of government could not have taken place without the enormous punched card files that were essential to the introduction of the New Deal social programs in the 1930’s or even the conduct of 20th century warfare. Certainly the growth of mega corporations such as those in the life insurance business, railroads or other massive undertakings could not have taken place without the mechanized handling of data.

A New Approach Looms

The idea was hardly new and the history of early attempts to find calculation aids goes back perhaps 50,000 years. There are examples of notched sticks and bones that have been dated to 30,000 BC. The development of early writing systems such as cuneiform approximately 4000 – 1200 BC were attempts at mechanizing business data processing.

As early as 1685, Gottfried Wilhelm Leibniz noted: *For it is unworthy of excellent men to lose hours like slaves in the labour of calculation which would safely be relegated to anyone else if machines were used.*

Gottfried Wilhelm Leibniz

However the development of mechanized data processing was well beyond the technical capability of any nation until the latter part of the 19th Century.

The events leading up to the punched card era are fascinating but are not the topic of this book. Only a few highlights are recorded here and these are primarily to illustrate the 'state of the art' at the time Herman Hollerith made his conceptual breakthrough at the end of that century.

Bearing in mind that all of Hollerith's equipment depended on the wide availability of electricity, anyone interested in the mechanization of data should start with the famous confrontation between Thomas Edison and Nikola Tesla on whether the future of the electricity industry would be with Direct-Current (DC) or Alternating-Current (AC). George Westinghouse settled the argument (one of the few Edison lost) by installing the first Alternating-Current electrical power system in 1886 leading to the adoption of AC as the standard in America. In turn, this led to the rapid economic deployment of the electricity so necessary for mechanization.

That same year saw another major breakthrough. William Burroughs founded American Arithmometer. The machine he developed, called the comptometer, was advertised as "the machine gun of the office". It was a key driven adding and listing machine and was the first key driven calculator that also printed its results. By about 1892, the machine added the ability to subtract (if this is not an oxymoron!).

However the comptometer and similar machines that were developed in the era were essentially 'one application' machines. They were fine for adding up data but if any analysis of that data was required, all of the information had to be re-entered.

Another Disruptive Innovation as Christenson later named his process was needed to really revolutionize the conversion of data into information.

The 'Hole' Story

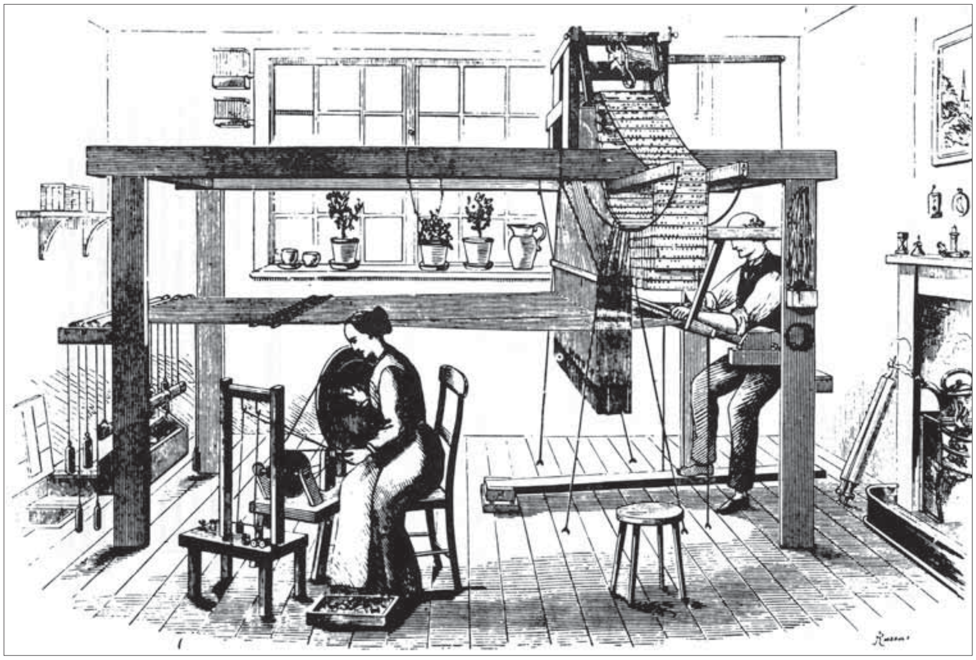
The idea of using holes in some medium as a control mechanism for a process probably goes back to Basile Bouchon in 1725. Bouchon used a perforated paper loop in a loom to establish the pattern to be reproduced in the cloth. However, the person who gets most credit for originating the conversion to punched cards is Joseph Jacquard who in 1801 used holes in cards as the programming method for his Jacquard Looms.

The Jacquard Loom

Charles Babbage adopted Jacquard's system of punched cards to control the sequence of computations in the design for his Analytical Engine in 1837. Amazingly enough for the era, this and a follow-on machine known as the Difference Engine might actually have worked but government funding for the project was cut off. In fact the Science Museum, London built a machine based on Babbage's design that did work as planned. There was a fascinating novel called *The Difference Engine* by Gibson and Sterling that speculated on what would have happened in the late 19th century had Babbage actually made his machine work.

For the sake of completeness, one should bear in mind that the idea of punched holes being used to control the sequence of a device also had applications in music. We are all familiar with piano rolls and punched card systems were actually used to drive organs. However back to the punched card and how it developed into the major data processing medium for the first half of the 20th century.

When Jacquard moved to punched cards instead of a perforated paper tape to control his loom, he did so to increase the ease with which control data could be changed. The unit record on a single punched card could be altered and then added back into a deck of punched cards. In these looms, the cards were actually strung together to form a program for the machine. However the flexibility of individual cards in the 'deck' became obvious.



The Jacquard Loom at work

The most important concept however was to get around the major limitation of machines such as those built by Burroughs and Felt and Tarrant by ensuring that the data only needed to be keyed once. When a single piece of data with its associated data fields was recorded on a punched card, that card could be sorted and used to extract different analyses without having to re-enter the data.

It was the original 'one-write' system.

Later the name Unit Record equipment was adopted by IBM to better describe the way in which the punched card was used.

Felt and Tarrant Comptometer

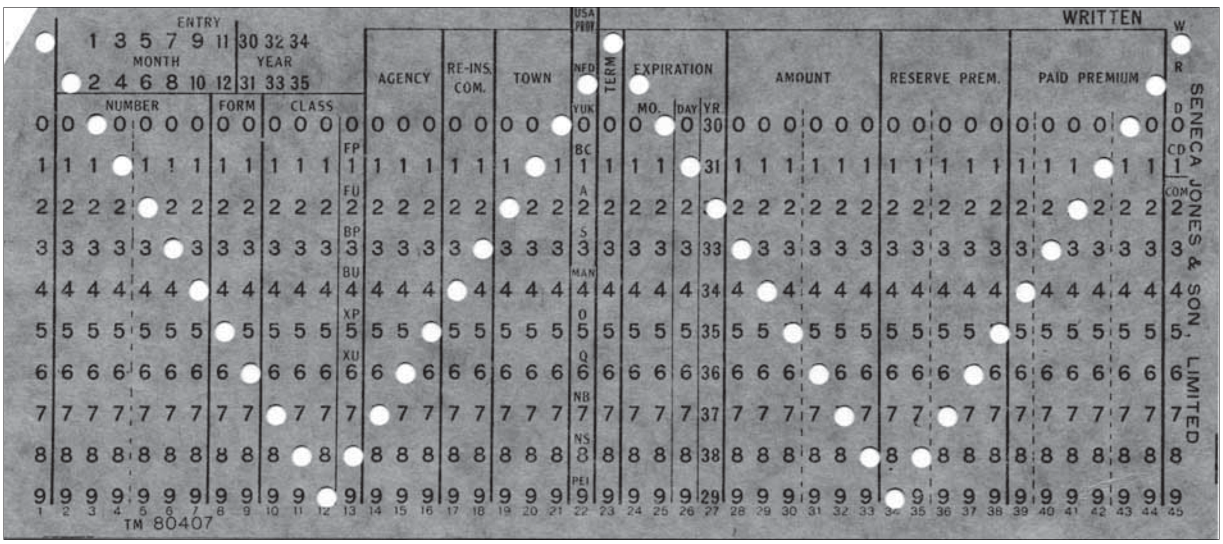
The 1890 Census

Early uses of punched cards for vital statistics took place in New York for their Board of Health in the late 1880s but it was a trial in St. Louis in 1889 that led to the acceptance of the punched card process for the 1890 Census.

The size of the original punched cards was copied from the US bank notes in use prior to 1929. These were somewhat larger than the current bank notes. The cards were $7\frac{3}{8}$ inches wide by $3\frac{1}{4}$ inches high with a thickness of .007 inches (187 x 82 x .178 millimetres). However the original punching format in 1890 was restricted to 24 columns with 12 punch positions in each. It should be noted that the coding on those cards did not take one column for each piece of information as was the case later. Rather each hole was assigned a specific meaning, e.g. male, citizen.

The original holes were round, a format that continued to exist in limited applications until the 1960's although it was largely superseded by the rectangular hole that we will discuss in a moment.

The capacity of the cards gradually increased until by the 1920s there was a standard format using 45 columns of round holes per card and 12 punched positions in each column.



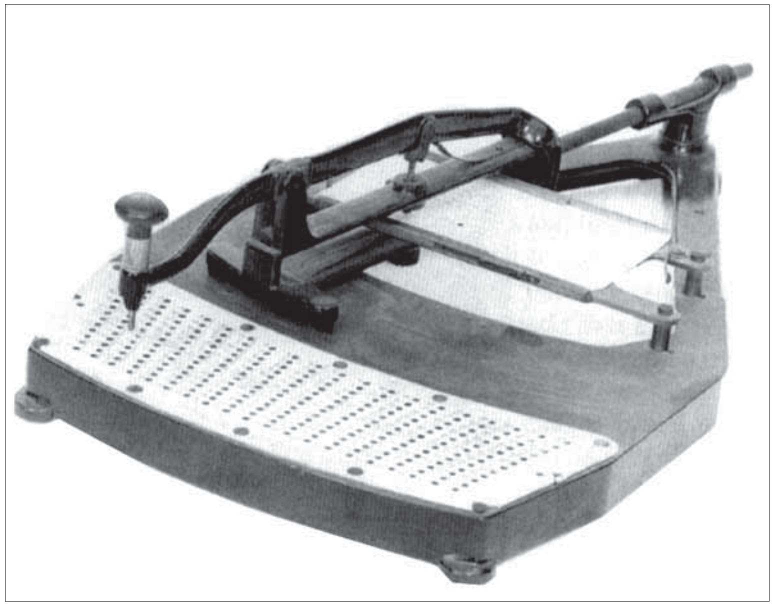
IBM 45 Column Round Hole Punched Card

As noted in the census application, each hole would indicate by its location whether the citizen enumerated was male or female, what age group they were in or similar data.

The punched cards were able to be read electrically. The holes in the card were sensed by pins dropping through the hole to make contact on a drum. This completed an electrical circuit and depending on the position of the drum, a counter in the tabulating machine would add one number. By the 1890 Census, the method of making contact had changed to a pool of mercury rather than a drum.

We will later look at various ways of punching cards but it is important to understand that in the initial application for the 1890 census, the only method of punching the holes in cards was a Pantograph. The card would be laid flat on the bed of the manually operated machine; the operator would select the digit he/she wished to punch by moving an arm over the appropriate spot and then manually punching the hole in the card. This was truly a unit record approach as this was limited to punching one hole at a time.

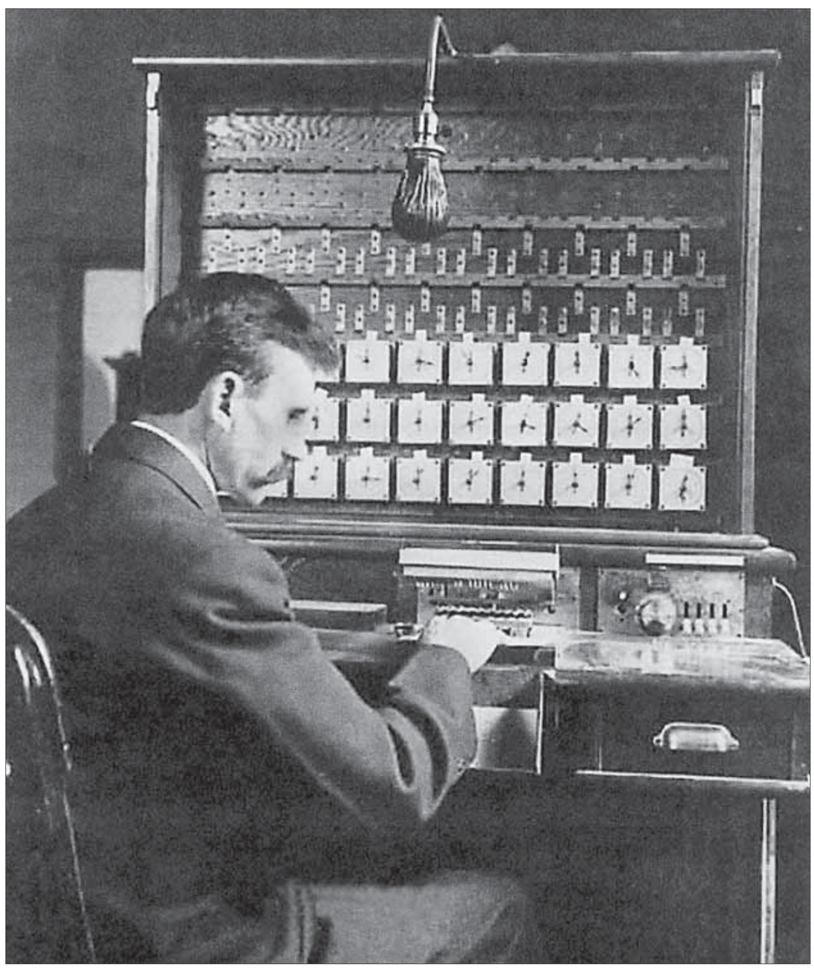
The operator had a template showing where the hole should be punched but it was to say the least a tedious process.



The Pantograph

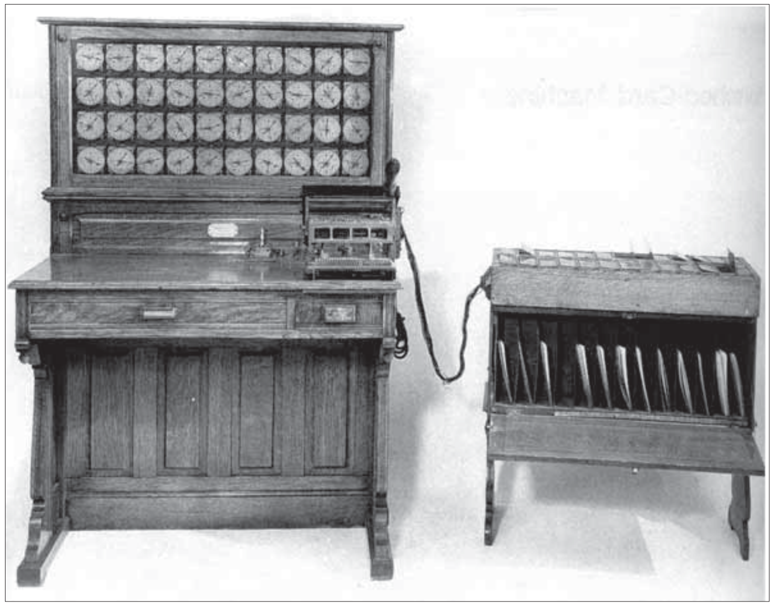
The Hollerith Electrical Tabulating Machine had a card reader although the cards were inserted into the reader one at a time. The early tabulator was simply a counting machine. It kept a running count of the number cards with a hole punched in the particular position. It had forty counters.

An experienced operator could tabulate 50 to 80 cards a minute. There was no printer. The results of a tabulation had to be read on the counter dials and written down by hand.



Early Hollerith Tabulator

The range of tabulations could be extended considerably if the cards were put in a useful sequence, e.g. sorted. Hollerith had devised a Sorting Machine which could sort the cards into as many as 24 categories, e.g. by country of birth. Based on the location of holes on the card, the lid on one of 24 sorter bins was automatically opened and the operator would put the card in that bin. The cards in different bins could then be tabulated separately for various purposes.



Tabulator with a Manual Sorting Device

We have now introduced the three most basic components of a punched card accounting system.

• The collection of the original data only one time by punching holes in a card.

• The sorting of the cards into a meaningful order for whatever the application may be.

• A tabulating of the cards by sensing the holes and having mechanical counters keep track of the results.

Herman Hollerith (1860 – 1929) had worked at the U.S. Census Bureau during 1879 – 82. It was then that he realized that machines such as those he conceptualized could dramatically reduce the time that would be required to process census data. In 1884 he applied for his first patent and as noted the equipment was used to tabulate census and mortality data in New York and a couple of other states. He then won a contract to supply such tabulating equipment for the 1890 U.S. Census. Interestingly enough from a Canadian standpoint, the Dominion Bureau of Statistics was one of the first to recognize the value of this approach and adopted such punched card equipment for its 1901 Census.

Punched Card Goes Commercial

Hollerith's first commercial customer was the Prudential Life Insurance Company. Two machines were installed at Prudential in 1891.

The next machines were installed at the New York Central Railroad in 1895. The advantage to the railroad was unbelievable as the Central alone processed nearly four million freight waybills a year at the time, each one by hand. The ability of the railroad to analyze who was shipping what and where on a weekly rather than a monthly basis was a tremendous step forward.

Hollerith's initial tabulators increased the totals displayed on the dials by one unit at a time. To handle the needs of railroad accounting, Hollerith developed integrating tabulators that borrowed an idea from the earlier adding machines of adding multi digit numbers as actually punched in the cards and totalling these amounts rather than just counting the holes. This was a huge conceptual advance.

In 1896, Hollerith incorporated his business as the Tabulating Machine Co. The company won the contract to supply tabulating equipment for the 1900 U.S. Census. In setting up this company, an interesting principle was established. The Tabulating Machine Co. did not sell the machines they produced. They leased them to customers. Considering the rapid changes and improvements, this was a very useful flexibility and was a practice followed by IBM in later years.

The obvious advantages of the punched card machines led to their rapid acceptance in the commercial field. In 1903 Marshall Field began to use Hollerith machines. In 1904 this was followed by Pennsylvania Steel. By 1908, the Tabulating Machine Co. had about thirty customers.

However not everything was smooth for Hollerith. In 1903, Simon North became Director of the U.S. Census Bureau. North set out to break Hollerith's monopoly over the supply of tabulating machinery to the Census Bureau. A conflict arose that led to the removal of all Hollerith machines from the Census Bureau.

The Bureau for the next few years moved to slower tabulating equipment supplied by Charles F. Pidgin. In 1907 the Census Bureau began to sponsor work by James Powers to develop an alternative to the Hollerith system. The Powers equipment was used for the majority of the 1910 U.S. Census.

It is interesting to note that the U.S. Census Bureau has always been somewhat of a maverick. As we will see later, they were one of the first to put the Univac into commercial use.

Powers set up Powers Accounting Machine Corporation in 1911 and the competition with the Tabulating Machine Co. moved into high gear.

In 1911 Hollerith's company merged with other companies to form the Computing Tabulating Recording Company (C-T-R). C-T-R was into other types of businesses including time clocks and weigh scales. However it was their tabulating equipment that would prove to be the major area of development.

Thomas J. Watson left National Cash Register to become President of C-T-R after disagreements with the NCR president John Patterson. He promptly set up a research department and soon C-T-R had vastly improved its products. By the end of World War I, almost every large insurance company and railway used the C-T-R machines with only minor sales going to Powers.

It is interesting to note that card manufacturing became a huge business in itself with C-T-R producing 80 million cards a month and adding a second plant in Dayton in 1918 producing another 30 million cards per month. Fred M. Carroll had developed the Carroll press, a rotary printing device for IBM cards that allowed such incredible volumes to be produced.

The Carroll Press

Not to be outdone, Powers began selling a line of alphabetic accounting machines in addition to its line of numeric machines. In 1927 Powers merged with Remington Typewriter, Rand Kardex and the Dalton Adding Machine Company to form Remington Rand Inc.

Although Remington Rand was to be a competitor for many years, by the 1920's, IBM had surpassed their sales and never lost their lead. By the beginning of the 1950's, IBM controlled 90% of all installed punched card equipment in the United States.

In 1924, C-T-R changed its name to International Business Machines Corp. (IBM).

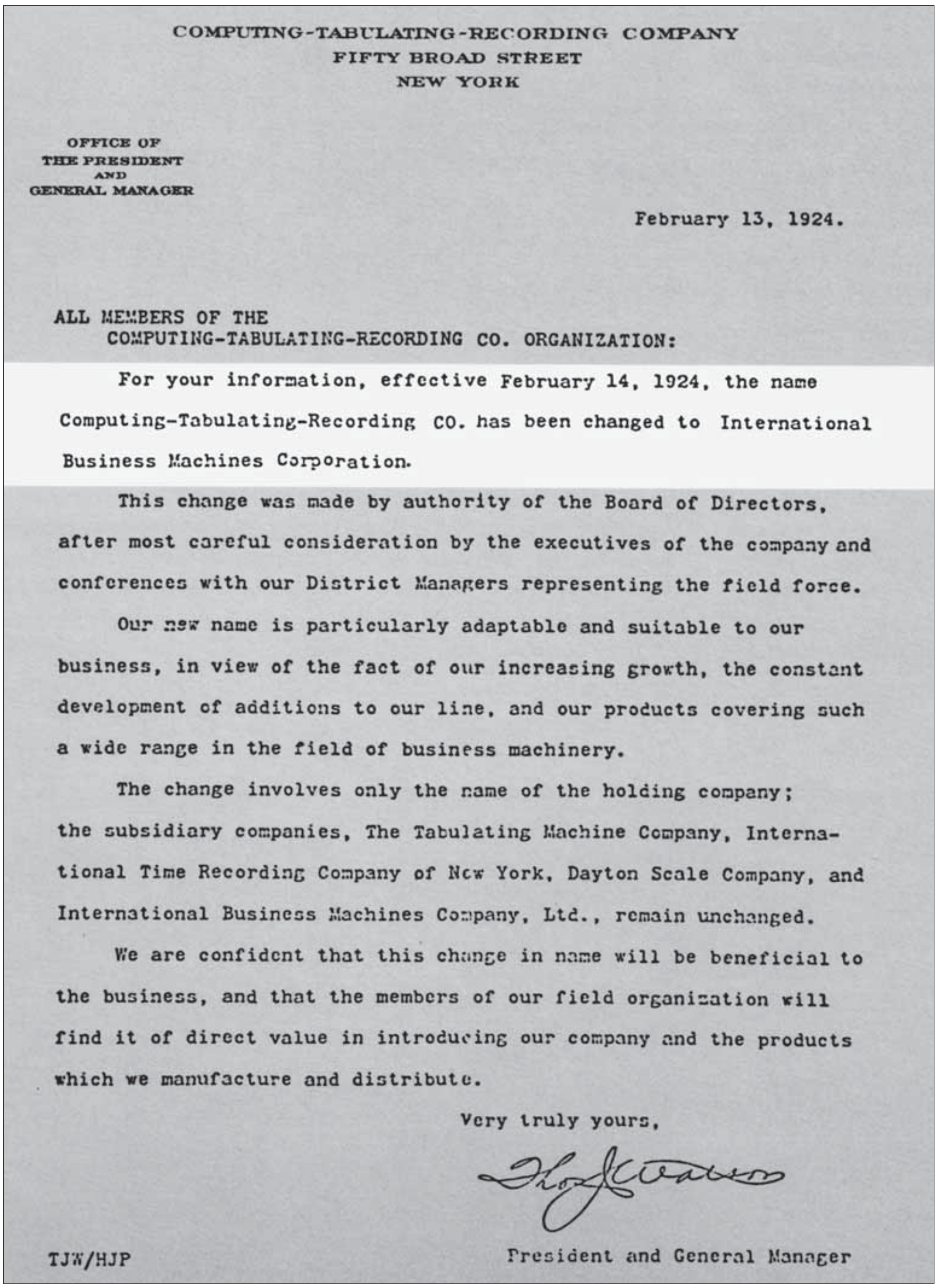
There is an interesting Canadian twist to this story.

"A Canadian named St. George Bond who was interested in the Hollerith machines received a license to establish the Canadian Tabulating Machine Company in 1910. His first customer was The Toronto Library Bureau. In 1917 the firm became incorporated in Canada as International Business Machines Company Ltd., a subsidiary of Thomas Watson's Computing-Tabulating-Recording Corporation (which later appropriated the Canadian branch's name)."
Northern Enterprise, Michael Bliss, Page 408

So the name IBM was first used in Canada.

Bliss goes on to note that by 1919 IBM had sales of more than $1 million of machines actually assembled in Canada. Several dozen of Canada's largest companies led by the railways and the life insurance firms had installed these systems in the 1920's. Canadian Pacific Railway was one of the leaders in this field.

We can now look at the development of individual components of punched card data processing systems, beginning with the cards themselves.



COMPUTING-TABULATING-RECORDING COMPANY
FIFTY BROAD STREET
NEW YORK

OFFICE OF
THE PRESIDENT
AND
GENERAL MANAGER

February 13, 1924.

ALL MEMBERS OF THE
COMPUTING-TABULATING-RECORDING CO. ORGANIZATION:

For your information, effective February 14, 1924, the name Computing-Tabulating-Recording CO. has been changed to International Business Machines Corporation.

This change was made by authority of the Board of Directors, after most careful consideration by the executives of the company and conferences with our District Managers representing the field force.

Our new name is particularly adaptable and suitable to our business, in view of the fact of our increasing growth, the constant development of additions to our line, and our products covering such a wide range in the field of business machinery.

The change involves only the name of the holding company; the subsidiary companies, The Tabulating Machine Company, International Time Recording Company of New York, Dayton Scale Company, and International Business Machines Company, Ltd., remain unchanged.

We are confident that this change in name will be beneficial to the business, and that the members of our field organization will find it of direct value in introducing our company and the products which we manufacture and distribute.

Very truly yours,

President and General Manager

TJW/HJP

Thomas J. Watson's letter of February 13, 1924 changing the name to IBM

Computing-Tabulating-Recording Co. and IBM logos through the years

Computing-Tabulating-Recording Co. logo from 1914

IBM logo and slogan circa 1937

A similar slogan was adopted from 1943-45 on the Canadian 5 cent coin with Morse code around the edges meaning: "We Win When We Work Willingly"

IBM logo circa 1954

IBM striped logo introduced in 1962

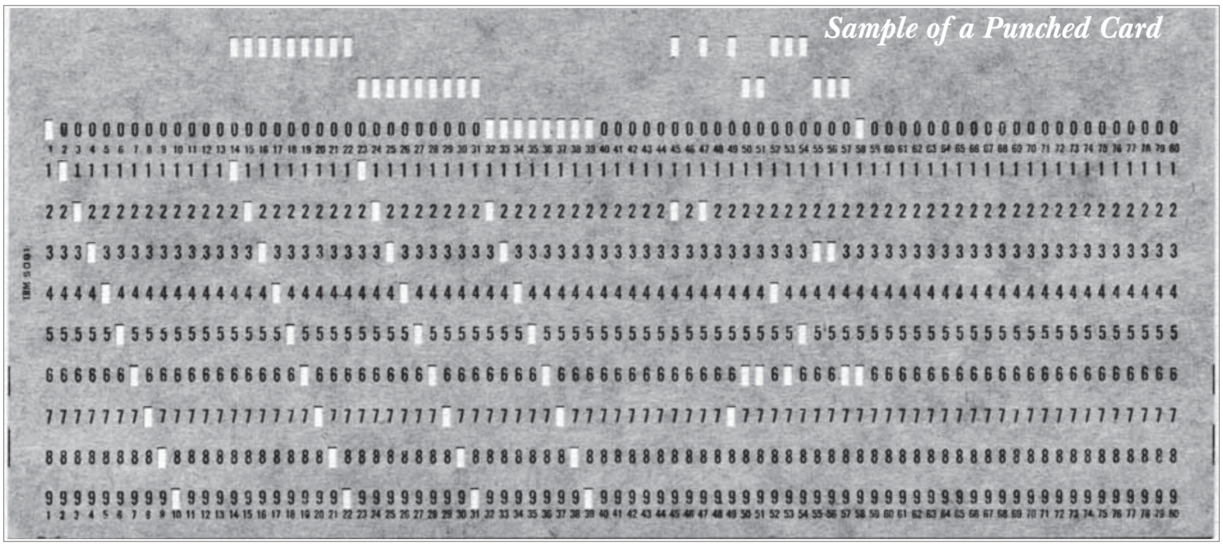
Round Pegs in a Square Hole

It's in the Cards

I briefly described the early development of punched cards using round holes sensed by pins dropping through the hole to make contact on a drum.

Remington Rand persisted with the use of round holes and developed a 90 column card. This involved dividing the card in two parts with 45 columns on the upper half and 45 on the lower half.

This format proved somewhat cumbersome for it made interpreting, i.e. printing the actual characters on the card somewhat awkward. This is a process we will describe later.



Sample of a Punched Card

The card that quickly moved to become the international standard was the IBM format of 80 columns with twelve punch locations in each. Each column could contain the digits zero through nine and had two zone punches known: 12 in the top row and 11 in the next row. These zone punches were used to code plus and minus signs and for a variety of other control functions. They were also combined with the digits to form alphabetic characters.

The breakthrough that allowed this format was to dispense with the pins dropping through a round hole and moving instead to a narrow copper brush that would detect the hole in a card while the latter was moving at high speed.

The narrow hole allowed 80 contiguous columns across the card.

This card format allowed a great deal of flexibility. As additional characters were required for more sophisticated applications, up to six punches could be used in any one column.

Although it was possible to use general purpose cards with just the numbers zero to nine printed for each column (card type 5081) or perhaps with a line running vertically every four columns to help read the holes (card type 733727), it was more common to print cards for specific applications. Each group of columns would then be labelled customer number, quantity, cost, etc.

It was normal that the cards would have the corner cut, most frequently in the upper left hand corner so that in a deck of cards it would be easy to spot one that was inserted backwards or upside-down.

The cards came 2000 to a box or about 143 cards to the inch. A group of cards is called a deck.

The cards could also be on coloured stock. This further helped the manual perusal of a deck of cards, e.g. customer name and address cards that could be used over and over might be of a different colour than the transaction cards that would be created especially for each application.

Do not fold, spindle, or mutilate

The title of this book is hardly original. In fact it is taken directly from a warning commonly printed on cards that were going to be circulated to the general public, e.g. punched card cheques or utility billing notices.

Obviously one would not want a punched card to be folded as this could easily cause a jam in one of the machines.

Mutilating the card would be equally undesirable, e.g. tearing it.

Almost no one today knows what a ‘spindle’ is. However it used to be common for employees to have a simple block of wood with a nail driven up through it on which used transaction notices, e.g. an order in a restaurant, could be stuck. This of course created a hole which would wreak havoc with the accounting machine. The idea was that a string could then be run through the holes when the items were removed from the spindle and these could then be stored for audit purposes.

You still see such an approach used occasionally but it has pretty well gone the way of carbon paper.

In fact Steven Lubar of the Smithsonian Institute wrote a very amusing article in May 1991 by the same name as this book outlining a cultural history of the punched card. It is very insightful as well as humorous. It covers the alleged dehumanization of people by punched cards. He even quotes a student at Berkeley as saying “I am a student. Please don’t fold, spindle or mutilate me.” His talk is available on the Web.
http://ccat.sas.upenn.edu/slubar/fsm.html

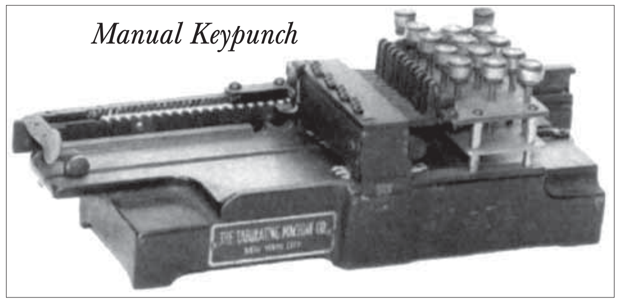
There was apparently even a murder mystery with the same title in the 1930’s although it had nothing whatsoever to do with punched cards!

So the IBM card became ubiquitous. We can now take a look at the wonderful machines that were designed to process the decks of cards.

A Real Punch-Up

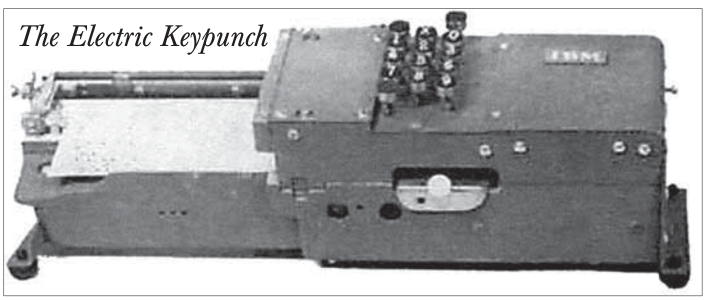
We talked briefly about the Pantograph Punch that was developed for the 1890 Census. While this had the advantage of allowing holes to be punched anywhere on the card rather than around the edge as a train conductor's ticket punch would do, it was still a painfully slow process. It allowed only the punching of one hole at a time.

A skilled operator could punch seven hundred cards a day. However the obvious answer was to devise a card punch with keys for each of the digits and some mechanism to have the card to progress logically from column to column, i.e. moving the card rather than moving the punching mechanism.



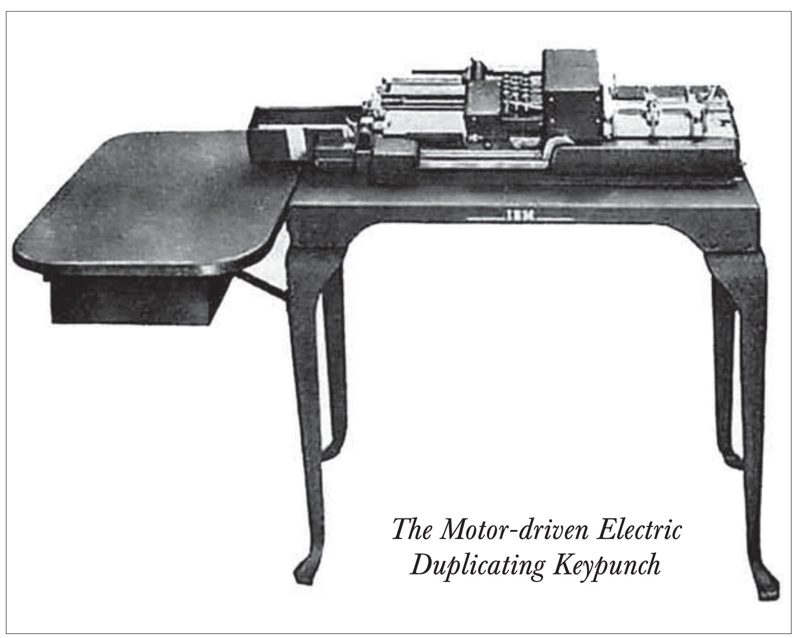
Manual Keypunch

The answer was Herman Hollerith's Type 001 manual numeric keypunch. This was patented in 1901 and is generally considered to be the first keypunch. It allowed the skilled operator to punch 200 – 300 cards an hour.



The Electric Keypunch

In 1923, IBM brought out the 011 Electric Keypunch. This was obviously a boon to the operator who no longer had to use manual pressure to punch the hole.

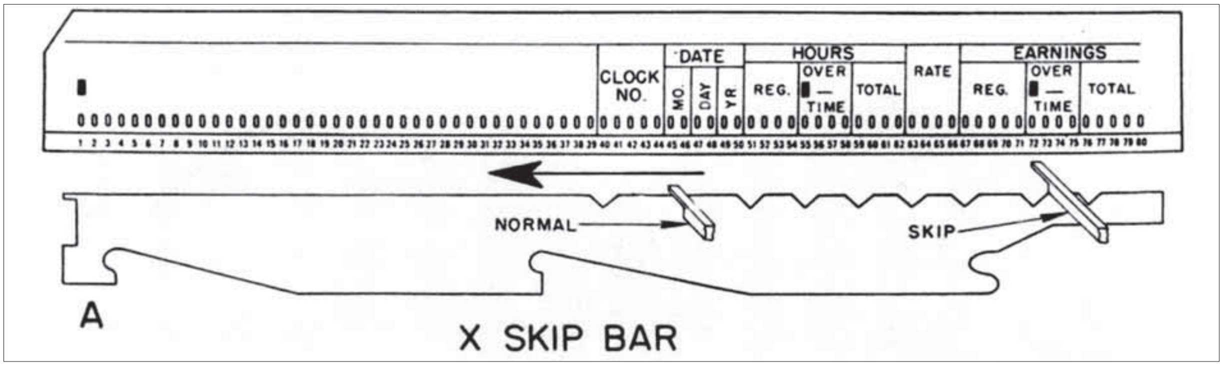


The Motor-driven Electric Duplicating Keypunch

Remember that prior to 1928, IBM cards were punched with round holes and only with 45 columns.

With the introduction of the rectangular hole and the 80 column card, IBM brought out a new device called the 016 Motor-driven Electric Duplicating Keypunch (1929). This was IBM's first punch with automatic feeding and ejecting mechanisms. Believe it or not it was marketed until 1960.

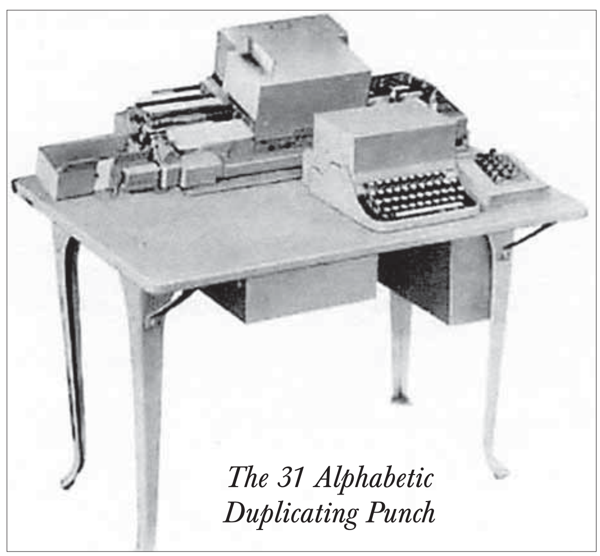
It is worth pausing for a moment to look at how this and subsequent electric keypunch machines moved the card through the punch bed. Obviously the only sensible way to feed the card was starting at the left hand edge, i.e. column one. However it was quite normal to want to skip certain fields and this was accomplished by the use of a Skip Bar. This was simply a narrow strip of fibre board the length of the card. It could be filed to indicate areas that were to be punched as opposed to skipped and V marks could be filed into the Skip Bar to indicate the start of particular fields, e.g. a rate field starting at column 63.



The Skip Bars were laborious to cut and I well remember filing these malicious devices only to end up putting one V in the wrong spot and having to start over. Fortunately they were replaced through most of my time at IBM. However the Skip Bar was actually used in a calculator called the 602 and therefore had a reasonably long if unloved life.

It is not worth tracking through all the early models but there are a few highlights. In 1933 the 032 Printing Punch was the first machine capable of punching letters as well as digits and most importantly could interpret the punches by printing the appropriate letter or digit across the top of the card over the appropriate column.

Operators became very good at reading the holes in the card but of course having the hole interpreted and printed on the top of the card was a great boon.



The 31 Alphabetic Duplicating Punch

There was a non printing model brought out in 1934 called the Type 31 Alphabetic Duplicating Punch. It had a typewriter-like keyboard and a separate numeric keypad.

The term duplicating meant that the Punch had the ability to duplicate information from a master card so the operator did not have to re-key constant information, e.g. a store number.

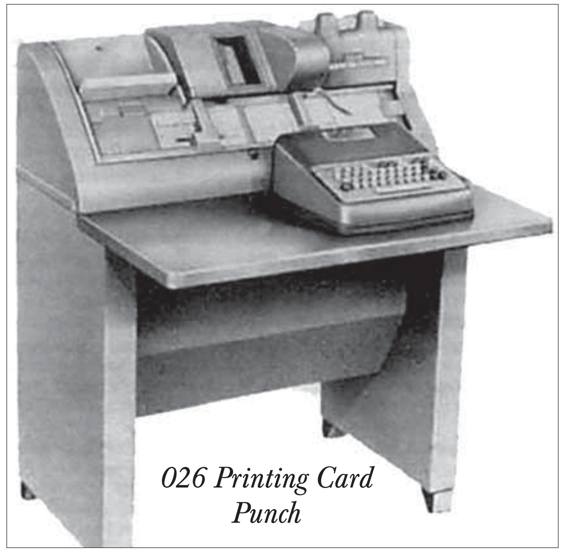
These machines carried IBM through the 30's and lasted until well past the end of World War II. There were still a number around in accounts that I serviced in the late 1950's.

The Post War Era

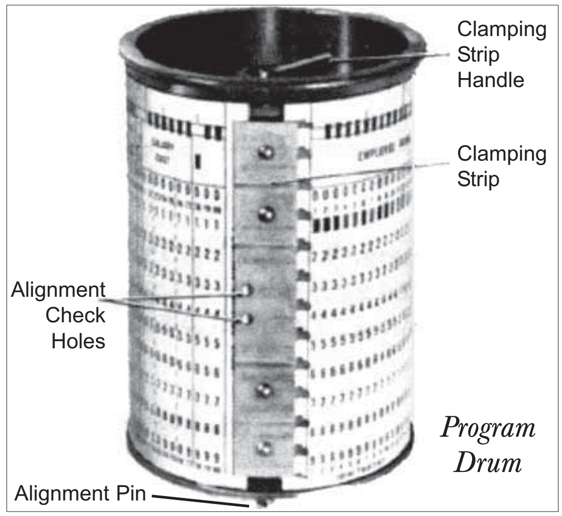
Everyone welcomed however the announcement in 1949, of the 024 Card Punch and the 026 Printing Card Punch. These two machines became the standard punches until the end of the Punched Card Era.

With the advent of these machines the Skip Bar was on its way out. This was replaced by a Program Drum on which a standard IBM card could be placed. The punches in the Program card that would now control the skipping, duplicating or other features including alpha-shifting. The cards could be easily produced and changed for each application. In fact you could put two programs on one Program card and switch between them with a Program Select switch.

The only difference between the 024 and the 026 was that the latter printed along the top of the card.



026 Printing Card Punch

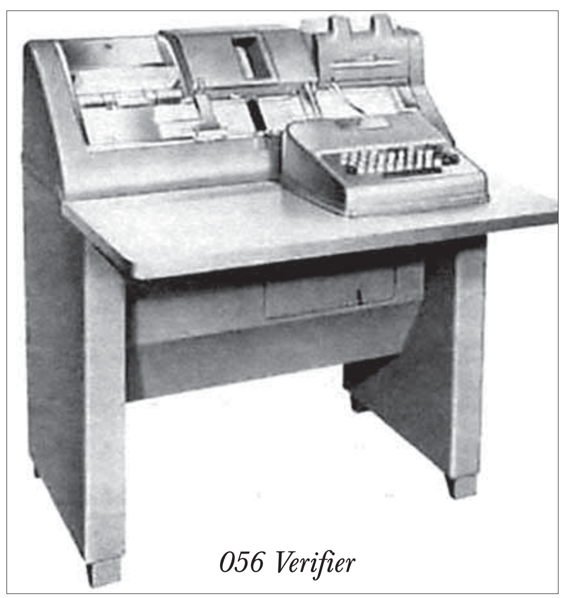


Program Drum

To Err Is Human

If the whole principle was to create a one-time record of a transaction which would then have multiple uses, it was essential that the initial recording be accurate. In later days, computers could be programmed to do “sanity checks” on the data, e.g. in a Census application, if someone was recorded as being 10 years old, it was almost certain they would not be married.

However the most common way of verifying the data was to re-key it using a separate machine called a Verifier. The complementary Verifier to the 024/6 was the 056, also announced in 1949. It looked almost identical to the card punches but as the operator re-keyed the information from the original documents, the machine would stop if what she re-keyed did not match with that of the originally punched card. If on a second re-key,



056 Verifier

it still appeared that the original card was wrong, the Verifier would put a notch at the top of the card over the offending column. The card would then be duplicated on a card punch up to the point of the notch and the correct character inserted followed by the duplicating of the rest of the card.

Cards that were properly verified received a notch in the right hand end of the card so that one could visually check that a deck of cards had all been verified.

The End of the Line

To bring the story up-to-date, an expansion of the number of symbols in the character set was needed with the announcement of the System /360. This required a new keypunch, the 029. This punch could handle 64 characters, sufficient to program in FORTRAN, PL/1 and COBOL.

029 Key Punch

The last key punch was announced in 1971. The 129 was an 029 with a buffer memory allowing data to be entered, checked and edited before committing it to the card. It could store up to six different formatting programs (equivalent to the Program Drum cards) and had enough capacity to be able to accumulate simple totals, primarily for balancing purposes.

It is interesting to note a couple of conceptual breakthroughs. The replacement of the Skip Bar by a Program Card was a realization that the Medium is the Message. One could use the data in a punched card to control the handling of other punched cards. This was something of a precursor to the idea of Stored Programs that we will cover shortly.

The second was the use of electronic memory in the 129. This was an obvious step although soon the whole process of punching was superseded by direct input to computers or direct recording on some medium such as magnetic tape.

In any case this now brings us to where we can examine how to get useful information from the data in the punched card.

Hoping to Avoid a Jam

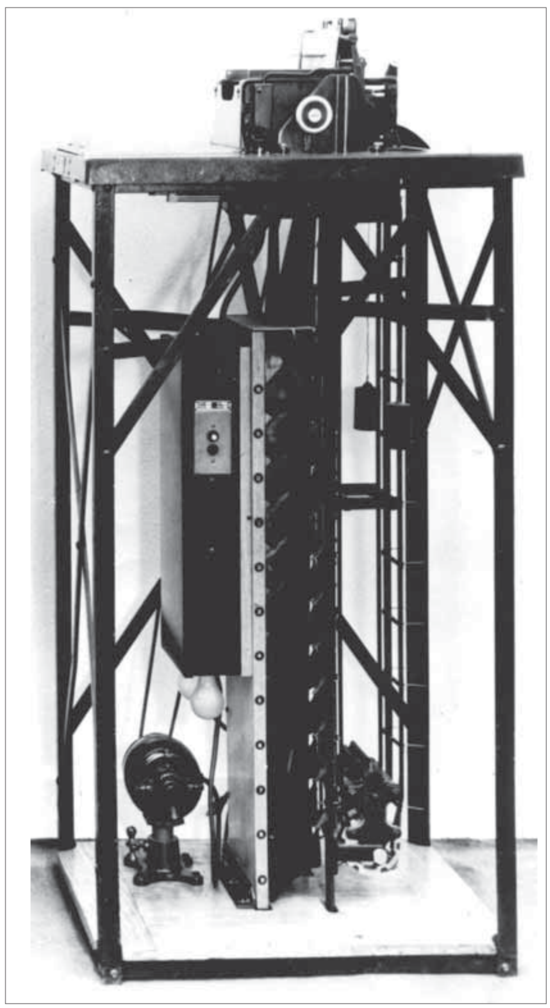
We have mentioned that the great advantage of the Unit Record concept was to allow the data to be reordered into any desired alphabetic or numerical sequence. To use a simple example of a billing application, one could assume that if a customer ordered 25 items and a single card would be produced for each item. The card would record the item number, description, quantity, cost, discount information, date ordered, customer number or any other relevant information. Once these cards had been put together with customer name and address cards and possibly special cards indicating particular discounts due to that customer, they would be used to produce the customer invoice. Then the item cards could be sorted together with those from other orders to produce reports on how many of a particular item were sold in a certain period, to update inventory records and to reorder the item as appropriate.

This would involve sorting the cards by item number.

Getting It Sorted Out

As noted, the earliest Hollerith sorting machine brought out in 1890 was a horizontal device that read a card fed manually. It had unit counters to record how many cards had a particular punch and could assist in sorting these into 24 categories. Based on the location of holes in a card, the lid on one of 24 sorter bins would automatically open and the operator would put the card in that bin.

In 1908, Hollerith brought out an electrically driven vertical sorter. With an automatic feed it was capable of sorting 250 cards per minute. It sorted into 12 pockets. The reason for making this vertical rather than horizontal was to reduce the floor space. While the organization using the device may have thought this was a great idea, the operators referred to it as the 'backbreaker'. Fortunately these machines were long gone before I had anything to do with them.



The Vertical Sorter

A horizontal sorter called the Model 75 capable of 400 cards per minute was announced in the late 1920's. A somewhat slower model called the Model 2 (250 cards per minute) also had a unit counting device on it, i.e. it could count the number of cards sorted into each pocket.

Sorting Principles

Unlike many of the later machines, sorters had only one Sort Brush which could therefore read only one column at a time. The cards were fed horizontally, face down nine edge first. The Sort Brush could be moved over the desired column and the cards were sorted into 12 pockets (there was also a 13th output pocket for rejects).

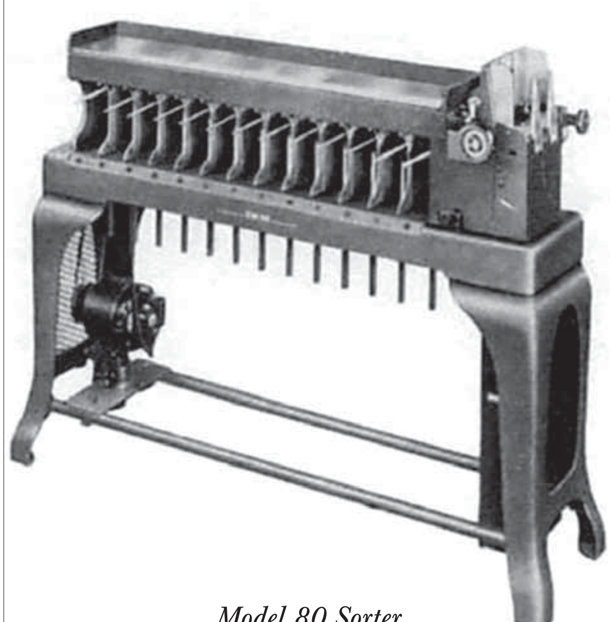
The sorting procedure was tedious in the extreme. If one had a five digit product number for example and wanted to sort the cards to put all like items together, one would have to start with a single pass on the unit column, the cards would then be pulled from the sort pockets in order and the process repeated for the second column, and then the third, etc. Eventually the entire deck would be in numeric sequence.

As one could imagine, sorting alphabetically was even more complex.

As some of the card decks had tens or even hundreds of thousands of cards, the chance of making an error was reasonably high.

Worse than that, cards jammed in the machines from time to time. The resulting pieces of 'confetti' had to be carefully reassembled and the card re-punched. Most sorting stations had a card punch close by for this purpose.

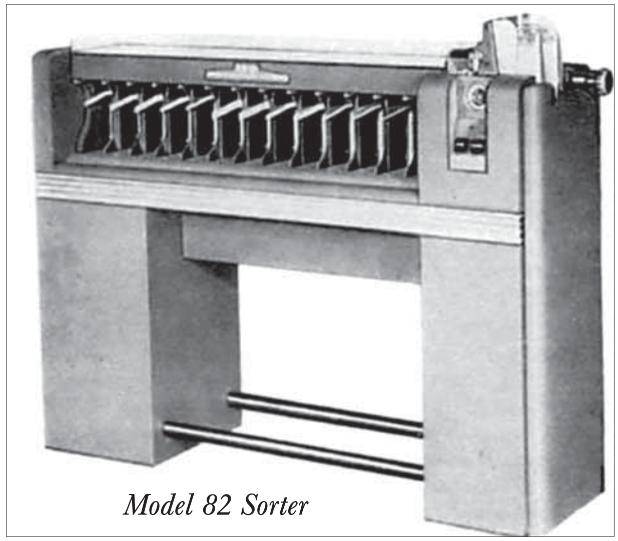
One could manually check that all of the nines or eights or whatever in a particular column were lined up by looking through the holes although this was difficult if there were many cards. Using a Sorting Needle was a better alternative. This was simply a metal needle slightly smaller than the rectangular punched hole with a loop on one end to hold on to. This could be inserted through the appropriate deck in the desired column and row to determine if the sort had been done correctly. Again this was unbelievably tedious and as we shall see, the accuracy of the sort could be checked by running it through a Collator which amongst other things could check the sequence.



Model 80 Sorter

Minor improvements were made to the Model 75 and about 1925, a new Model 80 was brought out sorting at 450 cards per minute.

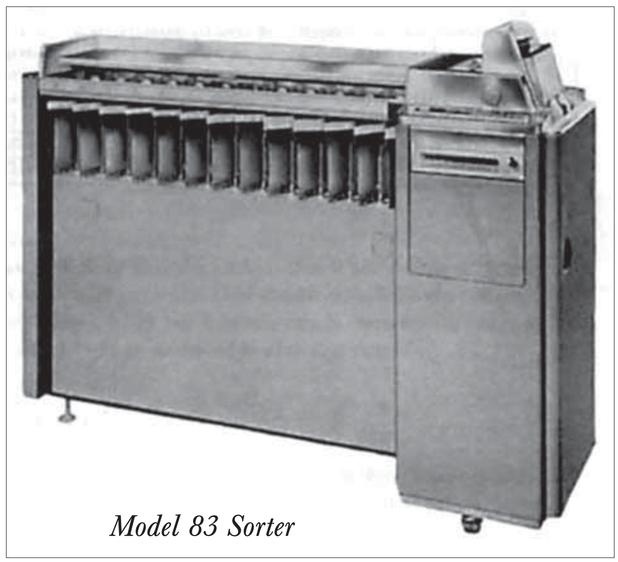
The most ubiquitous sorter however was the 082 brought out in 1949 with a speed of 650 cards per minute.



Model 82 Sorter

The speed of sorting machines gradually increased. The 083 sorter ran at 1000 cards per minute while the 084, the last announced card sorter ran at 2000 cards per minute. Needless to say this meant that card jams could occur even faster.

The 084 was unique in that it used a vacuum-assisted card feed mechanism that did not require the use of a card weight (a weight the size of a card that went on top of the deck of cards in the feed mechanism to hold the last card down).



Model 83 Sorter

The 084 also used an optical method of reading the card punches instead of the wire brush.

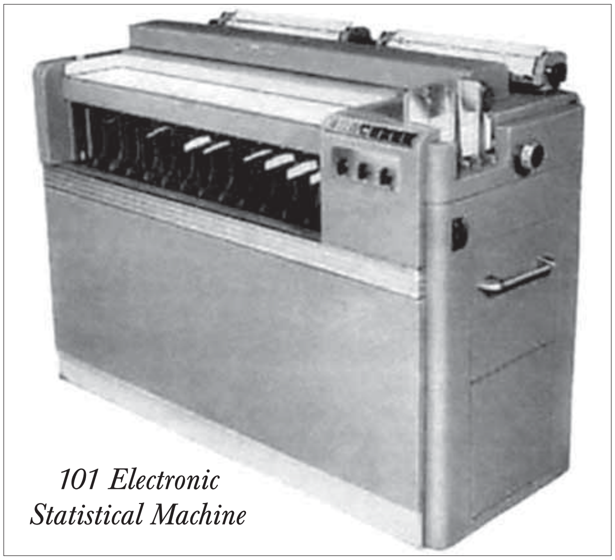
The down side to the 084 was that it was almost too fast. It had an extended card hopper but the pockets into which the cards were sorted filled up so quickly that it was difficult for the operator to keep up. The machine therefore had a somewhat limited use. It was also pushing the limits at which punched cards could be read (for some reason, IBM did not produce a card reader that operated at 2000 cards per minute which might have been a useful input device for computers as they became more common).

The Hybrid Sorter

There was one machine that should probably be included in the description of sorters. However to some degree, it was also an accounting machine. This is the 101 Electronic Statistical Machine.

It looked like a regular 082 sorter having the same number of pockets and being able to sort 450 cards per minute. However it was designed for not only sorting but also counting the number of cards with particular punches. It came in two models, the first having 60 unit counters and a less expensive model with only 15 unit counters.

Like the early Hollerith accounting machines, these counters only counted the holes in the card and could not accumulate totals by adding up numbers.



101 Electronic Statistical Machine

One might wonder what use such a machine would be. However I actually installed one at General Motors in Ottawa for the purpose of Truck Option analysis. GM produced many different models of trucks and each of these could have a wide range of options as is true today. These could include the colour, various interior features, horse power of the engine, etc. It became very important to analyze who was ordering what so that inventories could be properly balanced. The machine was relatively rare but was an interesting addition to the line.

It did have a removable Plug Board and therefore is an interesting transition to the next section.

By way of interest, the 60 unit 101 rented for U.S. $450 per month and the 15 unit model rented for $195 per month.

By comparison, an 082 Sorter rented for U.S. $60 per month.

Before moving to the other machines in a typical punched card installation, we need to examine another concept.

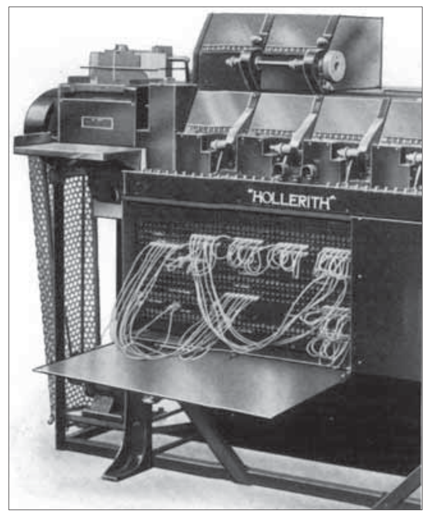
Getting Plugged In

To a limited degree as we have seen, the key punches were 'programmable' first with a Skip Bar and then with a Program Card.

Essentially sorters did not have a program (although a couple of later models had the ability to change a bit of wiring to allow the selection of particular digits in particular columns).

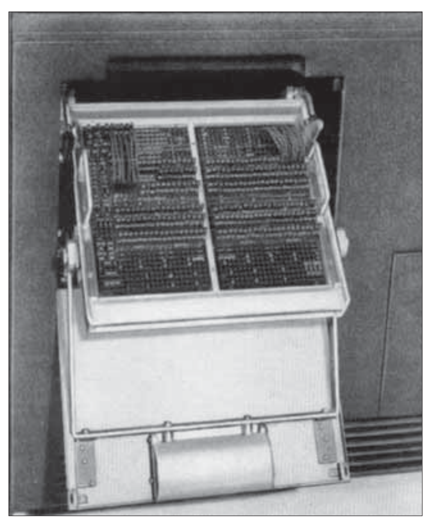
However all the other machines in the punched card family needed to be instructed as to exactly what they were to do.

Essentially all punched card machines were delivered as general purpose pieces of equipment. The operator 'completed the wiring of the machine' to make it do a specific job.



Permanently Attached Plug Board

Initially this was done by using pluggable wires that fitted into a control panel that was in turn built into the machine. If for example one wanted a particular column of the card to be printed in a particular location on a tabulator, a wire would be placed to take the impulse from one of 80 holes representing the columns in the card to a hole in the panel representing a particular print location. This is very similar to the operation of the telephone switching devices that connected calls by physically plugging a wire from the incoming call location to the desired outgoing call location. Such manual telephone switchboard operations were still in place in rural communities into 1950's.

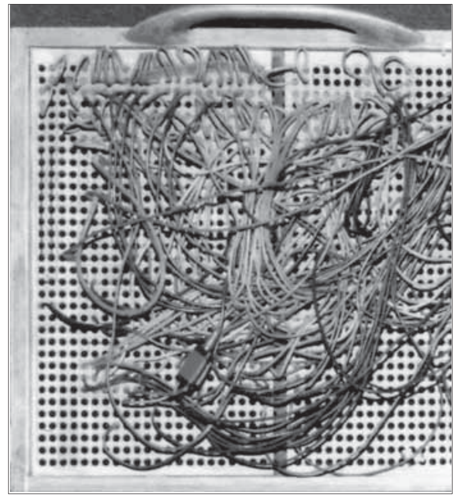


Removable Panel in a 519

For the accounting machines however this meant that each time a new job was to be run, the Plug Board had to be rewired.

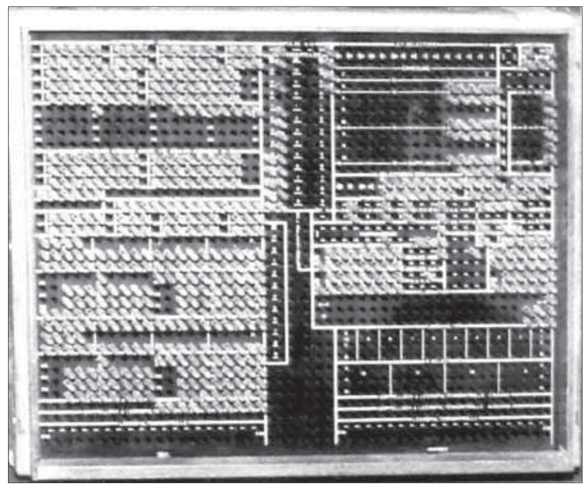
The obvious solution was to make the Plug Board itself removable so that it could fit into a rack on the side of the machine. A lever at the top would be pulled down and the Plug Board would be pressed against contacts in the machine. The Board could then remain permanently plugged for each application.

The wires used in the Plug Boards, or Control Panels to use their more correct name, were of two types. During the design and test phase it was usual to use wires of varying lengths and colours with tips on either end that allowed the wires to be easily removed. These tips had a copper contact point and when the panel was pressed against the internal contact points the circuit was completed turning the general purpose machine into a special purpose machine for that particular application.



519 Panel with Removable Wires (front)

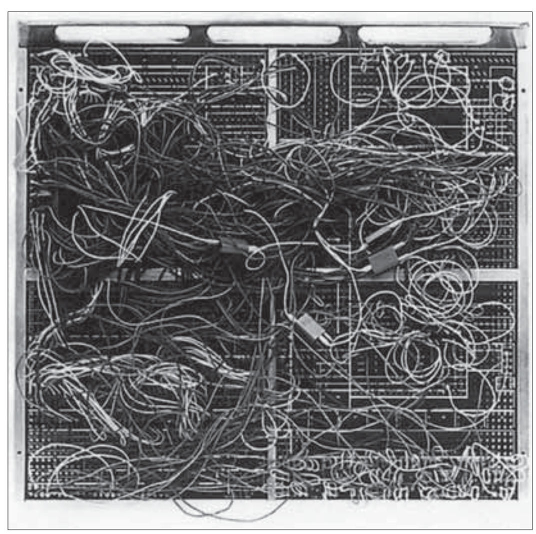
Once the panel had been tested, it was the usual practice to replace these temporary wires with semi-permanent wires. The only difference was that the semi-permanent wires had tips on either end that clicked into place, much in the way a locking screw expands slightly on the other side of the hole. These wires could be removed but only with a special pair of long nosed pliers. This meant that the panels which were regularly inserted, removed and then stacked in racks were less likely to have the wires jiggled loose.



519 Panel with Semi Permanent Wires (back)

The complexity of many of these panels was intense. The wiring often looked like a large bowl of spaghetti and it was sometimes literally difficult to get your fingers into already crowded areas of the board to insert additional wires.

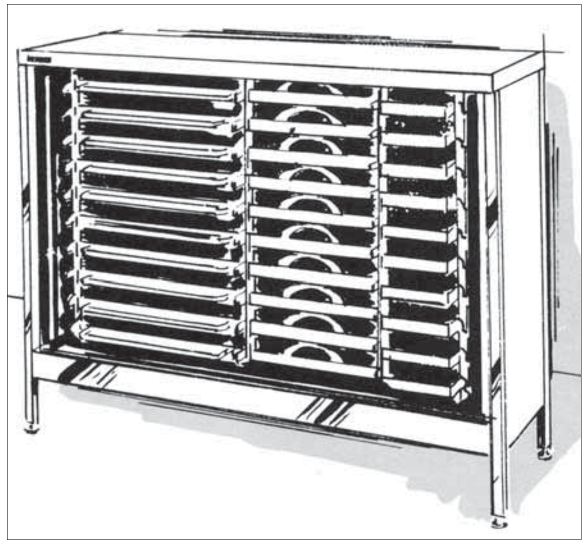
This is hardly surprising as each machine had to be minutely instructed as to which columns from a card to read, which fields were to be calculated and exactly where on a form, often pre-printed, the resulting data needed to appear.



407 Panel

As you can imagine, the panels for the more complex machines were fairly large, sometimes more than two feet square and when loaded with wires were quite heavy. However they served their purpose as a primitive way of programming machines.

When not in use, the panels were usually stored in specially designed racks. A huge business was soon built up providing auxiliary equipment for punched card installations, e.g. card racks to contain decks in various stages of sorting, card drawers in which to store files required for later use, the panel racks just mentioned and innumerable other devices, such as Tub Files which will be described in more detail.



Storage Rack for Plug Boards

Without leaping ahead too far, we need to briefly consider what goes on in the 'interior' of a typical Punched Card Accounting Machine. In order to give the programmer, if you wish to call the person wiring the Control Panel by that more sophisticated name, all the flexibility required, the machine had to have ways of allowing that flexibility. For example, Selectors were provided that could be activated by holes in the card (an X or 11 punch which was in the row second from the top or a Y or 12 punch in the top row). The Selector which was really just a switch could change where a field was printed or how it was calculated in line with the instructions on the Control Panel.

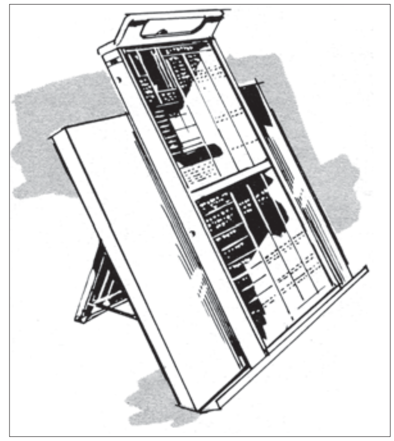
There would usually be a Digit Selector that would allow the programmer to do one thing if there was a nine punch in a particular column or another thing if there was an eight punch and so on.

All the machines operated on strict timing cycles (a practice also followed in early computers). Each machine effectively counted the cycles row by row as the card was read into the machine. You may recall my noting that a Card Sorter read the cards face down nine edge first. An accounting machine read the cards the same way although this was not the case with all IBM machines as we shall see in the next section. Fortunately all the machines had a label on the card feed indicating which way the cards should go!

For the sophisticated Plug Board plugger, an IBM manual would provide a timing chart in the back. This indicated exactly when during each card cycle particular impulses would become available and had to be used in time to cause a specific action to take place, e.g. a selector to be activated or left in its original position. Good programmers became very adept at using any available cycle that would be there in time to activate something they wanted to do. This practice used to drive the Customer Engineers (IBM's very talented maintenance people) to distraction as it was not always obvious why a particular wire in the Plug Board would be in a particular location.

This was the same type of sophistication in a more primitive fashion that has been used by computer programmers ever since, i.e. using imagination to go beyond what the machine's designer had planned.

Despite the fact that the programs on the Plug Board were not alterable other than by physically moving the wires, they did provide an amazing flexibility to make binary or multiple decisions based on conditions recognized in the incoming cards.



Stand for Wiring Plug Boards

With that general explanation, we should take a look at the more complex components of a punched card accounting system.

A Calculating Design

You may think we are never going to get to the place where an actual invoice, payroll cheque or other final document is produced. However there are a few more steps that we have to go through.

All the steps in the punched card accounting process had to be performed sequentially. This of course did not mean that you could not be sorting for one job while calculating another but for each individual application, the steps had to be performed in a very definite order.

After the original data had been recorded on a punched card, it was quite common that calculations had to be performed, e.g. quantity ordered X price X discount. These results would then be punched in another vacant field on the card.

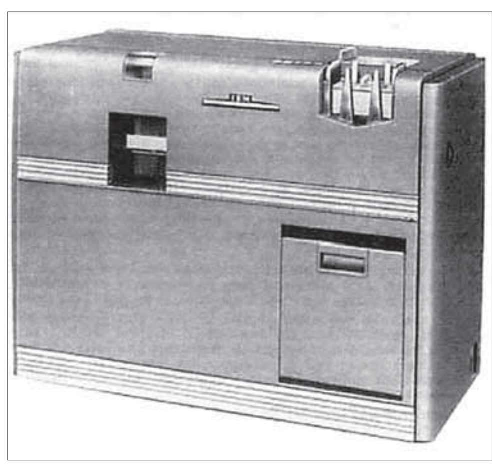
Until the advent of computers, multiplication and division had to be performed by a separate machine. Tabulators did not have that capability as they could only add and subtract.

So let's begin with our usual historical review.

In 1931 IBM produced its first multiplying punch, the 601. This machine could read cards (now fed face-up, column one first, i.e. lengthwise). It could add, subtract or multiply fields on the card and punch the result in the same card. This implied of course that the factors had to be in the early part of the card and the field for the answer in the latter part of the card.

This machine controlled the fields in the card by the much maligned Skip Bar.

The 601 could not divide. It was not until 1944 when IBM brought out an intermediate machine designed for World War II work called the Pluggable Sequence Relay Calculator or Aberdeen which had the capability of dividing.



602-A Calculating Punch

It led to the first general purpose calculating punch, the 602 which was announced in 1946. This was a commercial version of the Aberdeen. I will not spend much time on the 602 as it did not last long.

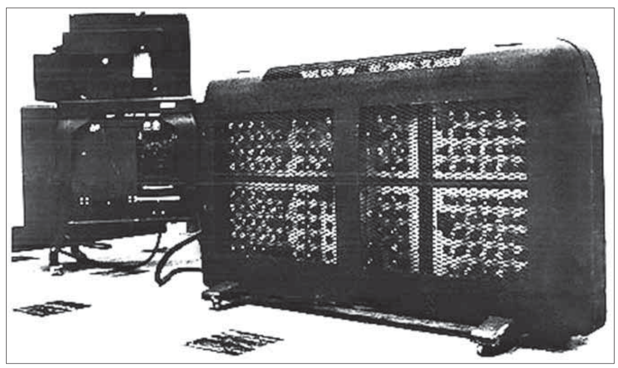
In 1948 it was replaced by the 602-A which was described as "a 602 that worked".

The 602-A and I never really got along. As was true of all the machines to this point, it was strictly an electro-mechanical device filled with counters. The machine was very slow as would be expected. In fact the speed depended on the number of calculations and the number of machine cycles required to do these.

I remember in my training class at IBM Don Mills in Toronto (run by Bob Beggs – it was the first formal training class run for IBM Salesmen in Canada), the challenge was to wire a 602-A to do a simple calculation. The aim was to reduce the number of machine cycles used to an absolute minimum and thereby maximize the throughput of this mechanical monster.

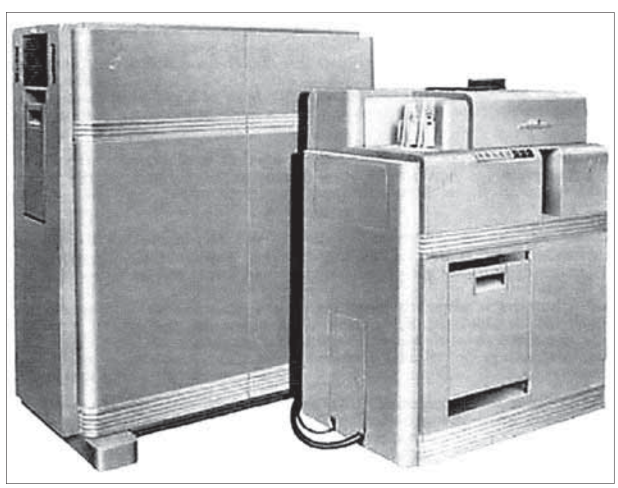
By looking at the aforementioned timing charts, I figured that one could actually execute a multiplication on the read cycle from a prior card. As long as one put a dummy card in first, this would mean that effectively the calculation of one card was overlapping the reading of the next. While not very practical, this approach caused the 602-A to process the cards at breakneck speed (for it anyway!). For once I passed the test with flying colours!

Fortunately the days of the 602-A and its mechanical predecessors were limited. In 1946 IBM began experimenting with the use of electronic calculating based on vacuum tubes. It briefly produced an electronic multiplier called the 603. As the name implies this could only multiply.



603 Electronic Multiplier

It was shortly replaced (1948) by the 604 Electronic Calculating Punch. The 604 performed additions, subtractions, multiplication and division hundreds of times faster than any of IBM's earlier electro-mechanical machines. It was the first IBM product to use modular vacuum-tube based pluggable units, later used in IBM's NORC and 701 computers.



604 Electronic Calculating Punch

The 604 was programmable by the ubiquitous Plug Board and could execute a program of up to 60 steps. It actually came in models with 20, 40 and 60 steps.

It contained 1100 vacuum tubes in a stand-alone unit. Attached to it was a 521 card reader/punch which provided both the input and output.

As the calculations were electronic, the 604 fed cards continuously (now face down 12 edge first) at a rate of 100 per minute. The 521 read/punch unit had a first reading station, a punching station and a second reading station. While one card was being read for calculation, another was being punched and a third could be read for checking. The ability to overlap the input/output operations combined with the electronic speed made this a very effective system and it soon became the calculator of choice.

To give an example of the flexibility of this machine, I installed one at Oshawa Wholesale, the supplier to a large chain of independent grocery stores known as IGA (Independent Grocer's Alliance).

The problem involved reading a number of fields from the card including the quantity ordered and several levels of discount. The difficulty was that although the 604 had considerably more capacity than the 602-A, it did not have enough registers in which to store all the factors. I could have solved this by making two passes on the machine but this was of course very inefficient.

I did however have a 40 step machine and could use as many of these cycles as I wished without slowing the machine down.

Fortunately the 604 also had a Shift Unit. The intent of this feature was to eliminate unwanted digits resulting from a calculation, e.g. it was only necessary to show dollars and cents but nothing beyond the two digits after the decimal point. I reasoned that I actually had enough storage on the machine but just not in the right locations. Many of the factors were small and therefore did not take up an entire register. By utilizing a number of the program steps and the Shift capability, I was able to store portions of the factors read from the card in the upper parts of registers not containing other information. Then by shifting back and forth I could re-assemble the factors and use them in the calculation.

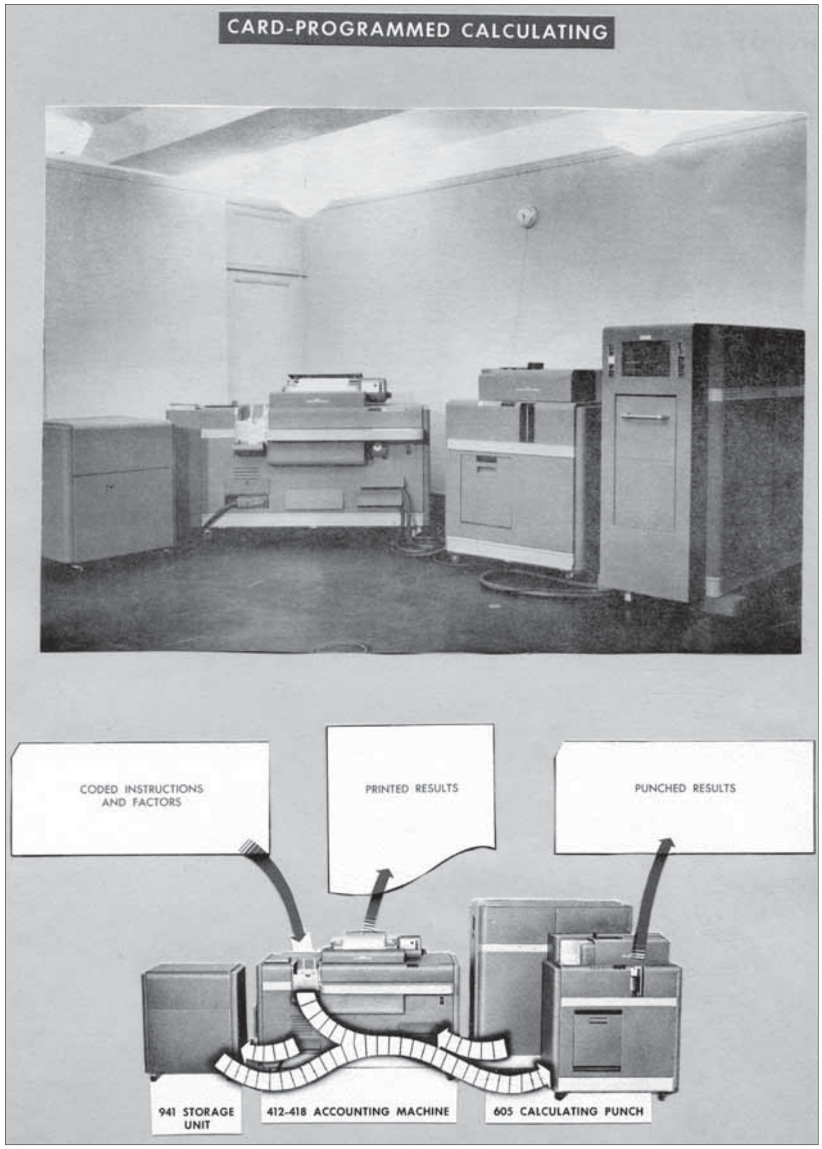
As mentioned earlier, I always had great respect for IBM's Customer Engineers and when they were called in to service a unit, they had to understand what the program was endeavouring to do. I remember getting a call late one night from Ken MacIntosh who commented "You son of a gun. It took me half the night to figure out what you were doing on that control panel" as by this time the panel was very complex.

The lesson learned from all this is one that has not been lost on either IBM when developing its famous Operating System or Intel or many others. That is, when in doubt, throw computer cycles at the problem.

It was my first experience at being able to use the almost unlimited electronic capability to program your way out of problems. A simple example but one that stuck with me for years to come.

In any case the 604 and I got along very well and I was not sorry to see the 602-A fade into history.

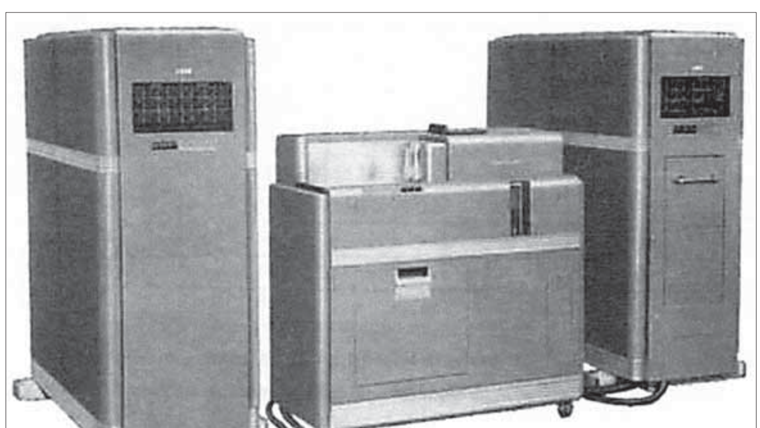
In 1949 IBM announced the 605 Card Programmed Electronic Calculator. This was the first of many attempts by IBM to create a primitive computing system capable not only of reading, calculating and punching cards but also printing the results. It was really nothing more than 604 with some auxiliary storage, a read/punch unit now called the 527 and one of the then available accounting machines, the 412 which had some alphabetic as well as numeric capacity or the 418 which is a numeric printer only.



605 Card Programmed Electronic Calculator

The main advantage was that it did speed up one step of the operation as the output cards no longer had to be read separately in an accounting machine as the printing could take place on-line.

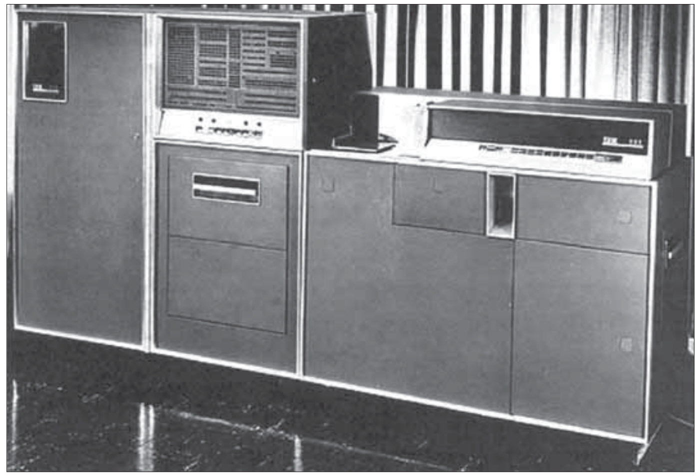
In 1953 a successor unit was developed called the 607. It was essentially a 605 with substantially more memory. If I had had one at Oshawa Wholesale, I would not have spent all those cycles moving digits around to get them where I wanted them. I would have had the registers I needed.



607 Electronic Calculator

For the sake of completeness I should add there was no 606.

The big breakthrough however came in 1955 with the announcement of the 608 Calculator. The 608 was the first completely transistorized machine available for commercial installation. It contained more than 3000 transistors and magnetic cores for dynamic storage.



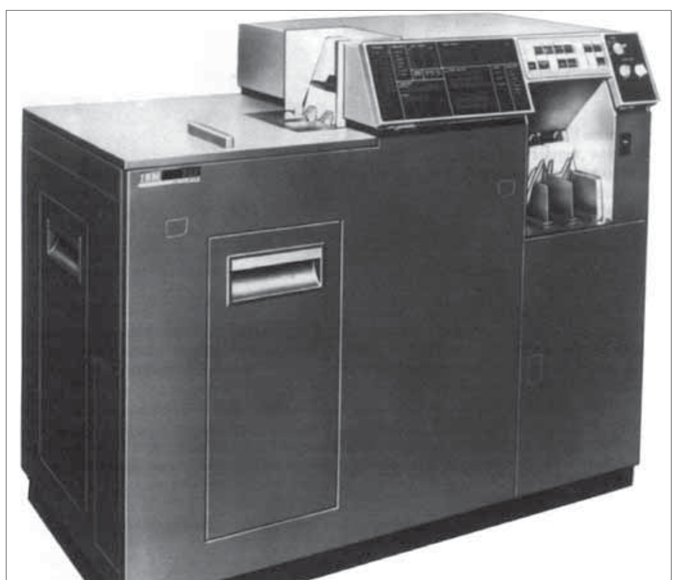
608 Electronic Calculator

The magnetic cores were to become the internal storage device of choice for a number of IBM machines. These tiny donut shaped metallic cores were only slightly larger than a pinhead. They were strung with three wires through the centre of the core and could be magnetized, un-magnetized or read within a few millionths of a second. As the storage was magnetic it could remember information indefinitely unlike a tube which of course lost the information the moment the power was turned off.

The 608 could perform some 4500 additions a second, a computing speed two times faster than the 607 introduced only two years before. It could multiply two nine digit numbers in 11 milliseconds.

It had associated with it a 535 card read punch and because of the increased speed of the central unit it could read and punch cards at the rate of 155 per minute.

The 608 was truly a pioneering machine. It was withdrawn from marketing however in April 1959.



609 Electronic Calculator

It was replaced by the 609 announced in April 1960. This was simply a faster version of the solid state 608 and was the last of the line of punched card calculators. It was still of course a plug board machine but now supported up to 144 programming steps. It operated at 200 cards per minute and had the card read/punch integrated into it making it a substantially more compact unit.

It was withdrawn July 1, 1968, a date that in many ways represented the end of the punched card era.

None of these calculators were computers in the accepted sense of the word. They were all moving toward the concepts being implemented in true computers although they were all Plug Board programmed systems. They did pioneer the concept of overlapping operations within one machine, something that the early computers largely lacked.

So you thought we were now ready to print the results. Not quite.

Around the Periphery

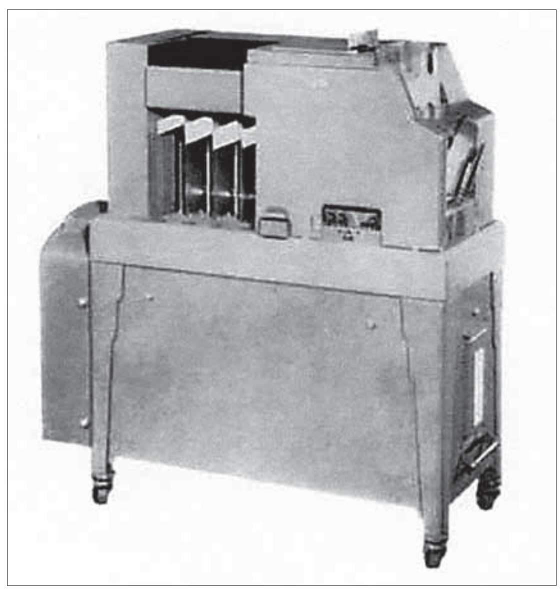
A punched card accounting system involved applications as simple as originating the data, sorting it in some desired sequence, possibly making calculations and then tabulating or printing the output. These separate and sequential steps however often needed to be augmented by other peripheral steps.

For example:

Collators

Suppose that each day of the month, using our billing example, you have sorted product files into sequence to get a daily sales report resulting from customers' orders. At the end of the month, you will likely want to have a consolidated monthly report. This would involve merging together or collating the individual files for each day.

The original requirement for a Collator was by the Social Security Department that received millions of records from employers all over the country. These had to be put together in some meaningful order and merged so the Department could make some sense of the data.



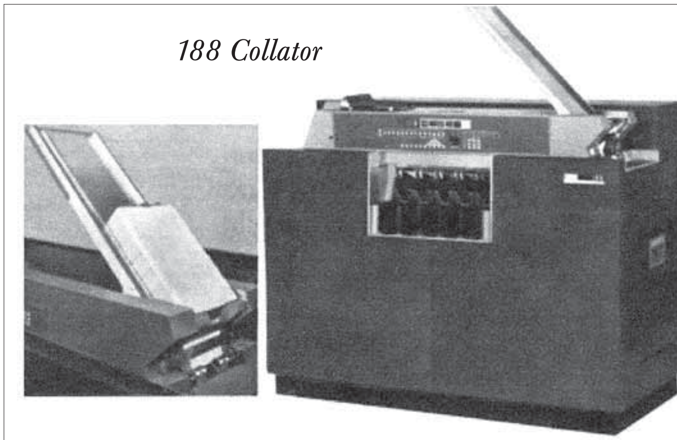
077 Collator

In 1937, IBM brought out the 077 Collator. It could read two decks of cards from two input hoppers and send the cards from the primary feed to hoppers 1, 2 and from the secondary feed to hoppers 2, 3 or 4 based on the comparison of the two input cards as controlled by the Plug Board program. Each card feed read 240 cards per minute.

A Collator could be used to file new card records into a new or existing card-based dataset (merging). It could also check the sequence of a file, remove duplicates, and on a limited basis even search for and extract desired records. I suppose this was a kind of mechanical database query and update system. It could even compare two decks so that one could find out how they differed but only up to 32 digits.

In 1958, IBM brought out the 085 Collator which handled numeric decks and the 087 which could merge or collate alphanumeric data. The input hoppers were enlarged to hold 800 cards and each of the four output pockets held 1000 cards. These models operated at up to 480 cards a minute in each hopper. Finally in 1961, IBM announced the 188 Collator with an extended hopper holding 2000 cards. This alphanumeric device could feed 650 cards per minute per hopper.

188 Collator



Interpreters

As noted, with the availability of printing card punches, cards that were originated on the punch could have a dot-matrix interpretation printed by the keypunch over the appropriate column.

Many cards however were produced in a different fashion, e.g. output from a calculator or as noted later, a summary punch.

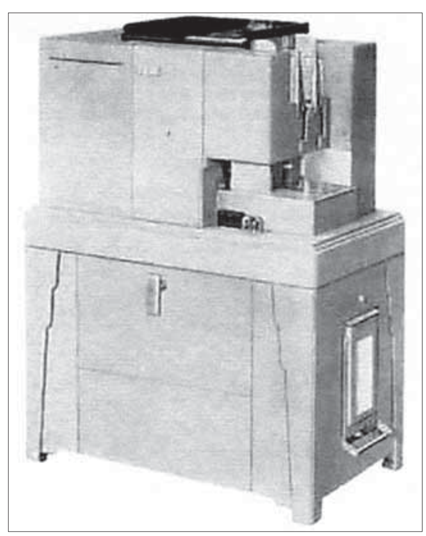
To be able to print the data on the card required a separate machine.

Most of these Interpreters were not capable of printing all 80 columns of the card. In fact this was seldom necessary and the printing coming off the printing keypunch was somewhat crowded and difficult to read. The early Interpreters would print only 45 characters but the print mechanism was such that the quality of the printing was quite high (in fact they used a Type Bar which will be described more fully when we get to the accounting machines).

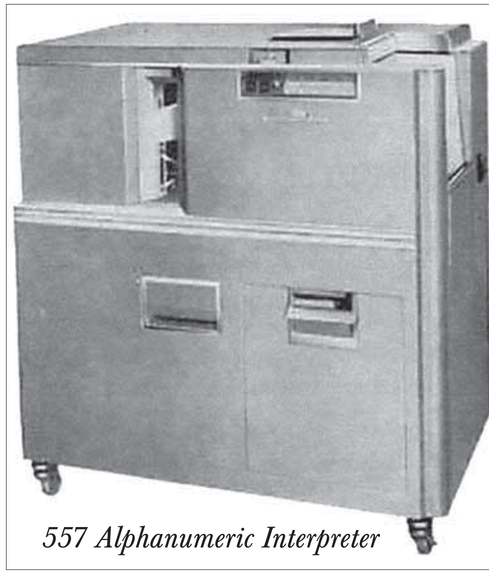
The interpretation did not have to take place at the top of the card as was the case with a printing keypunch. As the printing could be in, say the middle of the card, it led the way for an early method of printing punched card cheques. Millions who received U.S. Government cheques printed on IBM cards got them from special Interpreters rather than from actual accounting machines.

There were some early Interpreters, e.g. the 541 with very limited numeric capability but the first successful production Interpreter was the 550 with an automatic feed of 75 cards a minute. This was introduced in 1930 as a numeric only machine.

In about 1946, the 552 Alphabetical Interpreter was produced capable of printing 60 characters in two rows. About the same time the 551 Cheque Writing Interpreter referred to above was produced which could print in five rows, the rows being selected by a knob on the machine.



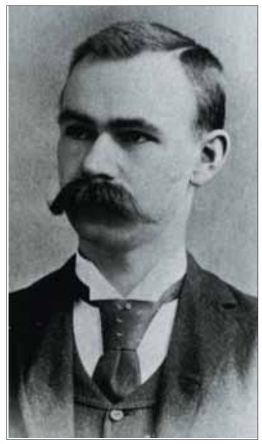
552 Alphabetical Interpreter



557 Alphanumeric Interpreter

In 1954 the 557 Alphanumeric Interpreter was produced capable of printing in any of 25 rows and with a speed of 100 cards per minute.

There were a number of other peripheral machines that IBM produced including most significantly the reproducing/summary punch machines. They sometimes factored into the sequence where it was advisable to make a copy of a deck for back-up or other purposes. They could also punch common data into a deck of cards, e.g. today's date, before the cards were keypunched. Referred to as Gang Punching, it was a faster procedure than using the keypunch to punch common data on each card individually. However these machines are better understood after a description of accounting machines. They were extremely versatile and an essential part of the punched card process.



Herman Hollerith,
1860 - 1929

Finally It All Adds Up

As noted earlier, when Herman Hollerith founded his company he called it The Tabulating Machine Company. This indicates the pivotal place that Tabulators or Accounting Machines played in the punch card process.

The original 1890 Hollerith Census Tabulator had only unit counters, i.e. they could only tabulate the number of holes in a particular position on a card. They could not actually read numbers. These machines had a manual feed and a handsome wooden cabinet. More importantly, they were hard wired.

In 1896 the Hollerith Integrating Tabulator was introduced, still with a manual feed but this system could add numbers as well.

By 1900 Hollerith had introduced the Automatic Feed Tabulator which was the first Tabulator with an automatic feed card reader. It was this machine that was used primarily for the 1900 Census in the U.S.

Because these machines did not have any form of external wiring, they were custom-built for a specific purpose.

The early tabulators could only handle positive numbers. Subtraction only became possible in the 1920's.

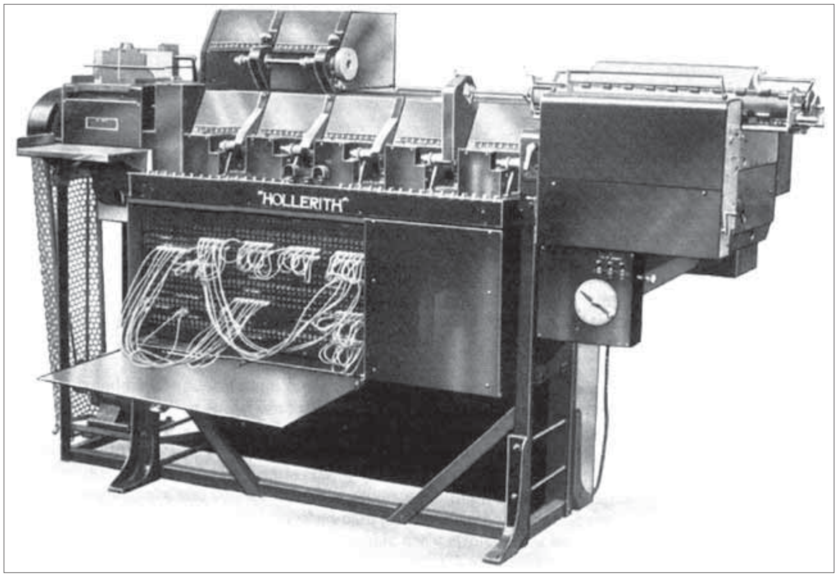
The Type 090 introduced in 1906 was the first with a metal cabinet but more importantly the first with an external wiring panel.

The next breakthrough came in 1921 with the Type 091 which was the first model to have a printer attached. This was effectively a typewriter that was added to the right hand side of the machine.

The next breakthrough came in the mid 1920's with the Type 3-S Tabulator. Not only did this have direct subtraction but had a removable plug board.

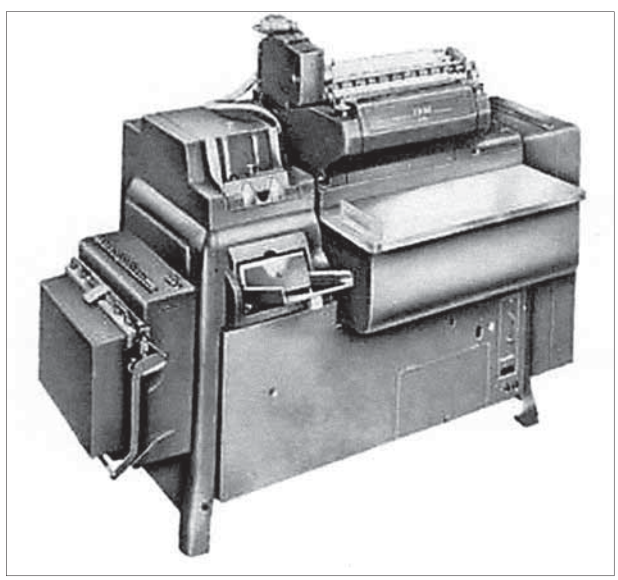
By 1928 the Type IV became the first 80 column card tabulator setting the standard for all future IBM punch card machines.

There was some further development with the Type 285 Tabulator *(see next page)* which was a numeric only accounting machine. But the machines that would truly move the field ahead were the 400 series.



285 Tabulator

In 1933 the first Alphanumeric Tabulator appeared (Type 401) and it was succeeded almost immediately in 1934 by the 405 Accounting Machine. The 405 had a numeric only counterpart called the 416. Both machines utilized a new printing mechanism – the Type Bar. As each card was fed into the Tabulator, the bank of Type Bars (one for each position that could be printed on the page) would rise up and then fall to the appropriate level so that the Type Slug, containing the letter or number corresponding to what was punched in a particular column on the card, would be opposite the appropriate printing location on the continuous form in the paper carriage. When all the type bars were lined up in the appropriate location, a hammer (one for each type bar) would push the type slug against the ribbon and the paper. The effect was to print a single line with the appropriate alphanumeric information.



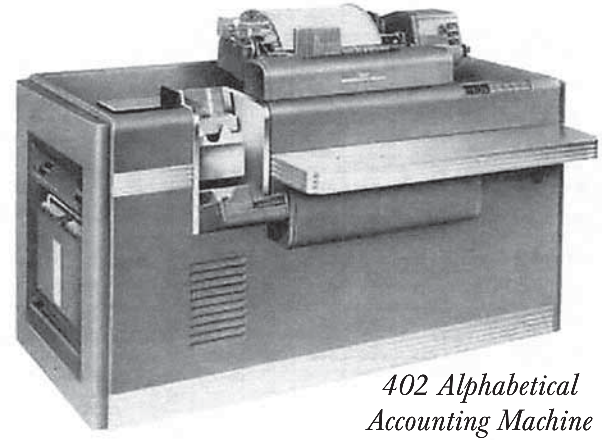
416 Numerical Accounting Machine

The type bars then returned to their home position and the whole process was repeated for the next card.

Incredibly enough a numeric machine such as the 416 could list and tabulate up to 150 cards per minute despite this ingenious but somewhat awkward mechanical printing mechanism.

As one might also expect, the noise from these machines was horrendous.

By 1948 a new line of accounting machines was brought out starting with the 402 Alphabetical Accounting Machine. This machine could have up to 88 type bars. It was reasoned that most of the alphabetic printing would be on the left side, e.g. name and address, product description, etc. and the right side would normally require numeric only printing. For this reason the 88 type bars were divided into 43 alphanumeric bars on the left and 45 numeric only on the right.


402 Alphabetical Accounting Machine

Each alphabetical type bar contained of course the 26 letters of the alphabet, the digits 0 to 9 and one special character position (usually an ampersand).

The numerical type bars contained only the digits 0-9. The odd numbered bars contained an asterisk and the even numbered bars contained the credit symbol (cr).

The 402 could be ordered in many configurations depending on the number of counters for adding and subtracting that were required and the number of type bars which could be reduced to 55 (25 alpha and 30 numeric).

To give you an idea of the monthly rental in U.S. dollars, the most fully equipped 402 cost $460.00 per month while the least expensive was $205.00 per month.

The speed was 100 lines per minute for alphabetic printing and 150 per minute for all numeric printing, reducing to 80 lines per minute in either mode in the least expensive model.

The paper carriage (Type 923) fed a continuous form through the back of the machine. The spacing on the carriage was controlled by punched paper tape that was created off line and moved in tandem with the continuous form. In much the same way that the program card in a 024 Punch would automatically skip to the next desired location, the continuous tape loop would cause the paper to move up to the desired location. For example, one might print three address lines from three separate cards and then skip a couple of lines to where shipping information would be printed then a couple more lines down to where the body of the invoice was to be printed.

The 402 could become equipped with a 916 Bill Feed which fed individual pieces of paper or cards for applications such as utility bills.

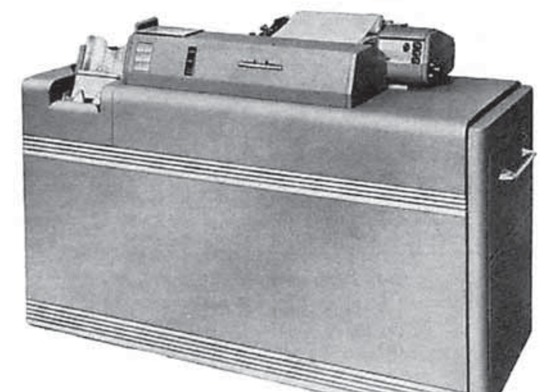
There were two more machines in the line at that time. A 403 had the ability to print multiple lines from a single card. This was actually useful as usually the information for, say a mailing address, did not require a separate card for each line. Perhaps 3 lines could be put sequentially on one card. The 403 had the ability to print from a card configured in this way.

The 419 was simply a 402 with no alphabetic capability.

The same control panel could be used interchangeably with all three machines.

The 402/3 accounting machine line was extremely popular and many were still in use 20 years later.

However, in 1949 IBM announced the last of it Electro Mechanical Accounting Machines – the 407. This was truly an amazing machine that pushed the limits of what one could do with gears and relays.



407 Accounting Machine

The first advance was to change the printing mechanism. Instead of type bars, the 407 had 120 type-wheels. These were mounted in one continuous 12 inch bank. Each type-wheel contained as expected the 26 letters, digits 0-9 and 11 special characters such as percent signs, dollar signs, commas or slashes. This allowed for quite imaginative printing.

The print-wheels would rotate and as the appropriate character lined up with the desired printing position, the wheel would strike through the ribbon to the paper. When all 120 positions had printed, the paper would move to the next line or wherever instructed by the Carriage Control Tape.

The 407 printed at a constant speed of 150 lines per minute.

The 407 had a very large control panel and allowed for great flexibility as to where and how information was printed and accumulated.

Two card reading stations were provided. It was normal to wire for counter entry or type-wheel entry from the second reading station. The first reading station was primarily used for control purposes to give the carriage control, relays or other devices time to prepare for what was going to be read at the second station.

The 407 Model A3 rented for $920.00 per month or almost double the cost of the top of the line 402. However the speed and the quality of the printing were such that the 407 rapidly became the workhorse for large installations.

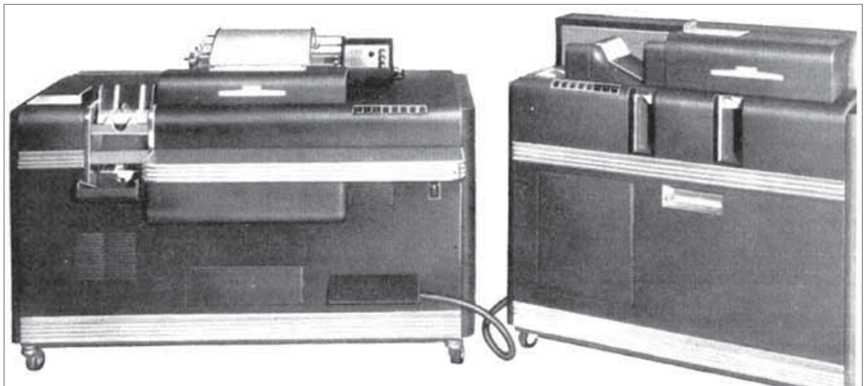
When combined with the 604 Calculator and a 083 Sorter, there was now a matched set of high quality punch card machines.

Summary Punching

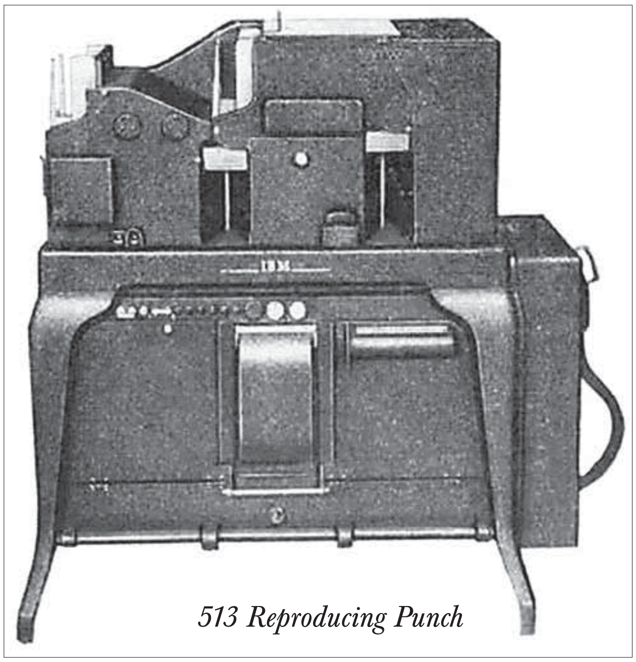
I mentioned that I would return with a description of another line of auxiliary equipment but that this was best understood after describing the accounting machines. These were variously known as Reproducing Punches, Summary Punches, Gang Punches or in typical IBM naming fashion Document Originating Machines.

The Reproducing Punches had two feeds. They could therefore be used to reproduce a card deck and because they were controlled with a removable plug board, could rearrange the data if desired.

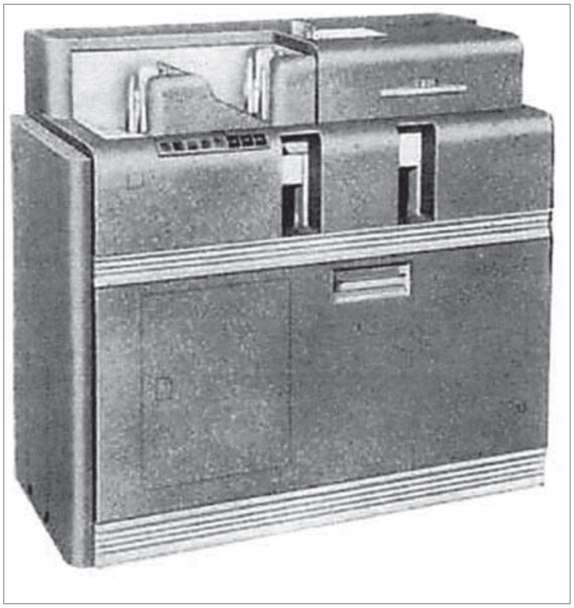
They could also automatically gang punch common information through a deck of cards as mentioned earlier.


A 514 used as a Summary Punch

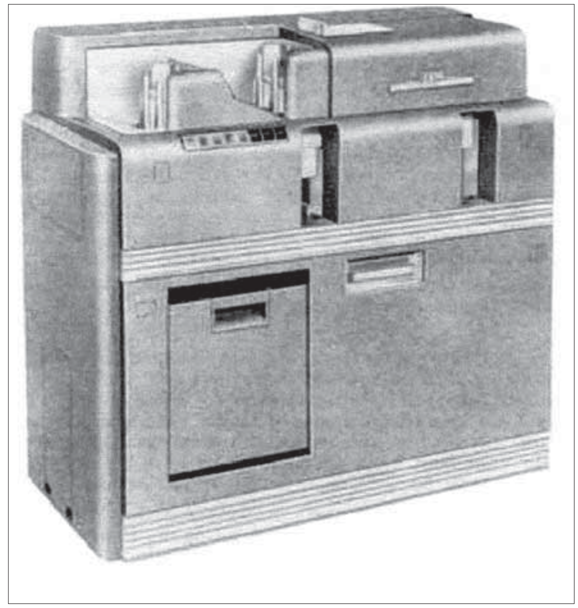
However an important use was as a Summary Punch. These machines could be attached to an accounting machine and could punch a summary card. For example, if the accounting machine was printing invoices, it would come to a final total and this total could be punched into a new card together with the customer number, date, invoice number or other information. This Summary Card could then be used to produce a month end statement. It would also of course be the input to the Accounts Receivable System. There was also a single purpose Summary Punch called the 523 which had only one feed so that it could gang punch and summary punch only.


513 Reproducing Punch

An early somewhat simple machine called the 513 Reproducing Punch operated at 100 cards per minute when gang punching or reproducing. Later Model 514 was widely used with the 402/3 accounting machines. These machines when used as a Summary Punch operated under the control of the accounting machine and hence the speed varied for this function.



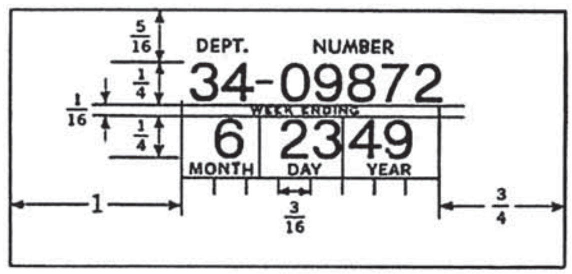
514 Reproducing Punch



519 Document Originating Machine

The 514 Reproducing Punch with summary punching capability rented for $100.00 U.S. per month.

A later model, the 519, also had the ability to print in large type across the end of a card. This was very useful for such applications as Time Cards that were placed in racks and were used by employees to register the coming to or leaving from a job. The numbers were readily readable when sitting in the rack.



An Example of End Printing on a Card

For very low volume applications there was a modified 026 card punch called the 526 which could act as a Summary Punch and Interpreter combined. As it punched sequentially, it was a much slower operation but it was useful in some smaller installations as it could also double as a key punch.

Summary Punching was recognized as a vital function as early as 1933 when a Type 31 keypunch was modified to provide this capability.

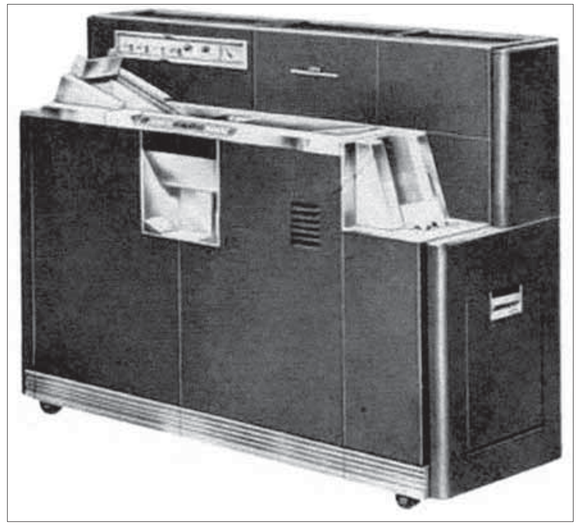
The 514 and 519 machines had another very important capability, Mark Sensing, but this will be covered in a later section.

526 Printing Summary Punch

Specialized Printers

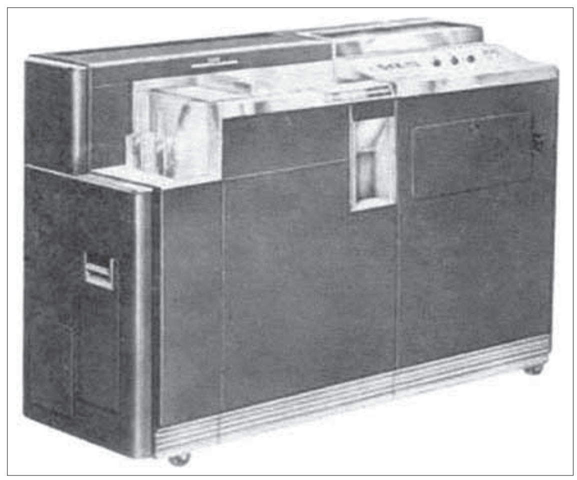
IBM produced some highly specialized printing machines although these were not tabulators.

One was designed to print on blank card stock at relatively high speed. The 938 Electrostatic Card Printer could read information from a card and like an interpreter, print the information on the card at 200 printed cards per minute. It was really a high speed interpreter that used the 'Xerox' electrostatic printing.



938 Electrostatic Card Printer

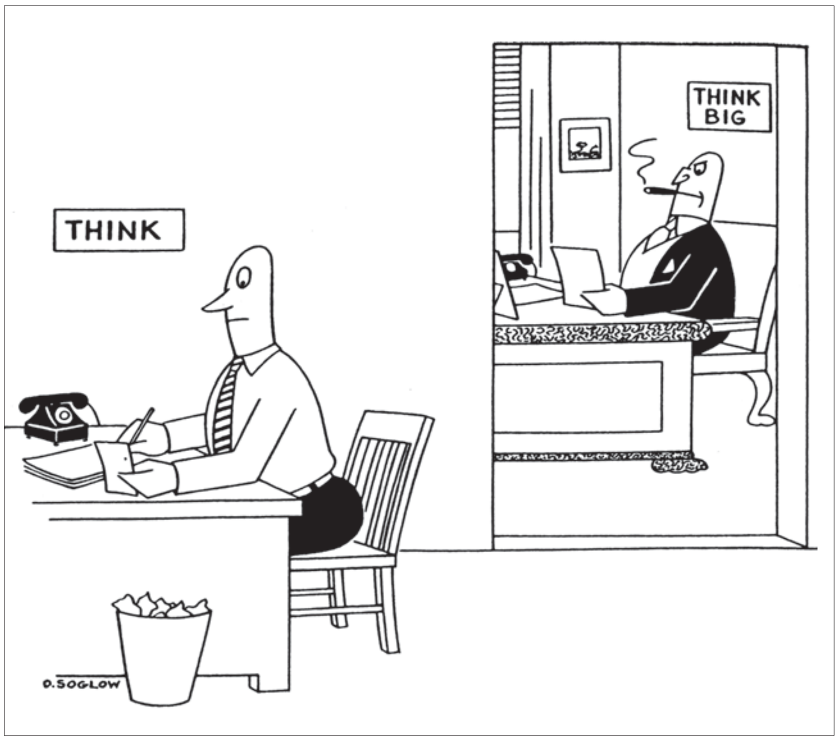
Another specialized machine was the 939 Electrostatic Address Label Printer. There was an obvious requirement in some applications for producing address labels and this machine could print them at 500 per minute. It was relatively expensive at $1,300.00 U.S. per month.



939 Electrostatic Address Label Printer

I had no hands-on experience with either of these machines but they should be acknowledged as interesting specialty units. They also forecast the obvious move toward non-impact printing although impact printing was to have a significantly longer life as we shall see.

With this description of the basic components of a punch card accounting system, it will be obvious that the systems could be quite complex. For this reason there was a tendency to centralize accounting, e.g. have all invoices produced in one location. Data however could originate anywhere the organization did business. This leads us now to a look at how you got information from one place to another.

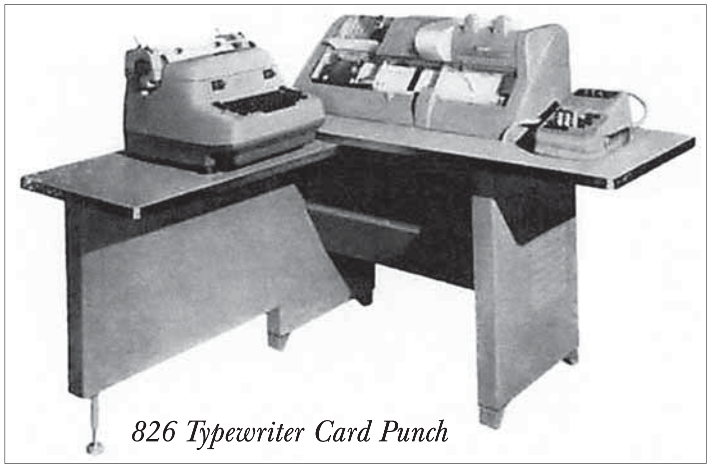

THINK
THINK BIG
O. SOGLOW

Getting From Here to There

It was not uncommon to want to create a unit record, i.e. punch card remotely, even if the computation and printing was done centrally. It was always possible to have one or more keypunches located at a remote site and simply ship the cards.

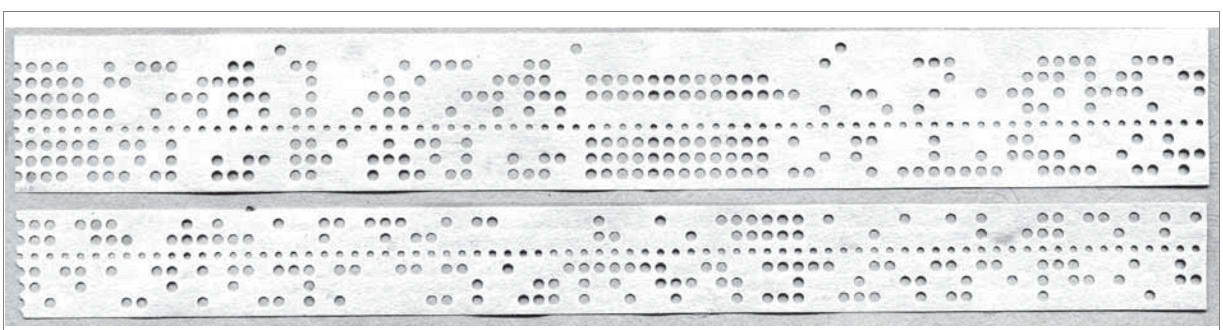
Occasionally it was useful to have a typed record at the originating location. For this purpose IBM developed an 824 Typewriter Card Punch. As the name implies, this was simply a 024 Card Punch (the 826 was the same unit with a 026 Printing Card Punch) and an attached typewriter. Select fields that were being typed could be punched. There was a slight difference in the character size on the typewriter distinguishing those items which had been punched.

However even in the days when there were no multi mega bit lines available from the telecos or cable companies, it was sometimes more convenient to have the information sent over standard telephone wires. A twisted pair did not have much band width but for certain applications, this was clearly preferable to shipping the original documents or cards.



826 Typewriter Card Punch

This leads us to a brief examination of Punched Paper Tape. Teletypes had been used for years and operated with a 5 channel code. The code was adequate for simple alphanumeric information but it did not have enough flexibility to allow check digits to be inserted to ensure the correctness of the transmission. IBM therefore developed a proprietary 8 channel code which could also be used with an 8 inch roll of tape. This would hold the equivalent of about fifteen hundred 80 column cards.



Sample of 5 & 8 Channel Paper Tape

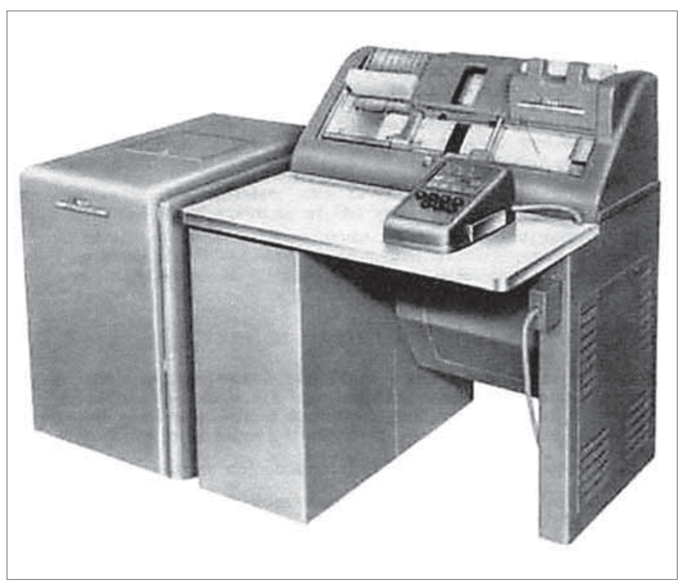
As it was clearly easier to create the data at the source, record it on punched tape and then transmit from the tape, IBM devised a series of machines to do exactly that. The paper tape could then be sent to an 046 Tape to Card Punch to be converted into standard punched card format. This unit simply looked like a 024 Card Punch with a paper tape reader attached.

An obvious alternative was to have direct card to card transmission bypassing the somewhat inflexible paper tape approach. For this purpose IBM developed the Data Transceiver. This again was a modified 024 card punch with an associated Signal Unit that could connect either to a telegraph or telephone line. The unit was reasonably slow as would be expected (the cards were of necessity read serially as with any type 024 card punch). Up to 11 cards per minute could be transmitted over a telephone line and up to 5 cards per minute over a telegraph facility. This assumes all columns on the card are being transmitted.

884 Typewriter Tape Punch

All of the above approaches had limited use. In those days it was hard to compete with the band width of a truck loaded with boxes of cards.

046 Tape to Card Punch



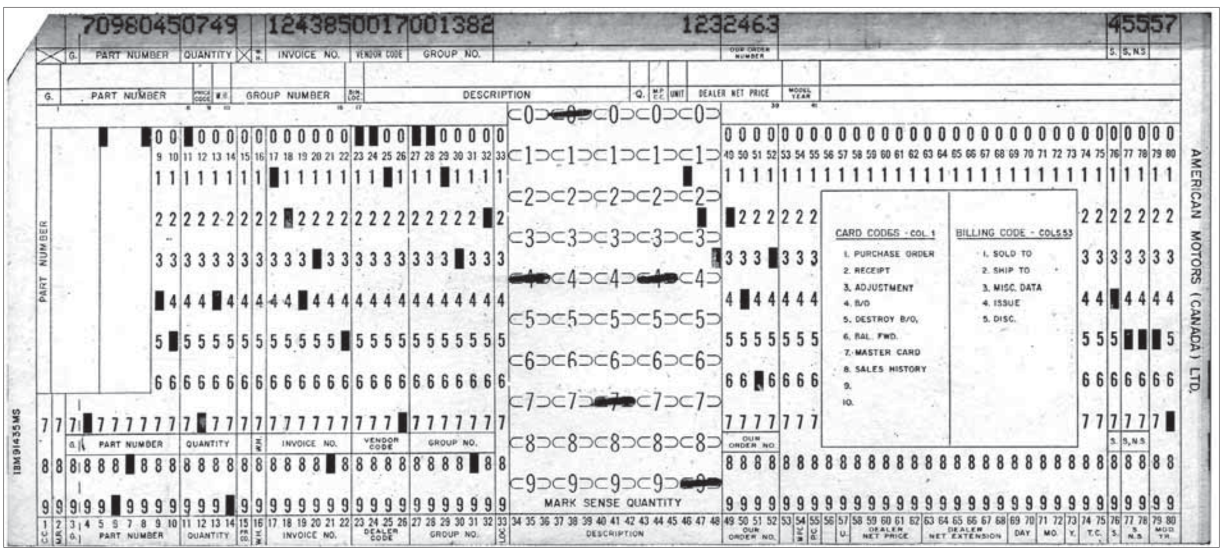
066 Data Transceiver

If You Know of a Better 'Ole', Go To It!

Key punching was always a laborious way of originating data. Everyone wished there was an easier way to get direct machine input from handwritten or machine printed documents. Indeed such methods were developed. One of the earliest was Mark Sensing.

Mark Sensing

The idea was simple but ingenious. The originator of the data could make a mark in designated areas of a punched card using a special pencil with very high carbon content. The marked area would be essentially the width of 3 standard columns. This meant that there would be 3 brushes reading each of the hand marked areas. A weak electrical impulse would be transmitted through the two outside brushes and if the circuit was completed across the mark on the card, this would be detected by the third brush.



Mark Sense Card

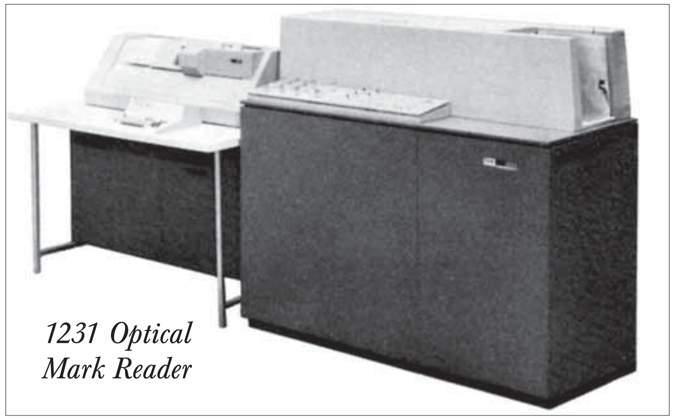
The aforementioned reproducing punches, e.g. 514, 519 could be equipped with the ability to read the mark sensing and convert it into punched holes for subsequent processing.

This process was widely used for meter reading and numerous other applications.

Optical Sensing

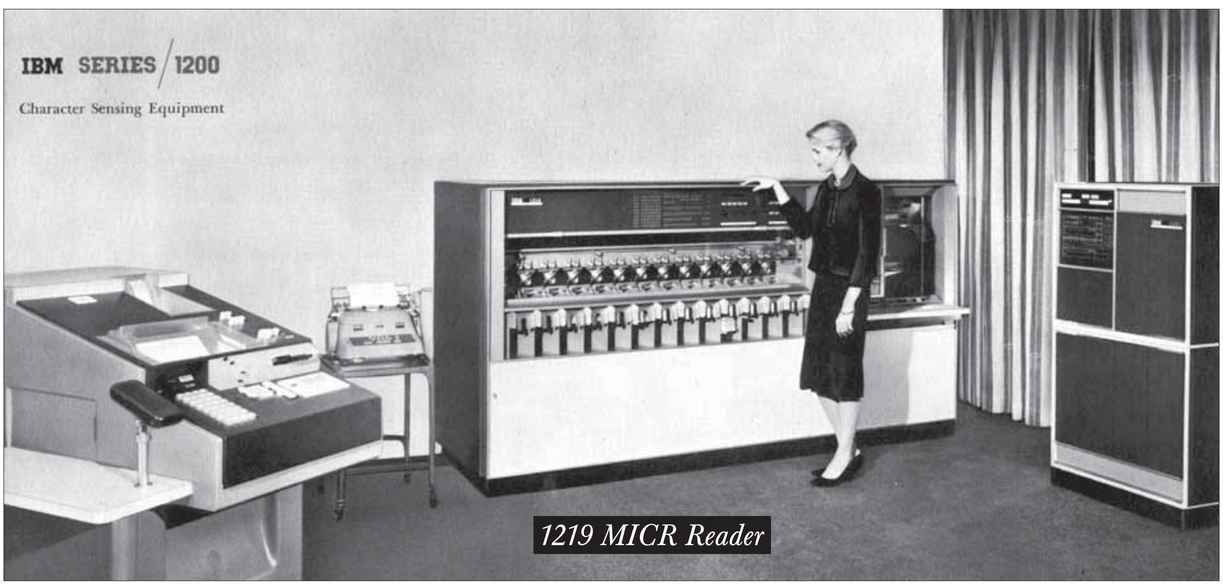
The next logical step was to optically scan a document looking for pencil marks in appropriate areas. A typical application was test scoring. IBM developed the 1230 Optical Mark Scoring Reader. An answer sheet could have a maximum of 1,000 easily marked response positions. No special pencil was required. The machine could read 1,200 sheets an hour and greatly reduce the test marking time. A 534 Card Punch could be attached to the 1230 and the scores recorded on punch cards. A later version, the 1231 Optical Mark Page Reader was designed for direct input into machines such as the 1401 or /360 Model 30.

The 1200 Series



1231 Optical Mark Reader

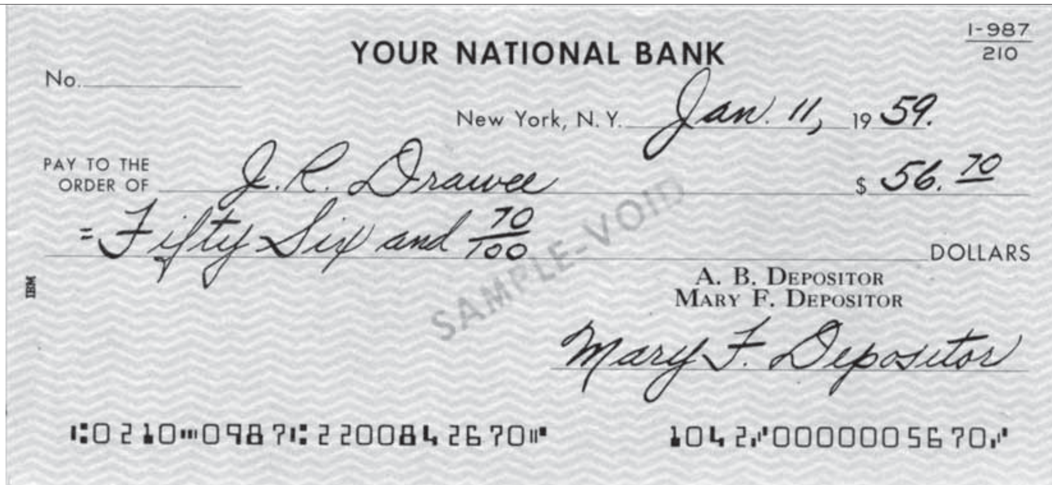
Banks had an even greater problem. They needed some way of handling the millions of paper cheques that were produced every day. One could hardly expect a cheque originator to mark sense the amount and the financial services industry chose instead to standardize on Magnetic Ink Character Recognition (MICR). Such information as the transit number identifying the originating bank and the client's bank account number could be pre-encoded on pre-printed cheques as is still the case today. When the amount was handwritten on the cheque, an operator could transcribe that also into MICR. The cheque could then be sorted and otherwise processed on specially designed MICR character readers. The 1219 MICR Reader looked like a large sorter with 14 pockets. Indeed that is what it was as this proved to be the only practical way for returning cheques to the originator with his or her statement. This practice is now being phased out as being very expensive for the convenience provided. A printed statement of all cheques is now a more common process.

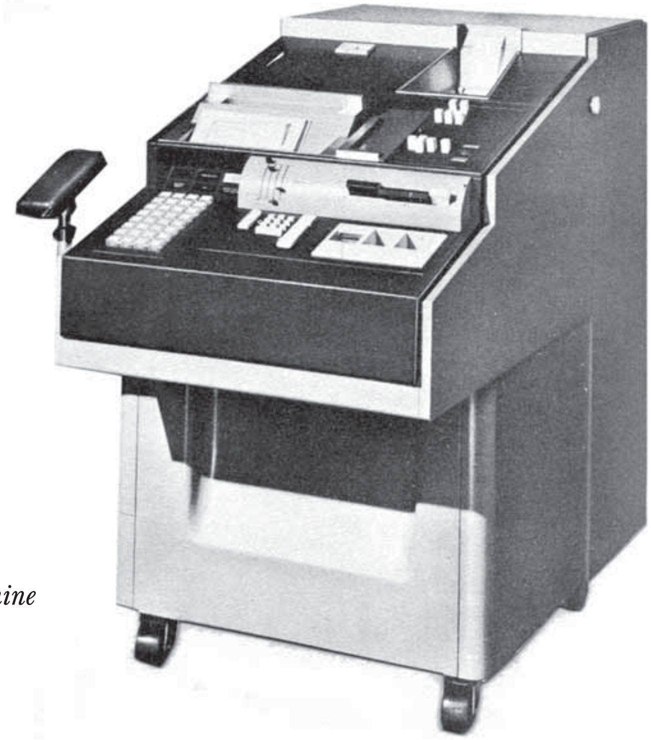


1219 MICR Reader

In case you are wondering how the operator transcribed the handwritten amount on the cheque into MICR, this was accomplished with an 801 Bank Proof Machine. These machines had limited accumulating capability and therefore could be used for balancing batches of cheques while actually inscribing the MICR amount on the cheque.
(See next page for illustration.)

The Bank of Canada had 'banks' of these (no pun intended).





800 Series
Bank Proof Machine

Reading Handwriting

Well not quite. However IBM did bring out the 1287 Optical Reader which looked something like the 1219 MICR Reader but could read digits carefully printed in a pre-selected area. This device of course had to wait for the development of computers to interpret the scanned images and so we are getting somewhat ahead of our story.

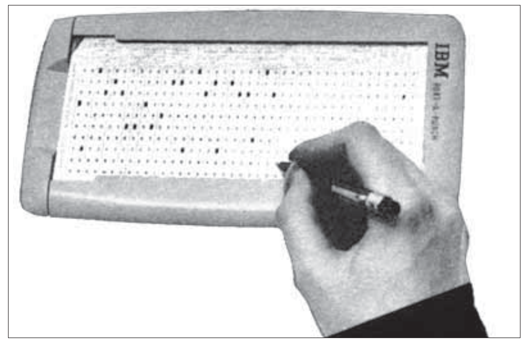
Data Collection

Many other attempts were made to bypass key punching as often as possible. The 1030 Data Collection System was an example of this. This was a unit that could for example read employees pre-punched identification badges and automatically add the time of entry or exit. The resulting information could be punched and used for subsequent processing.

There were many other developments aimed at capturing data at the source including any number of Process Control devices. However sometimes, simple is better.

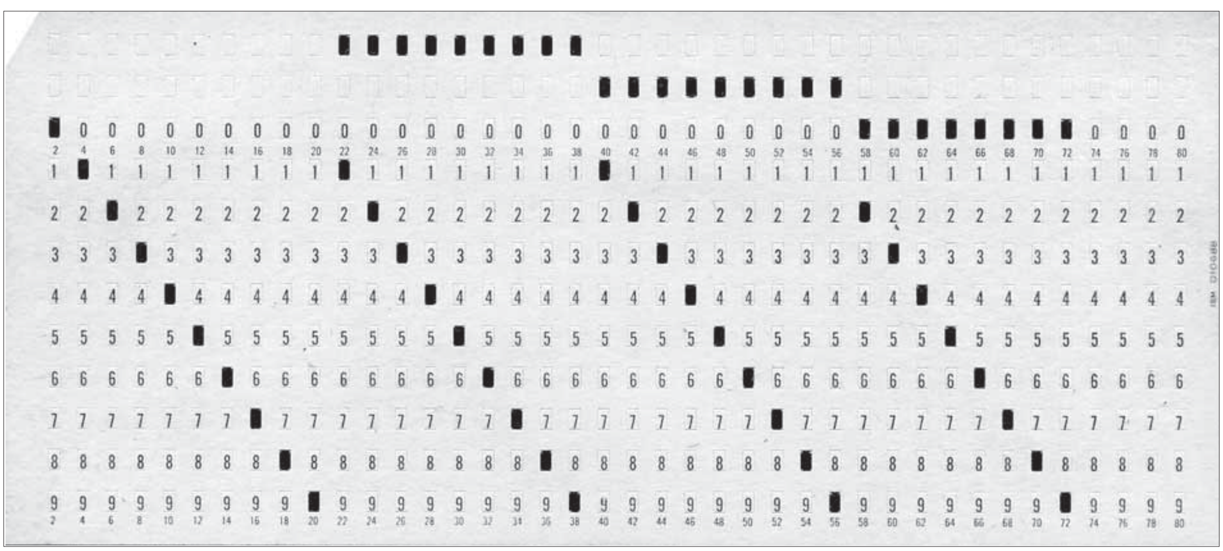
Port-A-Punch

There was even a non-mechanical, non-electric method of originating data. IBM developed a hand-held plastic unit just a little larger than an 80 column card. The cards that were used with this device were inserted one at a time. Each had 40 columns (or as many as desired up to this) of pre-perforated columns. The user could utilize a stylus to push out the appropriate number in each column. Behind each column was a soft pad that was scored vertically to line up with the columns. The chad was pushed through this into a container at the back of the hand-held device.



Port-a-Punch

This was a fairly easy way of originating data at source, particularly in remote locations. The only drawback was that the pre-perforated chads were in some danger of dropping out on their own if the cards were handled multiple times. It was therefore usual to simply reproduce the Port-A-Punch Cards onto regular cards for subsequent processing.



Port-a-Punch Card

But for some applications an even more ingenious solution was developed.

Three Men in a Tub

In order to reduce the amount of keypunching necessary, it was a usual practice to pre-punch cards with all of the non-variable information, e.g. in a wholesale billing application, cards could be made up containing the product number, description, colour, cost and any other useful data. When a customer placed an order, an operator would only have to retrieve the appropriate cards for the desired items. These would then be passed to a keypunch operator who would key in the quantity and gang punch the customer number into each card.

To this deck of cards for each customer would be added the customer name and address cards and any special shipping instructions or discounts that might apply.

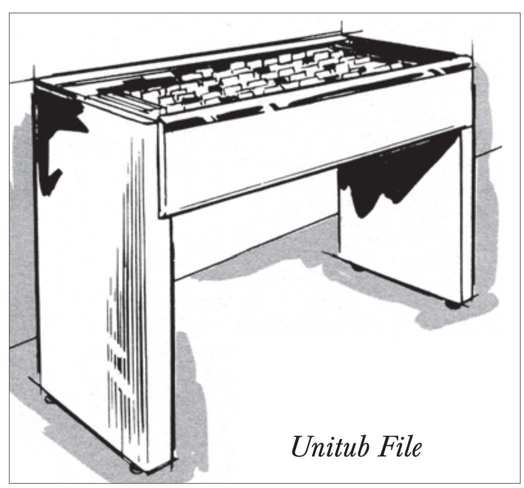
Needless to say this customer information could also be pre-punched and placed in files to be pulled along with the item cards. These large files were known as Tub Files.

Tub File with Removable Trays

To save space, the cards were normally placed on end which is why the end printing produced by machines such as the 519 Document Originating Machine could be particularly useful. The customer number for name and address cards and the product code for the item cards as ordered could be easily read across the end of the card.

Companies such as WrightLine produced special Tub Files for this purpose.

Unitub File

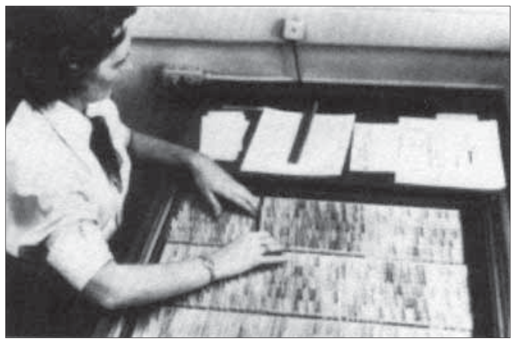


Unitub File

It was not long before it was realized that for certain applications, the number of cards in the Tub File could actually be made to represent the number of items still in inventory. Essentially this only worked if customers normally ordered a small quantity of each item. In a wholesale grocery operation for example, small grocers would normally order only one or two cases of any particular item. The operator could then select one or two cards from that particular deck and automatically reduce the inventory record.

Needless to say the process was prone to error and regularly had to be checked against the actual physical inventory in the warehouse. However at least this way one could run the cards in the Unit Tub File through a tabulator and come up with appropriate re-order reports, inventory costing and similar very vital data.

I emphasize this because one of the major transitions to electronic data processing was to endeavour to duplicate the Unit Tub File on some form of magnetic storage.



Tub File Operator

Getting it Right

One can easily imagine the number of steps that would have to be completed for even a simple application and these steps had to be done in a certain sequence.

Before a large job was started it would be normal to flow chart the whole operation. Plastic templates (a little larger than a punch card) were provided with cut-outs that could be traced. The role of each step was then identified as part of that particular process. There was a square for a tabulator, a diamond for a sorter, etc.

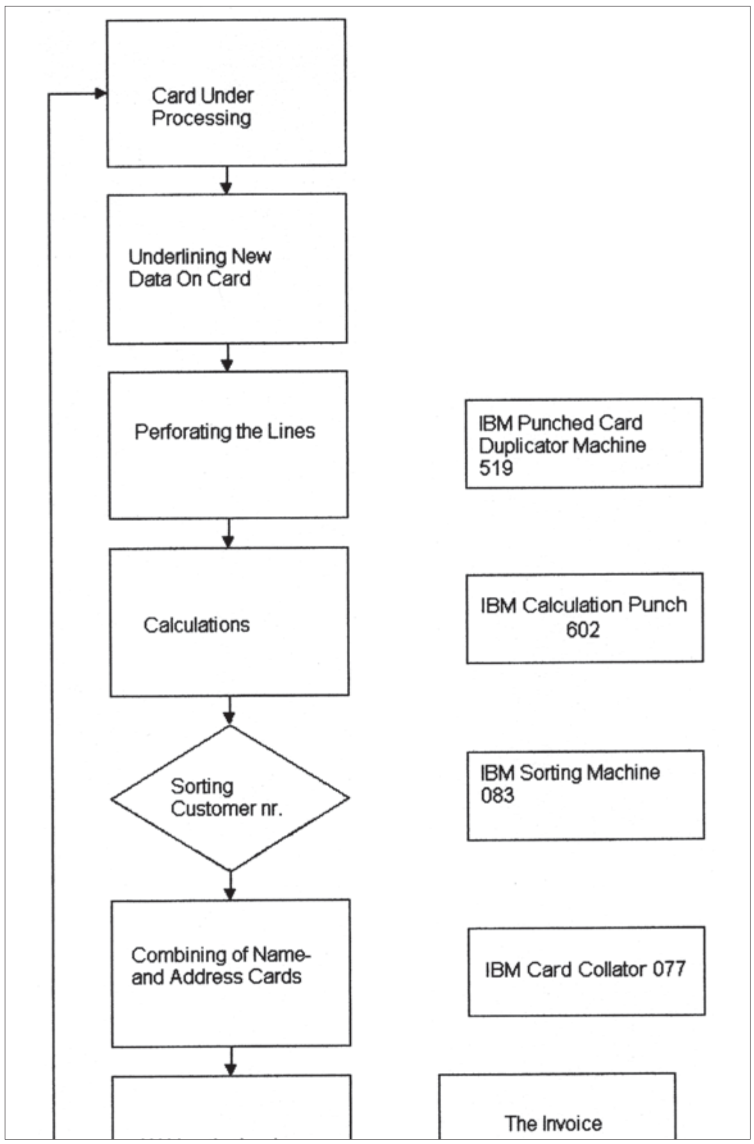
Sometimes these flow charts would run to many pages but they were the backbone of any good documentation of how a system worked.

To this would be added the wiring charts for the various control panels to be used at each point in the process.

Copies of the cards, printed output forms or other documentation could all be added as a checklist for the operators and as a method of training new personnel.

Of course like any data processing system, people tended not to keep the documentation up-to-date with all the usual ramifications when the systems had to be updated or when there were major changes in staff.

Nothing has changed in data processing in this area!



Typical Flow Chart

A bunch of punch cards
with several program decks

They've Gone About As Far As They Can Go

To try to simulate what would later be done on the more flexible Electronic Data Processing Machines, attempts were made to integrate punch card components in ingenious ways.

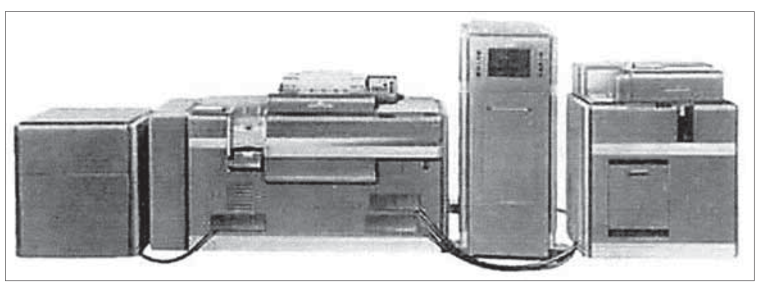
An example of this was the 858 Cardatype Accounting Machine. This rather simple device provided a low cost way of preparing a variety of documents such as invoices, payroll cheques or even insurance policies providing the volume was relatively low.

The 858 would type on a document (directly from IBM cards) using a standard IBM electric typewriter with additional information keyed into an auxiliary keyboard.

858 Cardatype Accounting Machine

The 858 unit itself could perform multiplication as well as addition and subtraction and could provide punched output using either paper tape or card.

Another example of this approach was the 605 Card Programmed Electronic Calculator or CPC described earlier.



Card Programmed Electronic Calculator

The CPC was announced in 1949 and some 2,500 units were sold. This simply indicated how much people wanted integrated data processing reducing the number of steps that had to be undertaken in a standard punch card application. I remind you however that the CPC was not a stored program device although it did the best it could with wired control panels.

Thomas J. Watson Sr. had always felt that 'his boys in Endicott' could solve just about any need with electromechanical devices. However, by now the punch card files in large insurance, wholesale, transportation and other industries, to say nothing of government, were running into the millions and sometimes tens of millions of cards. As wonderful as these punched card devices were, they had been pushed about as far as they could go.

My admiration for the ingenuity of machines such as the 407 and 604 has I am sure been recognized in my somewhat biased reporting on these machines.

Fortunately help was on the way. The next section of this book will explore the bridge between this type of equipment and the new Electronic Data Processing Machines.

II.
A PARALLEL PROGRAM

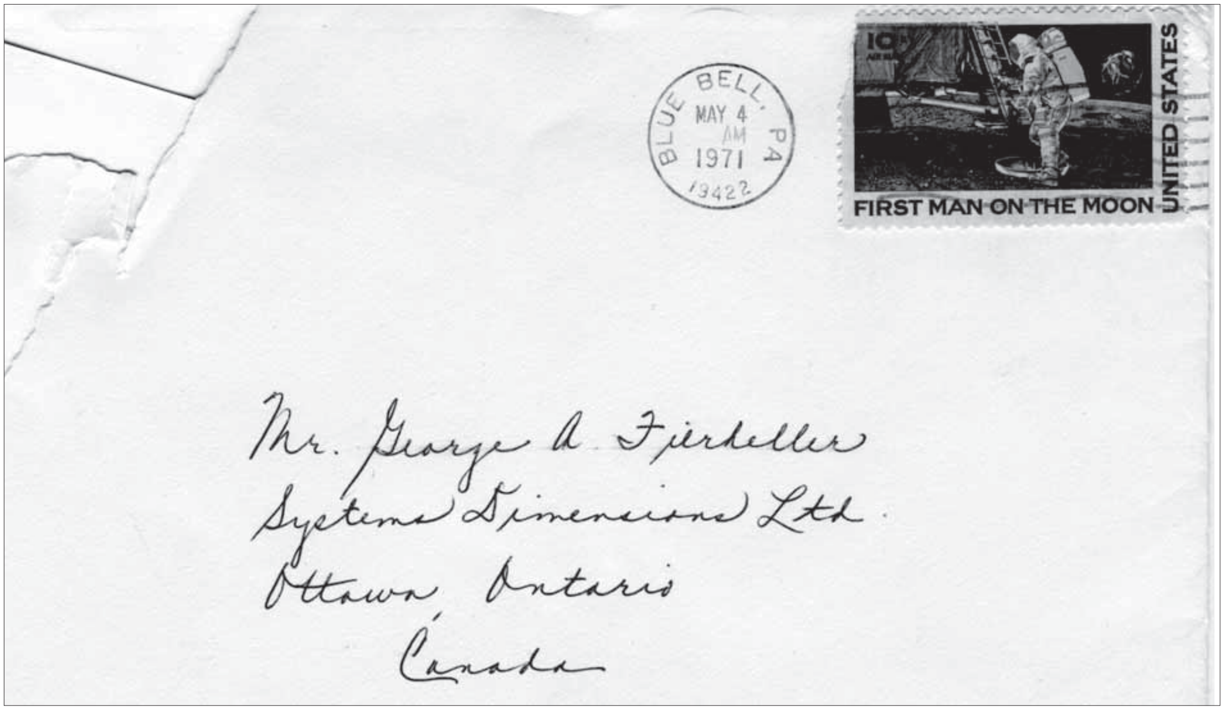
It Computes

In parallel with the final glory days of punch card equipment was the development of the electronic computer. As I tried to do with the early development of punch card data processing, I will provide a brief overview of the development of computers for those who may be less familiar with how this revolutionary development took place. Most would contend that it is the single most influential development of the 20th Century. Computer logic now finds its way into everything from simple household devices to sending the Voyager Spaceships on a grand tour of the solar system and beyond.

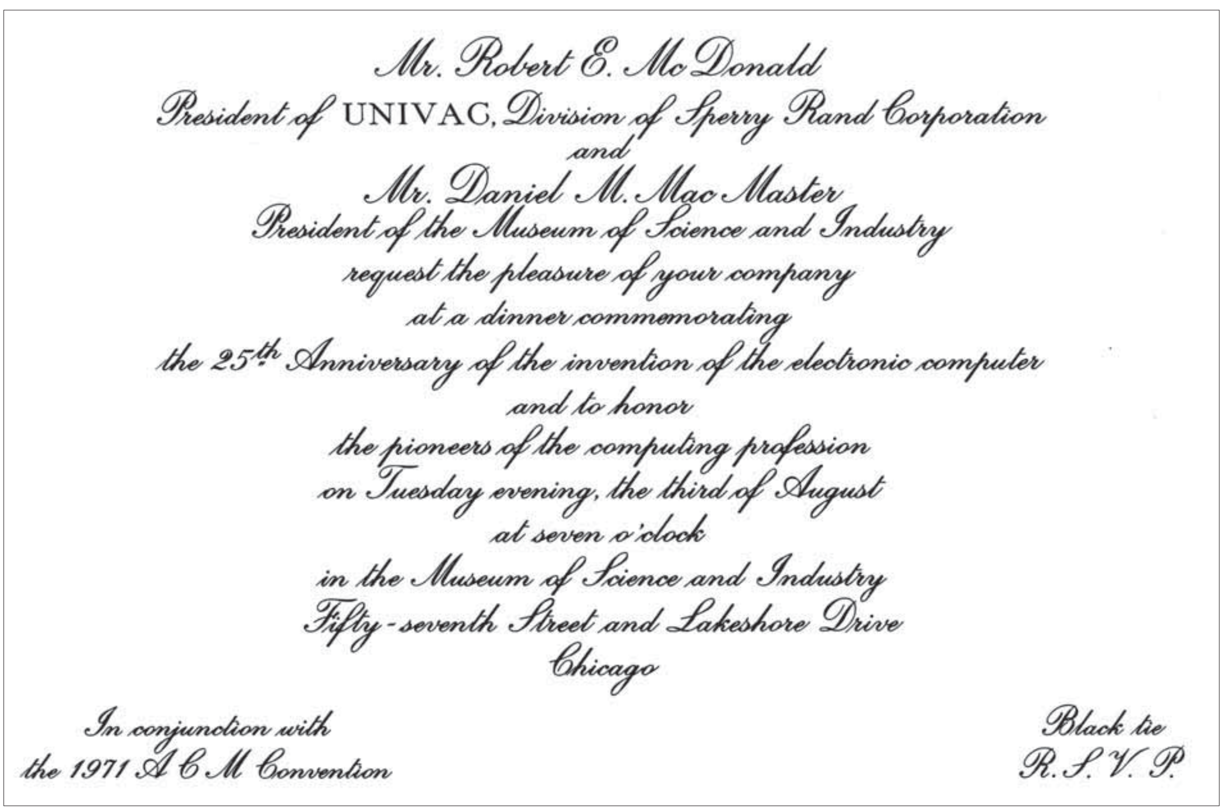
The detailed history is fascinating and has been well covered in a number of publications. I will try to cover just enough to support the theme of this book which is the interplay between punch card equipment and the electronic data processing machine in particular.

The electronic computer was not developed with the aim of pushing punch card equipment into history. The earliest computers were developed primarily for scientific computing. This is where we will start.

As with most major developments, it is not easy to say exactly who developed the first true digital computer. When I was President of the Canadian Information Processing Society (CIPS) that started its life as the Computer Society of Canada, I was invited to attend a dinner at the Museum of Science and Industry in Chicago on August 3rd, 1971. The purpose of the dinner was to commemorate the 25th Anniversary of the invention of the electronic computer. The dinner was organized by the Association for Computing Machinery and was really to celebrate the launching of the ENIAC in 1946. I suppose this event could be taken as the starting point for what were to become practical commercial computers. However, even Dr. J. Presper Eckert and Dr. John Mauchly, the co-inventors of the ENIAC, would not claim that they originated the theoretical background necessary for this breakthrough.



The mailing envelope for the invitation addressed only to Systems Dimensions Ltd., Ottawa with no postal address. It probably helped that we were located on Brookfield Road just across from the main post office!



Mr. Robert E. McDonald
President of UNIVAC, Division of Sperry Rand Corporation
and
Mr. Daniel M. MacMaster
President of the Museum of Science and Industry
request the pleasure of your company
at a dinner commemorating
the 25th Anniversary of the invention of the electronic computer
and to honor
the pioneers of the computing profession
on Tuesday evening, the third of August
at seven o'clock
in the Museum of Science and Industry
Fifty-seventh Street and Lakeshore Drive
Chicago

In conjunction with
the 1971 A C M Convention

Black tie
R.S.V.P.

The invitation to the 1971 25th Anniversary of the invention of the electronic computer

As an aside both were at the dinner and I had the opportunity to meet them briefly. Commander Grace Murray Hopper of the United States Navy spoke at the dinner. Commander Hopper was also one of the computer pioneers but from the software side. She led the charge to develop a common business oriented language (COBOL) amongst other major advances. Although more legend than fact, she is perhaps best remembered for supposedly having coined the term "computer bug". The story is that she had to remove and then subsequently preserve a moth that had become trapped between two relay contacts in the MARK II. True or not, it is a great tale.

Pre 1946

The development of analog computing is a fascinating story in itself but largely not relevant to the theme of this book. I refer you to *Computing Before Computers* for an excellent review of this technology. Analog computers were used for such things as anti-aircraft gunnery control and were pioneered by Bell Telephone laboratories (the M-9) and the even earlier work done by Vickers with their Predictor anti-aircraft control mechanism.

However the gradual realization that electromagnetic relays which could also be used for calculations led to many interesting developments in the 1930's. Some of these devices found their way into the previously discussed mechanical calculators developed for punch card accounting. However at least three individuals, Konrad Zuse in Berlin, George Stibitz in New York and Howard Aiken in Cambridge, Massachusetts pushed forward the idea of using relays combined with punch paper tape for program input. The machines they developed largely independently were capable of carrying out a sequence of elementary arithmetic operations as programmed in the perforated tape.

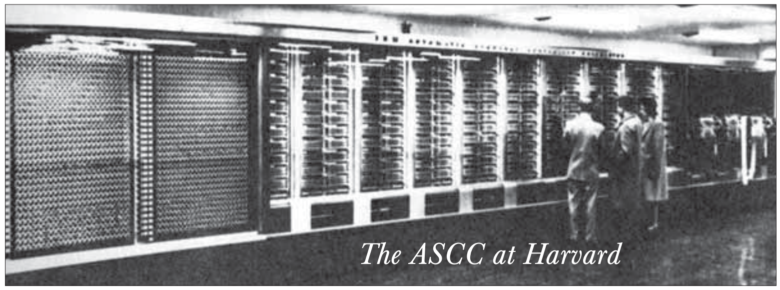
Zuse made the initial determination to use a binary rather than decimal system of enumeration as relays perform best in a simple on/off mode. At the time he was a student at Berlin's Technical College. He continued his work during the Second World War but was largely unknown outside Germany and had less influence on subsequent designs than that of two Americans.

By 1937 George Stibitz, Research Mathematician at the Bell Labs, also came up with the idea of using relays in a binary mode. Bell Labs built the Complex Number Computer which was also essentially a fixed sequence calculator. A complex multiplication took about 45 seconds on the machine but it did demonstrate how such a binary machine could be the basis of a more sophisticated computer. In the fall of 1940, the American Mathematical Society met at Dartmouth College in New Hampshire. Stibitz arranged to have the Complex Number Computer connected by phone lines to a teletype unit installed there. The computer must have impressed a number of the attendees as it included those who were to do such important theoretical work in the computing field as John von Neumann, John Mauchly and Norbert Wiener.

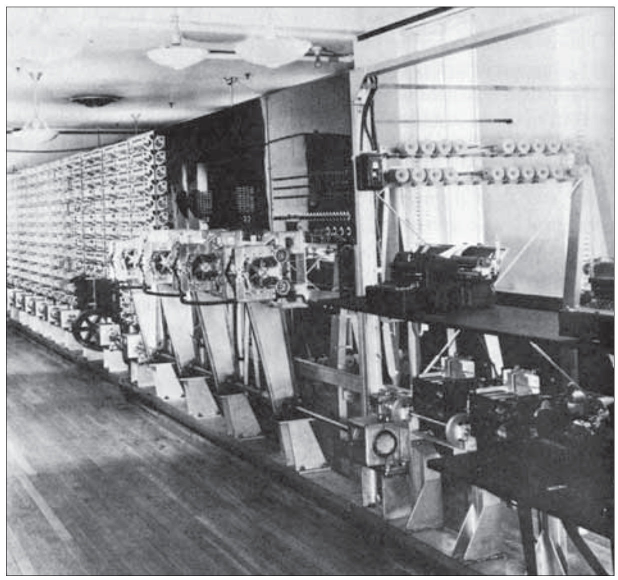
The third machine in this 1930's trio has a particular association with IBM. Howard Aiken at Harvard put forward his ideas for a "proposed automatic calculating machine" in 1937. IBM already had a strong association with Wallace Eckert, Professor at Columbia

University and had established the Watson Scientific Computing Laboratory there. Harlow Shapley, the Harvard Astronomer, suggested that Aiken get in touch with Thomas J. Watson Sr. who promptly assigned James W. Bryce to implement Aiken's proposal. IBM put up most of the half million dollars the machine would cost and although built to Aiken's design, it was actually made by IBM personnel in Endicott.

The machine when completed was called the Automatic Sequence Controlled Calculator (ASCC) and was moved to Harvard in 1944. The ASCC used a mechanical relay based memory and control.


The ASCC at Harvard

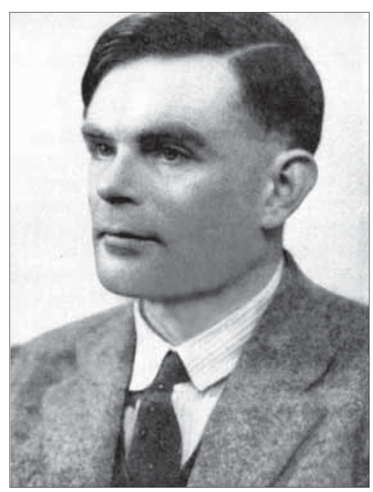
It borrowed many of the features of the IBM punched card machines including 72 accumulators. It was driven by a program on paper tape for the calculating sequence. The punched paper tape was in fact uncut IBM card stock.


Paper Tape Readers for the ASCC

Aiken went on to design 3 more large scale calculators called Mark II, III and IV. The ASCC became known as the Harvard Mark I.

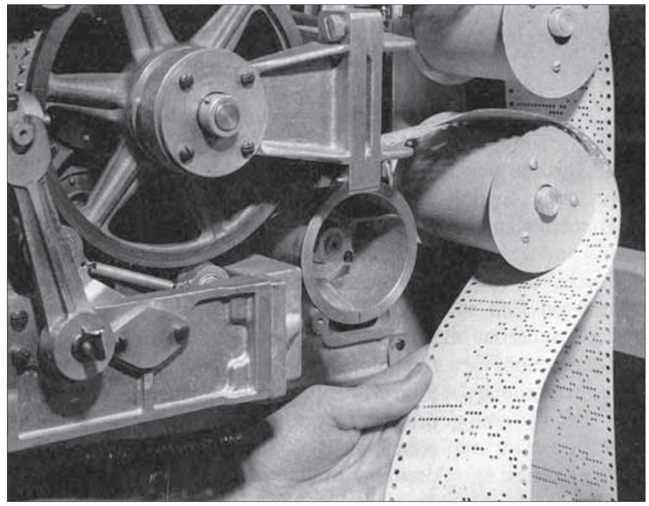
Colossus

A name not mentioned to date in the early development of computers was Alan M. Turing, the brilliant but very eccentric British mathematician. Turing had the idea for a computer that ultimately could not be differentiated from a human in terms of its responses. His work however was interrupted by the Second World War and he was recruited along with many others to Bletchley Park, the ultra secret operation set up by the British Foreign Office to decode German messages encoded on the Enigma machines. Turing was instrumental in developing a computer of sorts called Colossus. It did not have an internally stored program and its sequence of operations was modified by setting switches or plug-in cables. Still it was a very sophisticated machine and before the end of the war, ten were built. They were instrumental in shortening the length of the Second World War.


Alan Turing

A True Theoretical Computer

The electro mechanical devices as described above had the limitation that their programs were embedded on paper tape. This of course determined the sequence of the instructions and there was very little flexibility in terms of the program taking alternate paths.



Close-up of the Paper Tape Reader for the ASCC

Essentially a computer would start by reading data, often from a punch card, and then follow a series of instructions on the paper tape loop. In fact for years afterwards, when a computer could not get itself out of a sequence of instructions, it was referred to as being in a computer loop. In the early days, this actually was a loop of tape.

The breakthrough that created the modern computer was relatively simple. It was the realization that there was no inherent difference between data and instructions. All ended up as binary bits. If a computer program could manipulate data in various ways, it could manipulate its own program. All that had to happen was that the program needed to be stored internally in the computer rather than being read externally from paper tape or cards (it could of course be loaded this way).

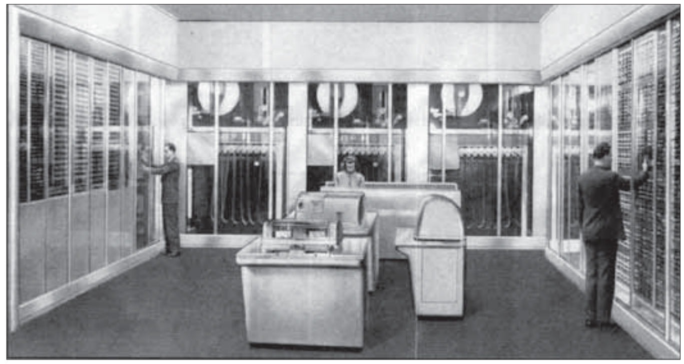
In 1945 Dr. John von Neumann published a paper proposing a new computer to be called the EDVAC (Electronic Discrete Variable Computer). It is generally considered to be the first comprehensive description of how to design a stored program computer.

Whether or not von Neumann (or Johnnie as everyone called him) deserves the sole credit for originating his basic idea, he was certainly the one who proposed how the approach could be made practical. Johnnie continued his imaginative work until his tragic early death in 1957 of bone cancer. I still have his last book, *The Computer and the Brain,* which is the incomplete lectures he had planned to deliver at Yale that year.

The IBM Selective Sequence Electronic Calculator

Despite this theoretical leap forward, other machines continued to be built because of a huge demand for scientific computing. Not to be outdone by the ASCC at Harvard, Wallace Eckert at the Watson Scientific Computing Laboratory at Columbia University designed and had IBM build the SSEC. This was in many ways a forgotten machine but it was one of the first to make extensive use of vacuum tubes. In addition to the 21,400 relays it still contained, it had 12,500 vacuum tubes. It operated under the control of a modifiable program.

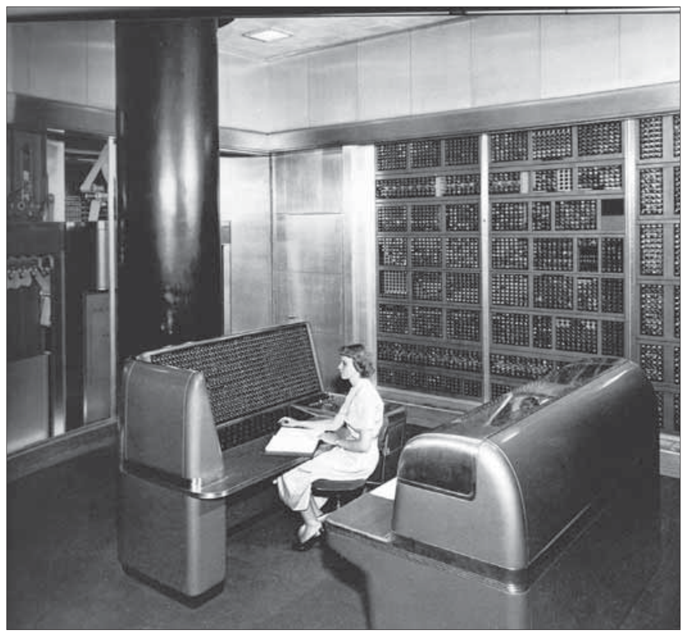
The machine was officially opened on January 27th, 1948 in the presence of a proud Thomas J. Watson Sr. The machine was originally installed at the computer laboratory but was ultimately moved to the new IBM headquarters at 590 Madison Avenue where it occupied a room 60 feet long and 30 feet wide. It was truly an immense machine.



The SSEC

It stored data on huge rolls of uncut IBM card stock weighing 400 lbs. per roll. There were 36 paper tape readers.

As the name implies, it had some capability of altering the sequence of instructions although strictly speaking it did not have an internally stored program. John Backus (the later developer of FORTRAN [Formula Translation]) said, "I think it is an extreme stretch to consider it the first 'stored program' computer even though one of the programs did use some specially prepared storage cells as the source of an instruction after some data was stored in it".



The SSEC Console

Certainly IBM did nothing to publicize this as a von Neumann computer.

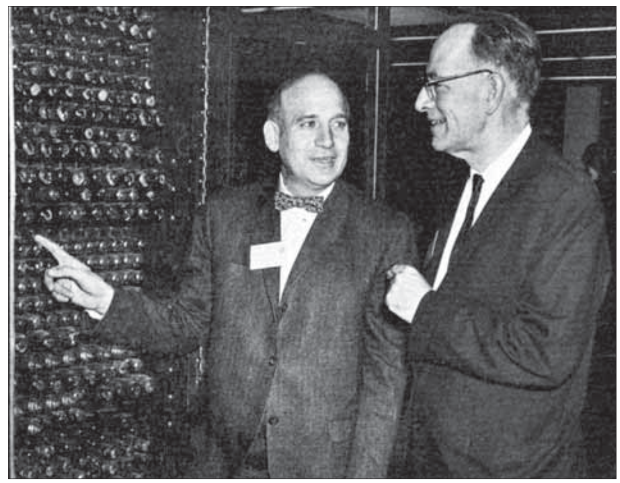
The ABC

Before proceeding with the story of the ENIAC, the Electronic Numerical Integrator and Calculator, there is one other event worthy of mention. In the mid 1930's, a Professor of Physics at Iowa State College, John V. Atanasoff put forward some ideas for an advanced calculator in which the program would be stored in a bank of capacitors. The machine was never successfully completed although he and the graduate student, Clifford Berry, did build a prototype. The machine became known as the ABC for the Atanasoff-Berry-Computer.

Although a U.S. patent for ENIAC as the first electronic computer was granted in 1964, this was voided by the landmark federal court case Honeywell vs. Sperry Rand putting the invention of the electronic computer in the public domain and providing recognition to Atanasoff as the inventor of the first electronic digital computer.

The ENIAC

Like Colossus, ENIAC had its beginnings in the Second World War. Typically, it grew out of the U.S. Army's need to compute firing tables for ordinance. When the United States entered the War in December 1941, the Army's Ballistic Research Laboratory in Aberdeen, Maryland was searching for some method of producing such tables. At the Moore School of Electrical Engineering at the University of Pennsylvania, John W. Mauchly met J. Presper Eckert. Mauchly had already conceived of the idea of an electronic calculating machine using tubes. In August 1942, he wrote a brief memorandum on "The Use of High Speed Vacuum Tube Devices For Calculating" in which he outlined the design that would later become the ENIAC.



J. Presper Eckert and John W. Mauchly in front of the ENIAC

Contrary to what most people believe, the original programming for the ENIAC was by our now familiar plugged cables. The users had to literally re-wire the machine each time to transform it into a computer that could solve a particular problem.

The ENIAC was completed in late 1945 (after the end of the war) but it continued to evolve and from 1948 on it became the first computer with an internally stored program.

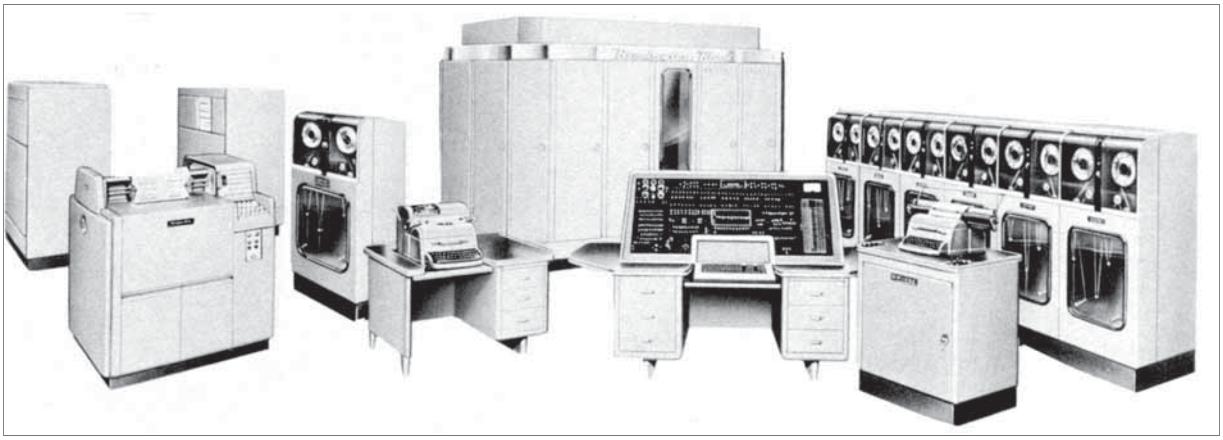
The ENIAC was used for some highly classified programs including the design of the Hydrogen Bomb. However it was ultimately moved to the Ballistic Research Laboratory's Aberdeen proving ground where it stayed in operation until 1959.

The Race Begins

Many universities and think tanks around the world started to build stored program computers with names such as Illiac at the University of Illinois, the Johniac at the RAND Corporation and the Weizak at the Weizman Institute in Israel. (The Johniac of course being named after John von Neumann.)

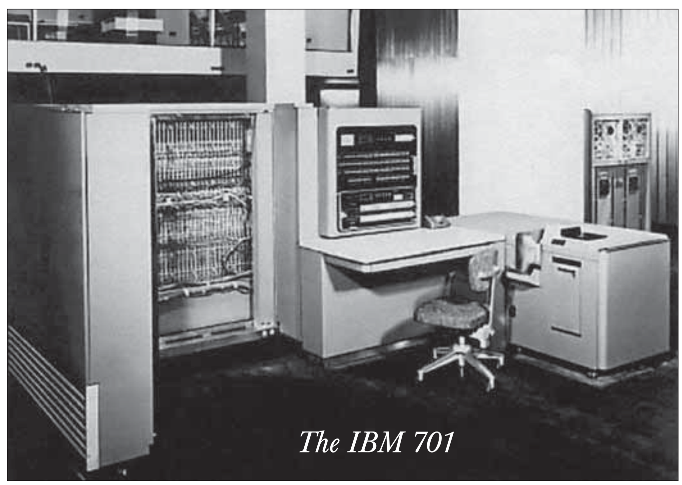
However it was up to Professors Eckert and Mauchly to lead the charge into the commercial computer field. They had left the University of Pennsylvania in 1947 to form the Eckert-Mauchly Computer Corporation. It was there they began working on the design of the UNIVAC (the Universal Automatic Computer). This was their first major contract and called for delivery of the UNIVAC to the Bureau of the Census for the 1950 Census.

The first UNIVAC was actually delivered on June 14th, 1951. Perhaps its most impressive achievement was its use of magnetic tape. This was the first real move away from



Univac 1

scientific computing and into the field of electronic data processing. It is interesting to note that this is the second time that the U.S. Bureau of the Census moved away from IBM (or Hollerith at the time) to what was to become Remington Rand (as successor to Power). This horrified IBM even though the UNIVAC was forced to use IBM's 80 column cards at the Bureau of the Census. IBM countered with its first production computer, the 701 Defense Calculator. IBM still did not call this a computer. Evidently Thomas J. Watson Sr. disliked the term computer as he felt people would interpret this as being a threat to their jobs. The reasoning is not too clear but a Calculator was his name for what was clearly a computer.



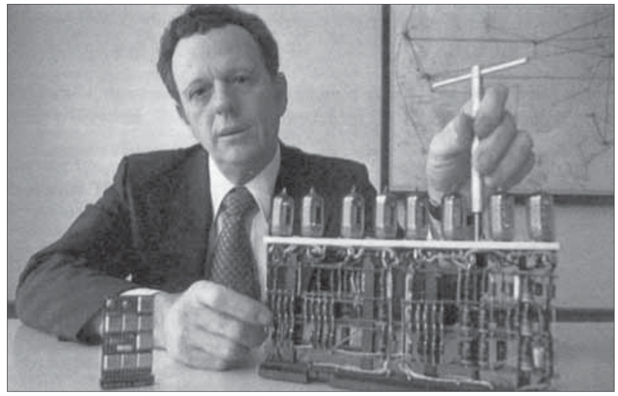
The IBM 701

The 701 was a scientific computer and internally stored its program on 72 Cathode-Ray Tubes (CRT's), sufficient to store 2,048 thirty-six bit words. It did have a magnetic tape unit (the 726) plus a magnetic drum which we will discuss in a moment and the usual card punches and readers and even a printer.

CRT Unit

Only 19 of these were manufactured as the 701 was rather promptly replaced by the 704. This was a similar machine but used magnetic core for its internal memory rather than the somewhat unreliable CRT's. It also had floating point arithmetic and a much expanded instruction set. 123 of these machines were sold between 1955 and 1960 making them a highly successful commercial venture.

I was responsible for the installation of the only 704 installed in Canada at AVRO Aircraft Limited. The interesting history of that machine is that it was discontinued from rental at AVRO concurrently with the cancellation of the AVRO Arrow. This led me to have the largest charge back in IBM World Trade history – not exactly the notoriety I wanted!



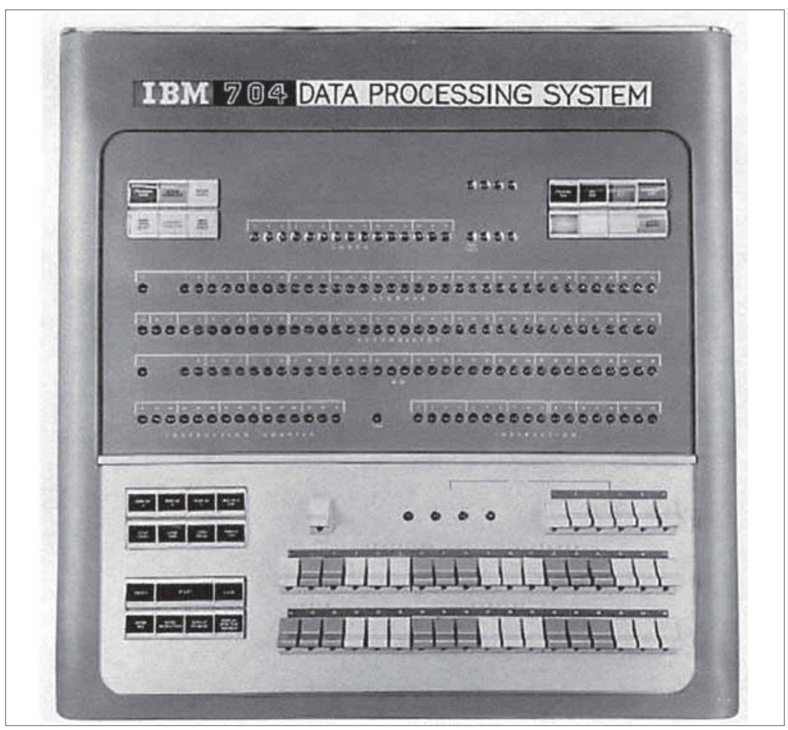
The Modular Tube Units used in the 701

IBM and others continued to produce machines that were predominantly meant for scientific computing. But this takes us away from the story of electronic data processing to which I will now return.

The 704

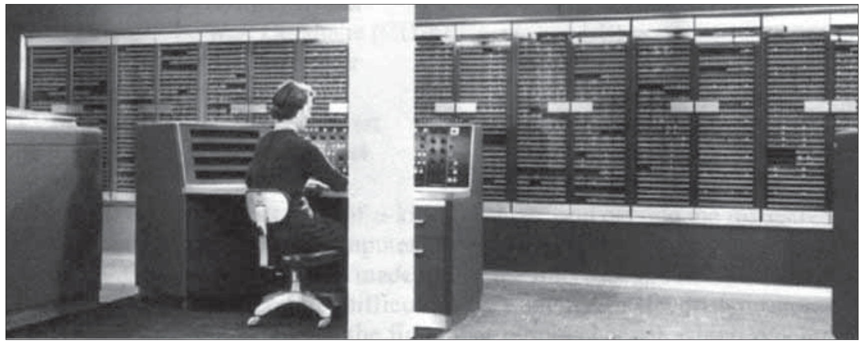
The First Supercomputer

The mid 1950's was a time of intense activity for IBM in the computer field. Before moving on to the production computers that would prove to be as equally useful for data processing as they were for scientific computing, it is worth noting one other remarkable machine. The Naval Ordinance Research Computer (NORC) was designed in parallel with the 701 with the aim in Wallace Eckert's words "to incorporate in this 'one-of-a-kind' calculator the most advanced developments. To this end no effort has been spared to secure extremely high speed, great reliability and simplicity of operation". John von Neumann named it "the most advanced machine which is possible in the present state of the art".



The Console of the 704

It is the first computer that really deserved the name super computer, although that term was not brought into common use until several years later, as it was the first whose declared purpose was to surpass all other computers.



The Naval Ordinance Research Computer (NORC)

The NORC was built between 1950 and 1954 at Columbia University's Watson Scientific Computing Laboratory (612 West 115th Street).

It went into service December 2, 1954 at a ceremony attended by Thomas J. Watson Sr., his wife Jeannette, Wallace Eckert, John von Neumann and a collection of senior officers from the Navy.

The Dedication of NORC

This immense computer was eventually moved to the Naval Service Weapons Centre at Dahlgren, Virginia. The story goes that Professor Edward Teller had been trying to have it diverted to the Lawrence Livermore National Laboratory arguing that the lab's nuclear calculations are more important than Dahlgren's ballistic calculations. However the Navy won and it stayed in operation there until 1968.

It was the most powerful computer on earth from 1954 until the IBM STRETCH in 1961.

It had the usual collection of input/output equipment, largely borrowed from the punched card field, e.g. the printers were essentially 407's. It did however, have reasonably advanced magnetic tape units (eight of them). These units could pack 510 characters per inch and could read at 71,500 characters per second. This was an amazing speed in those days.

The internal clock speed was one microsecond and it was capable of 15,000 operations per second.

The total cost of the machine was about $2.5 million (1950 dollars) and the profit to IBM was $1.00.

As with later super computers, the NORC pioneered some interesting advances including the first input-output channel to synchronize the flow of data into and out of the computer while computation was in progress. This was a simple idea but dramatically improved the throughput.

Like the 701, NORC used CRTs for its main memory (264 of them).

All of its input and output other than the on-line printers was from the magnetic tapes. It had offline card to magnetic tape converters.

Despite these IBM advances, the UNIVAC (Universal Automatic Computer) remained for almost five years after its installation on June 14, 1951 the best large scale computer in use for data processing applications. The latter area of course was IBM's home turf. IBM would have to react quickly and it did.

The 650 Magnetic Drum Data Processing Machine

The 650 although it was announced on July 2, 1953 was actually delivered at the same time as the NORC, i.e. December 1954. Its principal designer was Frank Hamilton who had not only been the chief designer of the SSEC and NORC but had become a legend for bringing out new systems in record time.

The Basic 650

This was the first machine that IBM actually referred to as a computer but more importantly used the term Data Processing Machine. It was intended to be IBM's first commercial business computer (and the first computer to make a meaningful profit). The basic machine had three components, the 650 mainframe, a 533 card read punch capable of 200 cards per minute input and 100 cards per minute output and a power unit, the 655 which had no operator access.

The 650 Magnetic Drum

The main memory for the 650 was a magnetic drum. It came in models of 1000, 2000 or eventually 4000 ten digit words.

The words were arranged in bands around the face of the drum with read heads located across the drum. The drum itself rotated at 12,500 rpm or approximately the speed of an airplane propeller.

Despite this, executing a program recorded magnetically on the face of a drum could be a slow process. For example if you were to read the first instruction from one of the columns on the drum, execute the instruction and then go to get the next instruction, it would have long since passed the reading area. This led programmers to try to optimize (a process called Sloptimization) their location of instructions around the drum placing each instruction several locations around the drum from the previous instruction so that it would be under the read heads by the time it was needed. All of this was plotted on large planning charts.

Initially the 650 (like all early computers) was programmed in machine language, e.g. an add instruction would have a two digit value and elsewhere in the word would be the physical address of the location of the number to be added. All this was cumbersome to say the least. In 1955 Stan Poley at the Watson Lab at Columbia University wrote the compiler for the 650 called the Symbolic Optimal Assembly Program (SOAP). It was not actually the first program to allow the programmer to use mnemonics and to automatically look after the allocation of instructions to the most optimal location (the first assembler was probably the one developed for the 701 in 1954). However SOAP was a major step forward. It allowed mnemonics such as MPY for multiply or PCH for punch.

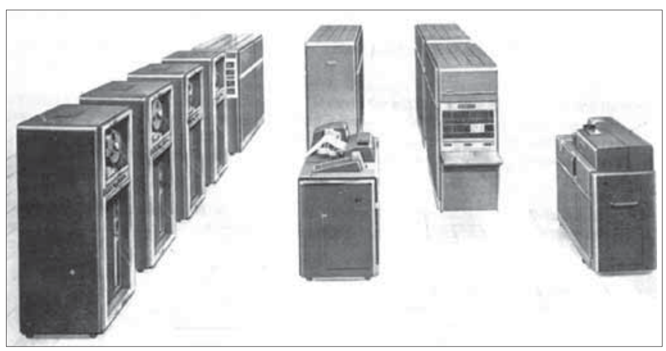
The 650 soon became the workhorse of the industry. Over 2000 were installed before it was withdrawn by IBM in 1969.

Over its lifetime, the 650 capability was gradually expanded by allowing it to have an on-line 407 accounting machine and 727 tape units.

At a rental of $3,750 per month for a 2000 word machine, it was in a price range that commercial institutions could afford.

The 650 was the first IBM computer to arrive in Canada and a demonstration unit was installed at the office at 36 King Street East in Toronto, as I recall, in late 1956.

I was responsible for one such machine at Orenda Engines, the developer of the power plants for the Avro Arrow.



The Expanded 650

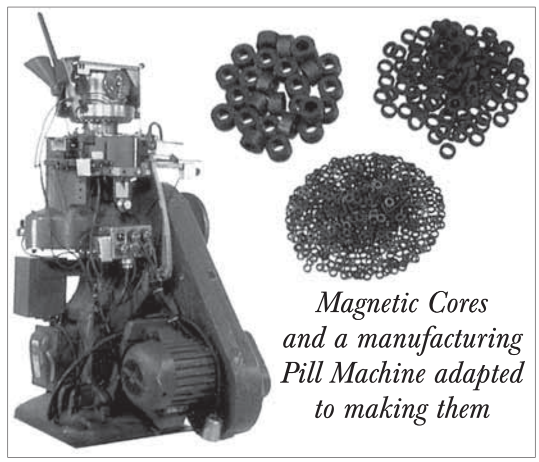
The 700 Series

It was clear that the 701 had been developed for scientific use and would not be able to compete adequately with the UNIVAC I for data processing purposes. IBM therefore announced the 702 which was a character-oriented computer with 10,000 characters of internal storage on electrostatic Williams tube (CRT) memory. The first 702 was delivered in early 1955 but it was already realized that this machine was inadequate for the rigors of data processing applications. The computer was too slow (it had a 23 microsecond per character memory cycle and took 115 microseconds to read a standard five character instruction). The magnetic tape system could read forward only and was completely unbuffered. The worst problem however was the unreliability of the electrostatic memory. At best the 702 was a stop gap and was quickly replaced with the announcement of the 705 on October 1, 1954.

The 705

In the 705 the CRT memory was replaced by magnetic cores. The five character access time was reduced to 17 microseconds. It still however did not have a buffered tape system.

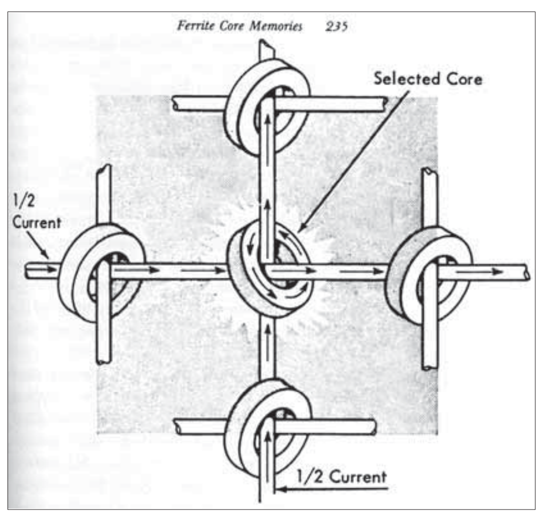
IBM always seemed to be able to find a way to compensate for the occasional inadequacy of its machines and brought out a standalone system called the 777 Tape Record Coordinator (TRC). This was a tape controller containing 1024 characters of magnetic core storage plus associated logical circuitry. Effectively it allowed such operations as the collating of tapes to be done off line to save the early 705 from having to do this without the benefit of buffering.



Magnetic Cores and a manufacturing Pill Machine adapted to making them

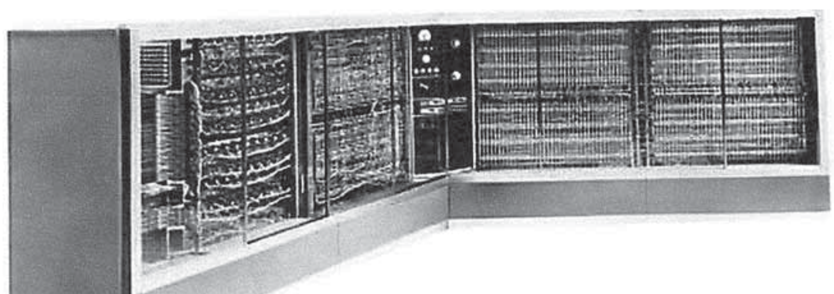
In 1958 IBM brought out the 705 Model 3 with a faster core memory and internal buffering. Backward tape reading however had to wait for a while.

In many ways, neither of these machines were really superior to the Univac 1 that had been delivered 4½ years before the 702. However as was to happen repeatedly over the next few years, Remington Rand was simply unable to match the marketing prowess of IBM and the 705 was soon firmly established as the standard in the large scale data processing field.



Magnetic Core Schematic

One of its advantages was its ability to handle variable length fields which were common in data processing but not normally required in scientific processing. Scientific computers were able to handle floating point operations and could use two words for additional precision. However the 705 was designed specifically for variable length alpha-numeric processing.



705 Model 3 Mainframe

After the demise of the Avro Arrow, I was transferred to Ottawa to be the Marketing Representative for the Dominion Bureau of Statistics that was installing a 705 Model 3 for the 1961 Census. Dave Yerex, the branch manager in the Toronto uptown office cautioned me that I was not to try to convert DBS to a 704 despite my experience with this machine at Avro Aircraft. I did not try and the 705 actually performed quite well despite having a somewhat cumbersome way of handling data.

As an aside, it is worth looking at the continued experiments to get input into computers in an efficient fashion. For the 1960 Census in the United States, Univac had developed an optical reading device that would sense marks on large sheets of paper that were marked in the field by the Census enumerators. This device called FOSDIC (Film Optical Sensing Device for Input to Computers) pushed IBM to develop a similar device for Canada. This was simply known as the Document Reader. It used similar large sheets (as I recall) about 14 inches square on which the poor enumerator had to mark the answers given by the occupant. The marks were read optically as in the case of FOSDIC.

The 705 was programmed to do extensive editing on the information to provide sanity checks on the data and to ensure that all fields required were filled out.

Although the 705 had on-line card readers and punches its primary input and output was on magnetic tape. In those days the 727 tape unit could accommodate 25-50,000 cards on one reel of tape. As the sales literature said, the 705 could duplicate a complete text of *Gone With the Wind* from one magnetic tape to another in 3½ minutes. Perhaps not too useful but an interesting comparison.

The 705 could have a 734 magnetic drum storage unit added to supplement the 20,000 positions of high speed magnetic core. In many ways this was the first attempt to have levels of internal storage, i.e. information could be moved from tape to the drum and from the drum to the core storage from which the program would actually be executed.

As will be quite obvious, the development of the 700 series led to a number of unfortunate incompatibilities between the 704 and the 705. They were designed by completely different divisions of IBM. Even the character codes were different. The 704 used odd parity checking while the 705 used even parity checking. The instruction sets were totally different.

The Competitive Situation in the Mid 50's

As I had indicated at the outset, I am most familiar with IBM equipment with which I had a very close association. Other companies however were active in the field. Honeywell had brought out a system called the Datamatic 1000, a magnetic core memory data processing machine. However by the time it hit the market in 1957, IBM had been delivering 705's for two years. In 1958 it was withdrawn from the market. There were many rumours that Honeywell was about to leave the computer field. However it did develop the Honeywell 800 series as a second generation system.

RCA (Radio Corporation of America) had been active in the computer field from the very early days. It decided to develop a very large data processing system designed specifically for business use called the Bizmac. It was advertised as the first truly variable word length computer and might have some claim to this fame having slightly predated the 705. However the most unbelievable feature of the Bizmac was that it could have 200 or more low cost tape transports. A reel of tape would more or less permanently occupy its own transport. To understand why this bizarre and expensive approach might have some appeal, it should be remembered that there was considerable physical activity required to mount and dismount tapes.

All tapes had a physical label on the outside and a magnetic label at the start of each tape so that the computer could ensure it was reading from or writing to the appropriate tape. A large application would require many tape changes. However the Bismac was very expensive and by the time the first was delivered in 1956, it was already outmoded. It ranked up there with the Datamatic as one of the interesting early failures. RCA did withdraw from the computer field completely after one more attempt at a commercial product.

Other companies such as Bendix aimed at the small end of the computer field with systems such as the G-15. It was another magnetic drum computer but was aimed primarily at the scientific market.

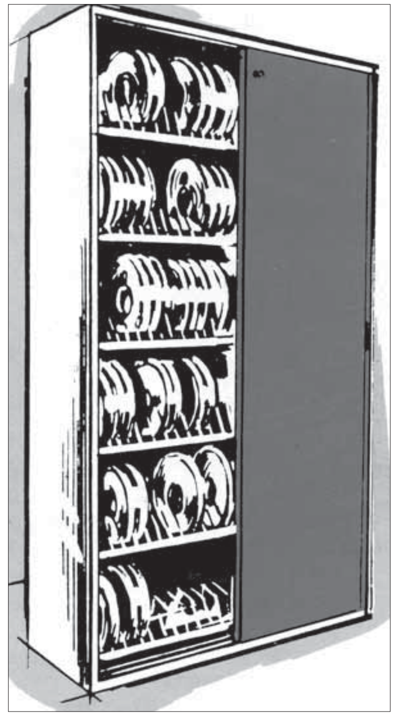
Burroughs kept its hand in the field but would make its big move with the advent of second generation computers.

The Transition from Punched Card Thinking

In the original data processing conversions from punched card to computer, it was understandable that the systems designers would take a largely one-for-one approach. The earliest systems simply read the punched card files to magnetic tape taking advantage of the much faster media. However on the 727 tape drive, there was a three quarter of an inch Inter Record Gap (IRG) which meant that the reading speed of 15,000 characters a second was quickly diminished by having to pass over these large areas of blank tape.

The obvious answer was to block the data at least to the extent that this could be accommodated by the internal memory of the computer being used.

With the advent of buffering in machines such as the 705 Model 3, the input could be overlapped with processing which in turn could be overlapped with the output. However this was severely limited by the internal storage of the machine which also of course had to accommodate the program and working space for the data.



A Tape Storage Cabinet

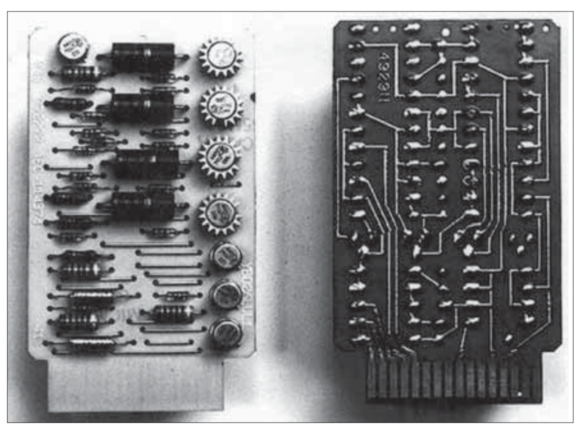
As the internal memory of the machines expanded (the 705 Model 3 for example could eventually have 40,000 characters of core storage), it became more common to use some of the machines computing capacity to convert from cards to tape and tape to printer for example using the mainframe. This was referred to as SPOOLING (Simultaneous Peripheral Operations On-Line).

Gradually the systems designers started to really understand what a computer could do with parallel operations as opposed to taking the very sequential approach that punched card accounting machines had necessitated.

However all of this required more internal storage and processing speed than many of the early computers could manage. Fortunately the second generation of computing was on the horizon.

This resulted from the development of the transistor.

The typical vacuum tube computer might have 1000 tubes and some 50,000 diodes. These generated an immense amount of heat in addition to taking large amounts of power. I well remember that when there would be a power failure (despite the supposed Uninterruptible Power Systems) the operators would frantically open the doors on the computer to try to prevent the tubes and diodes from burning out from the heat when they lost their air cooling.



Printed Circuit Cards with Transistors

The transistor was invented in 1948 and was seen at a very early stage as being the logical successor to the vacuum tube. Soon large transistorized computers would use 150,000-500,000 transistors.

As noted earlier, the 608 was IBM's first excursion into the transistorized field but it was not IBM that would lead the charge into the widespread use of transistors. This was left to the Philco Corporation. Philco had a contract with the U.S. Government Security Agency to build a high speed transistorized computer known as the Transac S-1000. This gave Philco the experience to jump into the general data processing field and by the end of 1957 they had decided to launch a major new effort later to be known as the Philco 2000. This was a high speed binary computer that was expected to be very attractive as a replacement for 704 and its immediate but short lived successor, the 709 which IBM had just begun to deliver. Like Remington Rand however despite Philco's head start it lacked sufficient marketing momentum. Before the first 2000 system had been delivered in January 1960, IBM was in production with the 7090, the transistorized successor to the 709 which was faster than the 2000 and of course compatible with the many programs that had been developed for the 704/9 predecessors. Philco was finally bought over by Ford but the company withdrew from the computer field in about 1964 ending another pioneering effort.

The fully transistorized 7090 was a great success and was subsequently upgraded to the 7090 Model 2 and then a 7094. This latter machine was the end of the standalone scientific computers as we shall see.

However in the scientific world, the race was on. Control Data Corporation brought out CDC 3600 which competed effectively against the 7094 Model 2. CDC continued to make a major run at the large scale scientific computer market with its super computers in the 6000 series.

Now back to the data processing machines. Honeywell had announced the 800 system of which they sold a fair number in the commercial field.

Burroughs came out a bit later with its very interesting B5000 computer. The B5000 however was late in delivery and turned out to be disappointingly slow when it finally was installed in 1963. They brought out a faster version called the B5500 and it continued to compete in the commercial field for a number of years.

General Electric brought out the GE 200 series which along with RCA's 301 and NCR's 300 series sold in reasonable numbers.

However none could compete with the now renowned IBM Sales Coverage.

IBM brought out a transistorized version of the 705 Model 3 called the 7080. It did so reluctantly as IBM had hoped to convert business users to the new 7070 series of computers. However there was such a wealth of legacy applications written for the 705, they had no choice. The 7080 perpetuated many of the inefficiencies of the 705 design but sold reasonably well.

It is worth considering why the conversion of programs was still difficult at that time. Many legacy programs were written in machine language or mnemonic follow-ons such as Autocoder for the 705 series. These could not readily be recompiled for a brand new system with a totally different instruction set.

This was to be one of the great advantages of general systems such as COBOL (Common Business Oriented Language) which should have been able to be easily recompiled for a new computer. This probably overstated how easy this was as new computers usually worked in different ways and considerable modification still had to be made to take advantage of the new system.

In later attempts to ease this conversion, IBM brought out Simulators which were effectively programs that would read the original code and use a program to operate it with the instruction set of the new machine. This as one would imagine was very slow and inefficient but it was a useful device for seldom used applications.

They later brought out Emulators which used the same concept but with the translation process built into hardware.

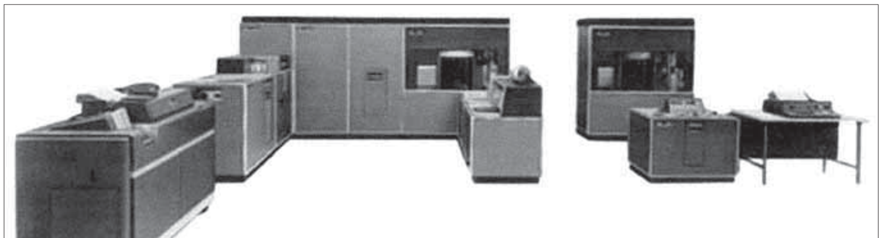
The divergent scientific and data processing lines at IBM led to two separate user organizations, SHARE for the scientific users and GUIDE for the business users. It used to be joked that at SHARE they spoke only FORTRAN and at GUIDE it was only COBOL. It was fairly obvious that sooner or later these two lines were going to have to be brought together and IBM was to make one more attempt to do this.

IBM endeavoured to pull the two computing streams together with the announcement of the 7070. However this was to be an interim step at best. We should now take a look at the next huge advance in conceptual thinking.

Big, Bigger and Biggest

Electronic data processing, like its predecessor punched card accounting, was only as useful as its access to huge data files. The advent of magnetic tape was of course a help but it was sequential processing. Everything had to be handled in batches.

Punched card accounting had endeavoured to get around this by setting up tub files where at least the relevant information could be plucked randomly as required. Clearly the company that could solve the random access to data would dominate electronic data processing. IBM made this huge breakthrough with the announcement on September 4, 1956 of the IBM 305 RAMAC (Random Access Method of Accounting and Control). On that day T. J. Watson Jr., by then President of IBM, noted that "this is the greatest product day in IBM's history and I believe in the office equipment industry".



The 305 RAMAC

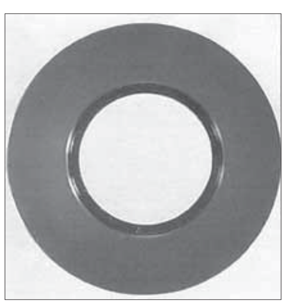
The concept was simple. The execution was anything but.

The main component of the 305 was the 350 Disk Storage Unit. This unit was comprised of 50 magnetic disks coated with an oxide paint. (As one of the designers, Rey Johnston, noted, this was essentially the same paint that was used on the Golden Gate Bridge.) To get the paint evenly on the surface of each of the rotating aluminum disks, the paint was actually poured on the surface of the disk and the centrifugal force was used to spread it uniformly over the disk surface. Another engineer found that filtering the paint through a silk stocking helped to ensure its uniformity.

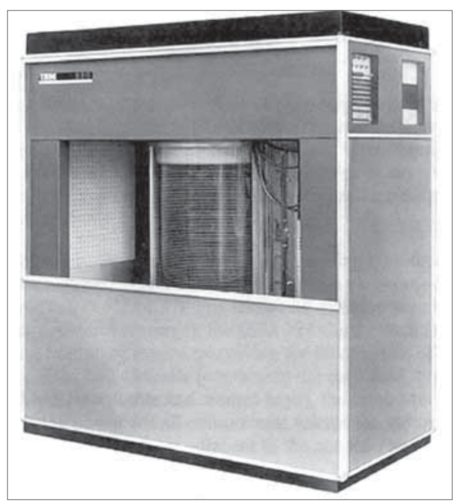
The disks rotated at 1200 RPM and the information was written on concentric tracks (20 to the inch). The information was read incredibly enough by a single access arm that could move up and down to access each of the 50 disks and then in and out to access a particular record.

The disk was organized into 50,000 100 character records.

The average seek time was about 600 milliseconds.



A Magnetic Disk



350 Disk Storage Unit

The RAMAC was one of the last vacuum tube systems designed by IBM but it pioneered the concept of random access processing. In many ways the unit was like having a one armed tub file operator but the conceptual advance made up for the somewhat slow access.

On February 27, 1984, the American Society of Mechanical Engineers designated the RAMAC as an international historic landmark emphasizing its revolutionary place in computer history.

The other components of the 305 system were geared in speed to the access time of the single arm. The 370 printer was an 80 position serial output printer with the same type of tape control carriage as the 400 series accounting machines. The 323 card punch provided for 80 columns of output punching and there was a 380 console which actually contained the card feed, a typewriter keyboard, and the appropriate indicator lights.

In 1958 the 305 was modified to add an additional 350 disk storage unit thereby doubling the capacity.

More than 1,000 305's were built before production ended in 1961.

Long before then, I had more than enough experience with the 305 than I felt I needed.

Installing the 305

One of my accounts while still in Toronto was White Hardware. This was the wholesale operation for a large series of independent hardware stores appropriately called the IHA (Independent Hardware Association). White Hardware serviced these relatively small independent operators in the days before the massive Home Depots and Canadian Tires took over this market.

The 305 RAMAC was a natural to replace their punched card system. As the IBM sales representative, I had to demonstrate the feasibility of this new approach. The data processing manager, Tom Scrymgeour and a private consultant Don Barber and I worked for days to design a system that we thought would work.

Having a 100 character record sounded like a step-up from the 80 columns available on a card. However, five of the positions were taken up by the actual address, literally the machine address of each record was 00000 to 49999. However there was sufficient room to put in all the rest of the product information. The system was sold and the installation was a success.

It was not always this smooth. During my time in Ottawa, I was primarily responsible for Federal Government business. There was however a large wholesale grocer in Ottawa called M. Loeb. In a fashion similar to White Hardware, M. Loeb was the local supplier to a string of independent grocery stores called IGA (Independent Grocery Alliance). A sales representative from the commercial division in Ottawa had installed a 305 RAMAC but before long it was in deep trouble. A small grocery store would endeavour to order a case of canned peas and would instead get canned artichoke hearts. The store owner and others started to write Bert Loeb, the President, complaining that the demand for artichoke hearts was negligible in a small Ontario town and they should get their act together. It appeared quite likely that the 305 was going to get thrown out.

With my White Hardware experience, Al Hewitt, the branch manager asked me if I would see what I could do to straighten out the situation. My first meeting with Bert Loeb was quite memorable.

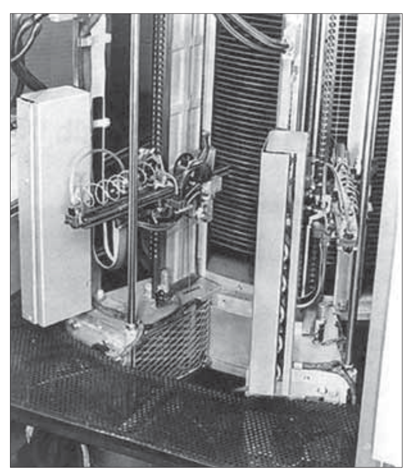
When I walked into his office he said ‘sit down’. He then walked over, threw his annual report in my lap and said “we made a profit last year. I intend to make one this year. What are you going to do about it?”

IBM sales school had not quite equipped me for this but I asked for a couple of days to look at the system to see what could be done. The problem was obvious. There was a matrix table set up as was quite common with 305 installations to relate a product number to the aforementioned machine location. Over a short period of time, this table had become corrupted and the cross references of course gave the wrong product. The solution was equally simple although it took some nights and weekends to redo the whole table and then build in a checking program to ensure that the produce code ordered matched the produce code at the appropriate machine address location.

A couple of days later I went back to Bert to report on the progress. I indicated as politely as I could that the problem was not really a machine problem but a systems problem and M. Loeb had to take some of the responsibility.

At that point Bert called in his data processing manager and said “you’re fired”. He then turned to me and said “now I have solved my problem, what are you going to do about yours?”

With IBM’s usual approach of taking responsibility for customer satisfaction, we put in several IBM juniors and working around the clock as mentioned managed to get the whole system back up and operational within about a ten day period. The installation was saved.

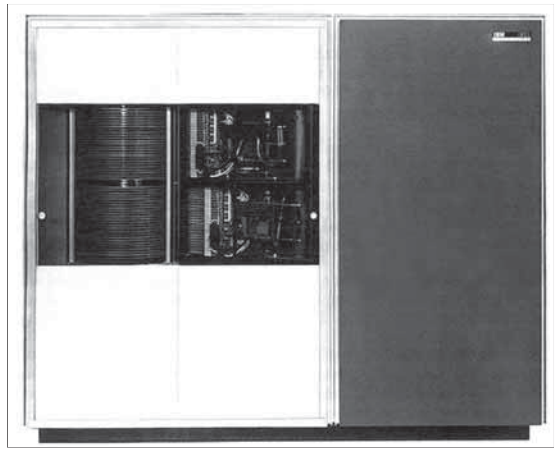


The 350 Disk Storage Unit with an Additional Access Arm

Bigger and Better

There was no limit to the desire of the data processing community for larger and larger random access storage units. As noted above it was shortly possible to add an additional 350 disk storage unit to the 305 RAMAC, doubling the capacity from five to ten million characters. A further step forward on the 350 was to add a second read/write access arm to somewhat reduce the seek time.

On June 2, 1961, IBM announced the 1301 Disk Storage Unit. This was designed to work with the 7000 series computers amongst other systems. One of the major advances was to have vertically aligned read/write heads, one for each disk surface. This eliminated the need for vertical access motion of the arm between disks. It also introduced a slightly different file organization concept as what was effectively happening is that you now had access to concentric 'cylinders' of data at the same time hugely increasing the efficiency.



1301 Disk Storage Unit

The 1301's disks rotated at 1800 RPM and the recording density was increased to 520 bits per inch of track. This was possible due to a reduction of the average head-to-surface distance. The result was a storage capacity per square inch of surface that was thirteen times better than that of the 305 RAMAC technology.

Further multiple units could be attached to a 7000 series computer using a 7631 File Control Unit providing a maximum on-line capacity of 280 million characters for the 7000 series machines.

It was this unit that was used with the celebrated SABRE reservation system devised by IBM for the airline industry.

There was however another approach to expanding the random access storage capability of systems. This would be to design a removable disk storage.

On October 11, 1962, IBM announced the 1311 disk storage drive. This drive provided random access storage for two million characters. Again the density was increased to double that of the 1301 by further reducing the space between the head and the disk by a factor of about two.

The unique feature was the IBM Disk Pack (later designated the 1316). It was an interchangeable package containing six 14 inch diameter disks in a four inch stack. It had a removable cover with a handle on top that would allow the 1316 to be placed on the 1311 disk storage drive and then the cover (looking not unlike the cover of a cake plate) would be removed.

1311 Disk Storage Drive

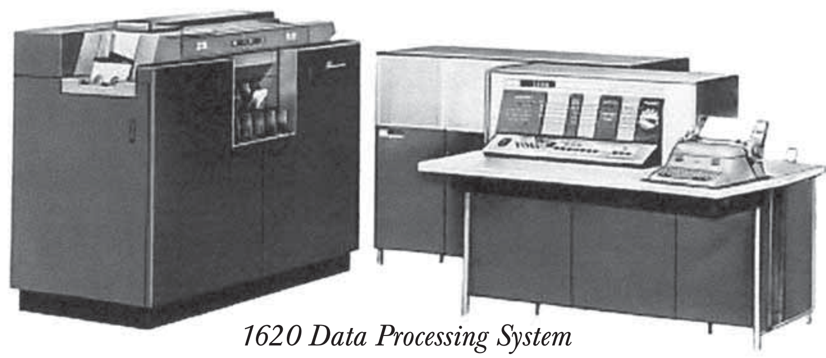
To put into perspective the storage capability of a 1316, it would hold about the equivalent of 25,000 punched cards or about a fifth of the reel of tape at the then current tape density.

The 1311 system offered a relatively low cost random access storage for a variety of machines and was something of a compromise between tapes and disk. Some analysts believe that the removable disk pack was probably one of the major factors in the phase out of the punched card era.

The final model of the 1311 was withdrawn in 1975.

It should be noted that IBM had continued to develop systems designed primarily for scientific data processing. One of the small systems was a 1620 data processing system and its companion 1710 control system. I installed a 1620 at Algonquin College in Ottawa where it was used for student training amongst other things. The 1311 was designed so it could interface with such systems.

We will come back to the ever hungry audience for huge data storage. However we need to pause for a moment to look at the next major development in the demise of the punched card system.

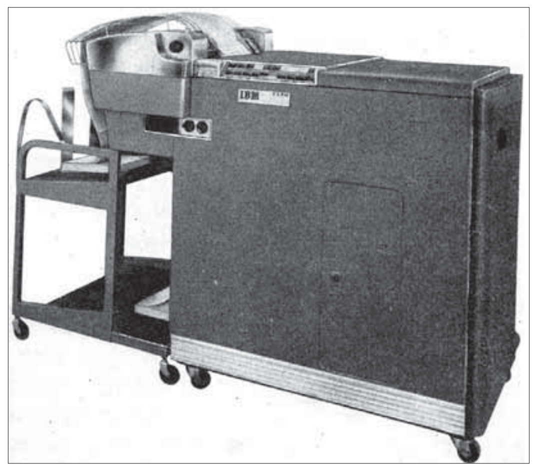


1620 Data Processing System

Rey Johnson went west in 1952 to start up IBM's first laboratory in that part of the country. Three years later, the small group of engineers he assembled had produced the 350 RAMAC, the industry's first magnetic disk file. Johnson, was an IBM Fellow and holds 90 U.S. patents.

The Machine the Salesman Can Install

To this point the fastest printer in IBM's regular line was the 407 at 150 lines a minute. There had been earlier high speed printers. For example Burroughs had a printer that had 48 printing positions in each line and could operate at a speed of 900 lines per minute. However it, like an early IBM printer, the 720 was a dot matrix printer. The printing was not great and the carbon copies actually provided better printing quality than the original. The 720 had 60 print positions and operated at 1000 lines per minute.



720 High Speed Printer

A 730 was also brought out with 120 print positions operating at the same speed. These early models were intended to work with the 700 series computers (an interesting mechanical feature of this IBM high speed printer was that it had only half as many heads as print positions. The printing operation was actually accomplished in two separate cycles requiring the print heads to be repositioned to print a second character).

I have always been amazed at the mechanical ability of any of these computer printers and their ability to respond so rapidly to a print instruction. I suppose this is no different than the incredible escapement mechanism in a piano. When you think about it, the time from the striking of a piano key until the note is actually played must be extremely minute or the pianist would get far ahead of the notes he is actually hearing. This is just another example of leading edge mechanical technology that is quite remarkable.

The UNIVAC 1004

But back to the story. With the 407 being the only widely used punched card printer, its speed was clearly a limiting factor in any data processing system.

Remington Rand's UNIVAC division, seeing the vulnerability of this area, announced the UNIVAC 1004. It had a card reader and punch and was a small transistorized computer. However the huge step forward was a 600 line a minute printer.

To attack the 407 market, UNIVAC brought out two models of the 1004, logically called Model 80 and Model 90 referring to the type of cards that could be used. There was obviously a tiny market for the 90 column card relative to the huge potential in IBM's market.

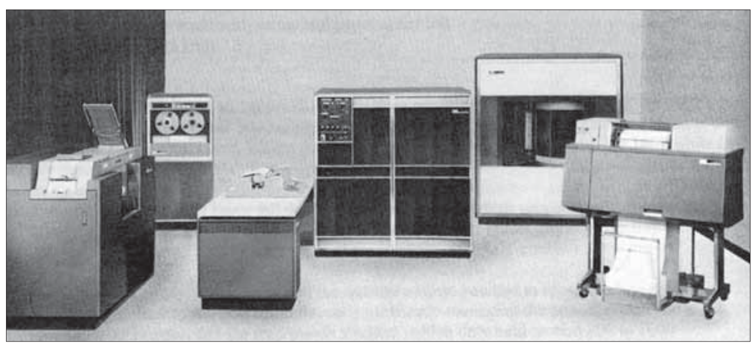
There was a downside however. UNIVAC chose to design the 1004 printer with a drum for the printing mechanism. Unlike the 407 where the individual print wheels could rotate to the desired character, stop and then an entire line would be printed, it was necessary to 'print on the fly' as the drum continued to rotate. (There was one complete set of characters around the drum for each of the columns that could be printed on the page.) No matter how well adjusted, this tended to produce a wavy print line.

However the speed made up for the quality and many IBM sales representatives expressed a deep concern over the vulnerability of the aging 407 market. I was no exception with rows of 407s installed at accounts such as the Bank of Canada. The Bank in fact ordered some 1004s and began replacing the 407s.

IBM's response though a bit slow was magnificent. In October 1959, IBM announced the 1401 data processing system. This was a stored program transistorized computer that was intended to be the first affordable general-purpose computer. It was planned to replace the accounting machines and calculators that still provided a cheaper alternative to the 650.

The 1401 was an astounding success. It was the first computer to sell over 10,000 units.

It was a decimal, i.e. not binary computer with variable word lengths composed of eight bit bytes. It was the business counterpart of the 1620.



1401 Data Processing System

It was supposed to be such a simple machine to install that 'the salesman could install it' much as the salesman had installed earlier punched card equipment where the customer needed that kind of assistance.

It was not actually that easy to use. Originally it could only be programmed in an assembly language although a quickly announced version called Autocoder was a step forward. However IBM imaginatively brought out RPG (Report Program Generator) which made it relatively easy to design report formatted applications. Actually FORTRAN and COBOL were also later added although neither was a large seller on the 1401.

The 1401 computer itself originally had internal storage of 1400, 2000 or 4000 bytes. In no time it was determined that this needed to be increased and a 1406 additional memory capacity unit was developed that could increase this up to 16,000 bytes.

The system had the 1402 card read/punch that read 800 cards per minute and punched 250 cards per minute.

It could also have a variety of magnetic tape units added, initially the 729 and ultimately the 7330. It could also have a 1405 disk storage unit attached which depending on the model could have up to 20 million characters of storage (a direct descendant of the original 305 disk file).

1401 With Tape Drives

However the wonder of the 1401 was the 1403 printer.

The 1403 printer could print up to 600 lines per minute using a full character set and up to 1385 lines per minute numeric only. However the paper could move through the machine at a maximum speed of 75 inches per second when skipping over blank areas. The paper shot through the machines so quickly that the output bin had to be motor-driven to pull it in.

But this was not the end of the wonder of this machine. Rather than trying to print from a drum or even print wheels, the printing mechanism was a spinning chain. The chain spun horizontally, and hammers would strike the chain through the paper at exactly the right time for the character to be printed. Because the chain was horizontal, the printing was in even lines unlike the wavy 1004 output.

1403 Print Chain

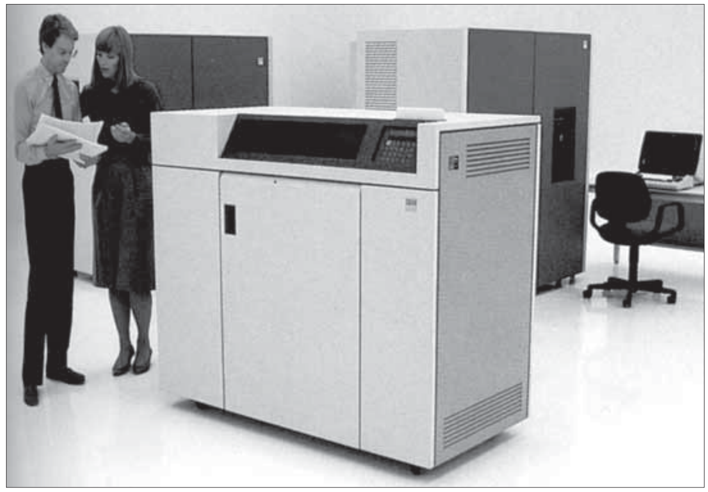
Not only was the 1401 to become one of the most popular data processing systems ever produced, it served as an auxiliary device to large computers. It was ideal for reading and formatting cards to magnetic tape and of course printing from magnetic tape offline.

It remained a standard for high quality impact printing until the 1401 system was withdrawn from marketing in 1971.

IBM's lead in the computer printer business continued. Despite the adage that computers were supposed to do away with paper, IBM brought out a 'train' printer which was an improvement on the 1403 chain printing mechanism that could essentially print at double the 1403's speed.

It did not stop there however. The highest speed impact printer produced was the 4248. This system could print up to 3600 lines per minute. However impact printers were rapidly on their way out. In 1975 IBM announced the 3800 Printing Subsystem. This was a laser printer that could now print up to 20,000 lines per minute.

However once again this is getting ahead of our story.



4248 High Speed Impact Printer

The Beginning of the End

The 1401 had really spelled the end of punched card accounting although card files continued in use even with the 1401. Punched cards continued as an input device although they were starting to be replaced by devices that could go directly from a keyboard to magnetic tape for example. A Canadian, Mers Kutt, developed such a data originating device and it was manufactured in Canada by a firm call Consolidated Computer. At various times, Bill Moore, a past President of IBM, Bill Hutchison, a well known consultant in the data processing field and others were involved in this company. I was on the Board as a representative of the Federal Government who had become a major investor in the enterprise. Ultimately Consolidated Computer failed and it became more feasible to input directly into a mainframe now that large random access storage was becoming available.

We will come back to the continued development of random access storage but should pause to acknowledge the next major breakthrough in the computer field – the announcement of the System /360. However before we get there, we should touch briefly on a few other IBM developments in the intervening years between the 701 and the announcement of the /360.

IBM had developed a number of special purpose systems. We mentioned the SABRE reservation system. IBM also built the huge SAGE system for NORAD. However one of the most interesting developments was in fact something of an IBM failure.

IBM had realized that to stay in front of the computer field, it had to be at the leading edge of building super computers. It had recognized this with NORC and some of the earlier computers described. During 1960 IBM recognized the need for a leading edge computer that could test a number of new developments. They launched the 7030 project, otherwise known as STRETCH. It was expected to perform the work of about eight 7090s or 100 times the speed of a 704. The specs were worked out with the Los Alamos Scientific Laboratory and stressed high arithmetic speeds. Ultimately the design objectives proved too ambitious for the hardware capabilities of the time and across any reasonable range of applications, the 7030 proved to be equivalent of only about five 7090s.

STRETCH

The 7030 was a pioneering effort in several areas. It was one of the first truly multiprogrammed machines. It had enormous internal capacity with over 150,000 transistors.

However it stumbled in some of its very advanced concepts. One of these was the Look Ahead approach. The 7030 used tiered internal memory to speed up the retrieval of instructions. It would look ahead at the instructions it was going to have to use and then would move these instructions into a higher speed internal storage. However as most programs contained many branches, this approach proved to have its limitations. It became ultimately impractical to look ahead to too many optional paths.

The 7030 was still an impressive step forward but the failure to reach its design specs led the then Chairman, Tom Watson Jr. to write "making an example out of STRETCH shook up the engineers alright, but it turned out to be a grievous mistake. The engineers understood me to be saying 'no more of those big machines around here'." This was reported in his book *Father, Son and Co*. However many of those who worked closely on the STRETCH project were already putting forward the concepts of a new integrated computer line that would essentially eliminate the separate projects IBM and others had always had for data processing machines and for scientific computers. The design of the new line was to be "the responsibility of Drs. Brooks and Amdahl", Fred Brooks and Gene Amdahl were of course only two of a huge team working on this project. It was dubbed simply Project X.

On April 7, 1964, IBM announced the System /360 with six models, the 30, 40, 50, 60, 62 and 70. I was sent off to the pre-announcement school and participated in the launch in Ottawa on that day.

The story of the development of the /360 is well covered elsewhere (particularly in the book *IBM's /360 and Early /370 Systems* by Pugh, Johnson and Palmer) and the details in terms of its impact on punched card systems are only somewhat relevant.

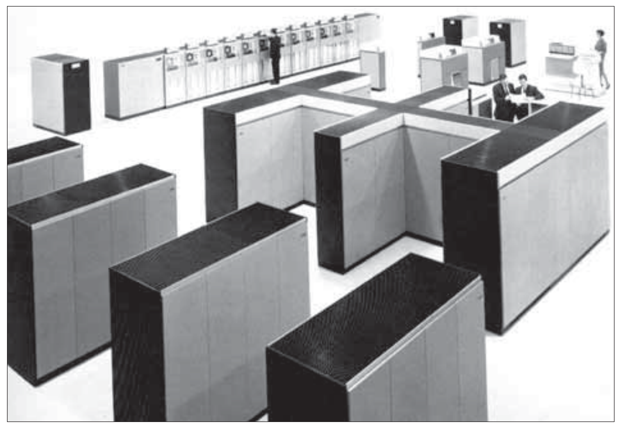
System /360 Model 50

However the concept of a single integrated line of data processing/scientific computers all using essentially the same instruction set and most importantly the same operating system was absolutely revolutionary. The system settled on a 32 bit word (a logical binary number as opposed to the 36 bits of a 704 for example). It turned out however that a single operating system over this range of computers was not feasible and this this led to the development of the much smaller but understandably less capable Disk Operating System (DOS).

My experience with the System /360 involved in being responsible for one of the first System /360 to be installed outside the United States (a System /360 Model 40 at the National Research Council) and a Model 65 at such institutions as the Central Data Processing Service Bureau of the Federal Government and the University of Ottawa.

Leaping ahead in the story slightly, after three members of the IBM office, John Russell, Senior Systems Engineer, Guy Morton, Systems Engineering Manager and I left to start Systems Dimensions Ltd. in March 1968, we ordered and installed the largest System /360 that IBM had at the time – the Model 85.

That story is told in *Finnie's Family* (available on the website at www.gfierheller.ca) but I was reminded the other day of another pronouncement by Tom Watson Jr. In days when his labs were experimenting with Cryogenics, he made the comment that he would never see a system of his delivered in a refrigerator. Maybe not. However the System /360 Model 85 was water cooled. He did deliver a system that had to be installed by a plumber! I will come back to a brief discussion of why this was necessary.



System /360 Model 85

However the real reason for taking this story as far as the System /360 was to talk once again about the advances that were coming in random access storage and how these finally put punched card systems to bed.

Some Way Out Systems

One advantage I had working with the Federal Government was that they were always interested in new advances in mass storage and therefore I had several trips to Poughkeepsie, San Jose and elsewhere with Federal Government representatives to look at new leading edge systems. I will only touch on a couple of these.

In April 1960 IBM's Data Processing Division (DPD) announced that it had developed a computer tape system that could read and write at a rate of 1.5 million characters a second. This was roughly the equivalent of four full length novels a second. The system was designated TRACTOR. The tapes were stored in an automated tape-cartridge library containing as many as 640 sealed cartridges, each containing an 1800 foot long tape capable of holding 120 million characters. The dust-proof cartridge was designed to be mounted, dismounted, stored and retrieved automatically. If one were really interested in way out figures, this was the equivalent of about 220 miles of magnetic tape and at its full capacity TRACTOR was capable of storing 60 billion characters of information, enough to house a library of about 150,000 volumes.

In addition to its phenomenal transfer speed, TRACTOR could swap one cartridge for another in about 18 seconds.

It was designed originally for the U.S. National Security Agency and remained in operation for about 14 years.

It was obviously a compromise again between random access storage and tape storage where the access needed to be fast but not totally random.

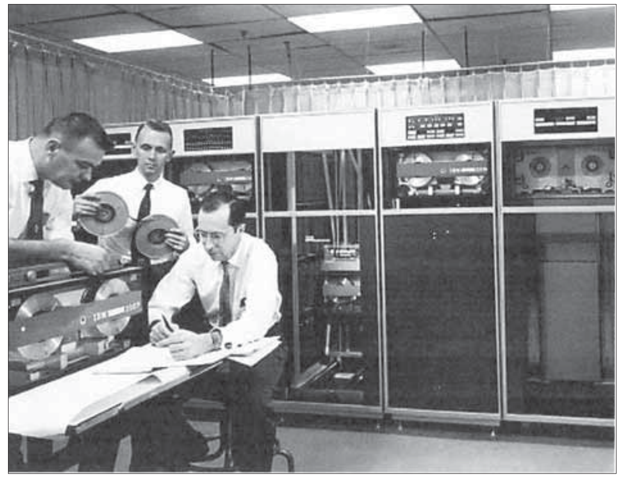
On October 23, 1961, IBM announced a commercial version of this known as the 7340 Hypertape Drive. This was also a tape mechanism where the reels were in a sealed cartridge. The transfer rate was between 170,000 and 340,000 characters per second depending on the mix between alphanumeric characters and decimal digits.

It was intended to work with the 7074 which was a 7070 with a somewhat faster processing system. One such system was installed with the Federal Government in Ottawa.

Ultimately a Model 3 of the 7340 was announced with the double density of 3022 bites per inch. However the 7340 did not enjoy widespread acceptance although it worked very well. The main reason was the continued emphasis on direct random access processing.

We left that story with the fixed disk 1301 and the removable disk storage drive, the 1311.

With the announcement of the System /360, new random access devices were brought out.



TRACTOR

7340 Hypertape Drives

2321 Data Cell Drive

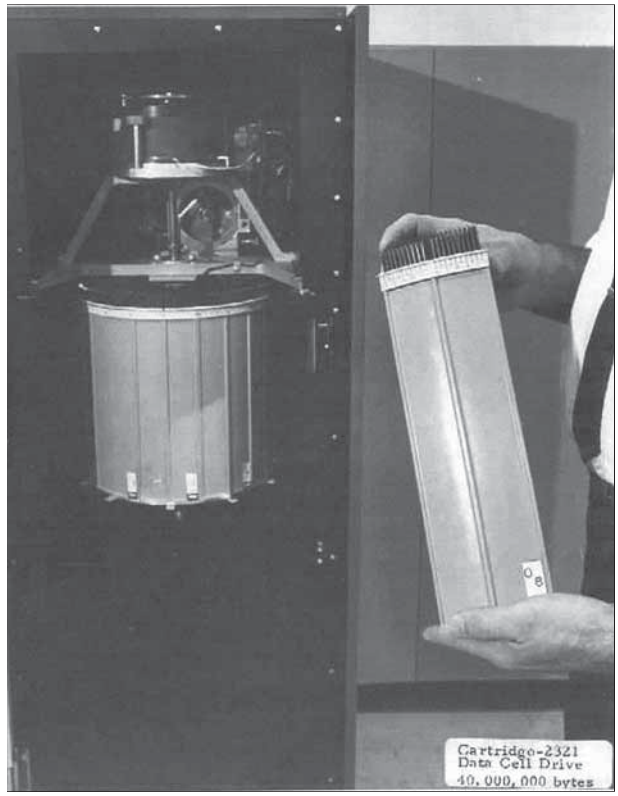
The first was the 2321 Data Cell Drive. Originally known as the MARS file it was a random access device that could store between 400 and 800 million characters. Multiple drives could be attached to a System /360. In fact eight such 2321s could be attached through one control unit giving a total access of up to 6.4 billion digits.

The information was stored this time not on magnetic disks but on magnetic strips which were held in cells mounted vertically around a rotating cylinder. To retrieve or write information, the Data Cell's positioning system rotated the cylinder to locate the specific cell it needed.

Each cell contained ten strips and each cell could be removed and replaced by another.

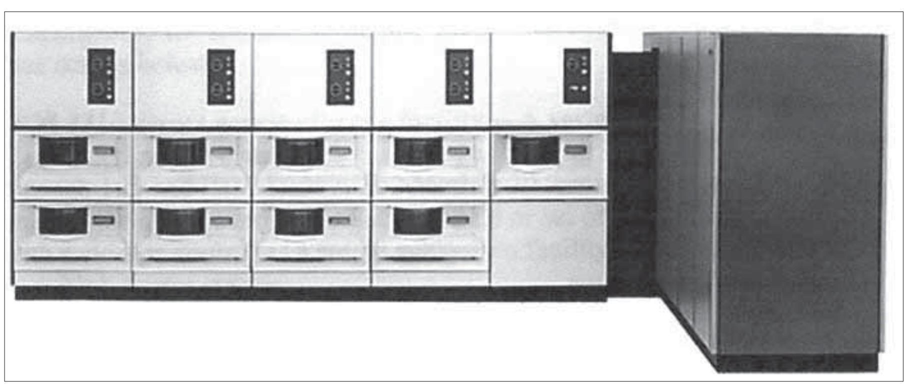
The access time varied from 95 to 600 milliseconds depending on the addressed strip position.

There was no follow on product to the 2321 because of the rapid advancement in disk drive technology. My recollection of this unit was that it was somewhat noisy with a sound reminiscent of a washing machine.



A Data Cell

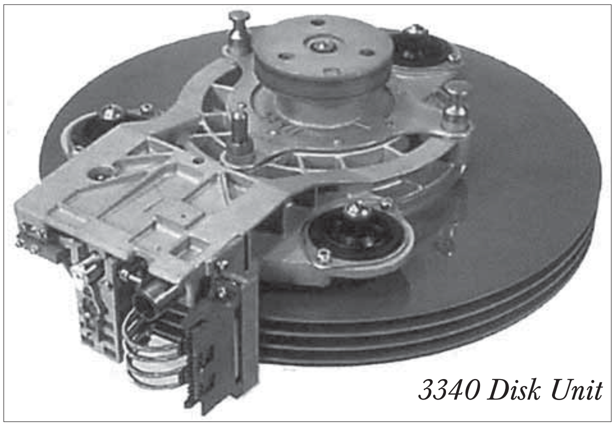
It's relatively short life (it was withdrawn on January 6, 1975) was partly due to the announcement of the 2314 direct access storage facility which was announced April 22, 1965.



Direct Access Storage Facility

The 2314 provided eight disk drives and a spare together with a control unit, all in one facility. A new disk pack similar to the 1311 but with eleven disks greatly increased the storage capacity of each pack.

In later models, the average access time was about 60 milliseconds with a data transfer rate of between 312,000 and 624,000 bytes per second once the appropriate record had been reached. The advantage of the removable disk packs again provided some of the capability of a tape system with the random access feature that was so desirable.

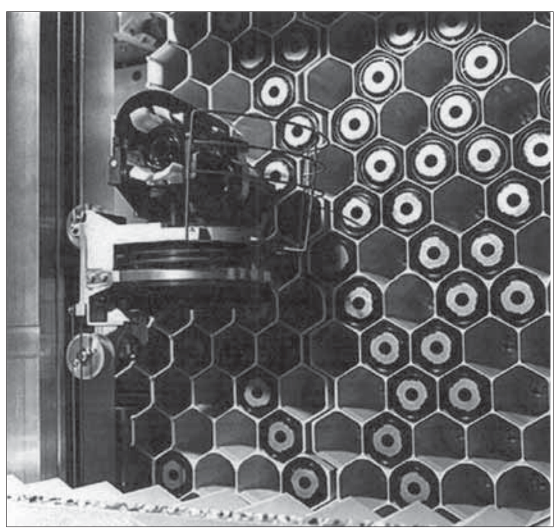


3340 Disk Unit

IBM continued to improve their disk systems. In 1973, the 3340 disk unit was introduced (the project was known as WINCHESTER). The 3340 doubled the information density of IBM disks to nearly 1.7 million bits per square inch.

Earlier than this however IBM took a brief fling at a different type of storage device. This was photo-digital storage. This was a read-only device but was felt to be useful for applications such as the National Library. The device was called CYPRESS. The items to be retrieved were stored on photographic film which was placed in small containers that were stored in a honeycomb-like configuration. They were retrieved on demand and moved by a compressed air system to a central reader. I had one of the containers (unfortunately now misplaced). I remember being told that the compressed air shot these tiny cartridges from their home in the honeycomb to the reader at about the speed of a bullet.

This type of compressed air transport would be familiar only to those senior citizens who would remember a similar type of system that was used in retail stores in the 1930's. Where stores such as Eatons and Simpson's did not want to have decentralized cash (and credit cards were virtually unknown) a clerk would place the bill for whatever the customer had purchased together with the payment in a small brass cylinder with felt rings around either end. The cylinder then would be put into a pneumatic tube and relayed to a central cash location. Change would be provided if required and the cylinder returned to the point of sale.



3851 Storage Compartment

Pushing the story ahead however, IBM then brought out the 3850 mass storage system. This was the monster storage device of its day. Building on the concept of CYPRESS, the 3850 recorded information on magnetic strips in small capsules. This of course had the advantage over CYPRESS of being able to be written on as well as read. The small capsules were held again in a honeycomb arrangement where they were fetched by a mechanical hand, brought to a reader/writer which retrieved the magnetic tape inside. The data was then transferred to/from a disk unit and was used for processing in the normal way. A 3850 installed at the Columbia lab had a capacity of 2000 cartridges holding 50 megabytes each, i.e. over 100 gigabytes. Each cartridge contained approximately 770 inches of magnetic tape. Two cartridges could hold up to 100 million characters of information, equivalent to one 3336 disk pack.

Data Cartridge compared to a 3336 Disk Pack

All of this takes us well beyond the time when punched card files were essentially gone. I have only included this to demonstrate how the size of files being handled had necessitated the development of such advance systems.

The next section is just for fun.

A Lot of Hot Air

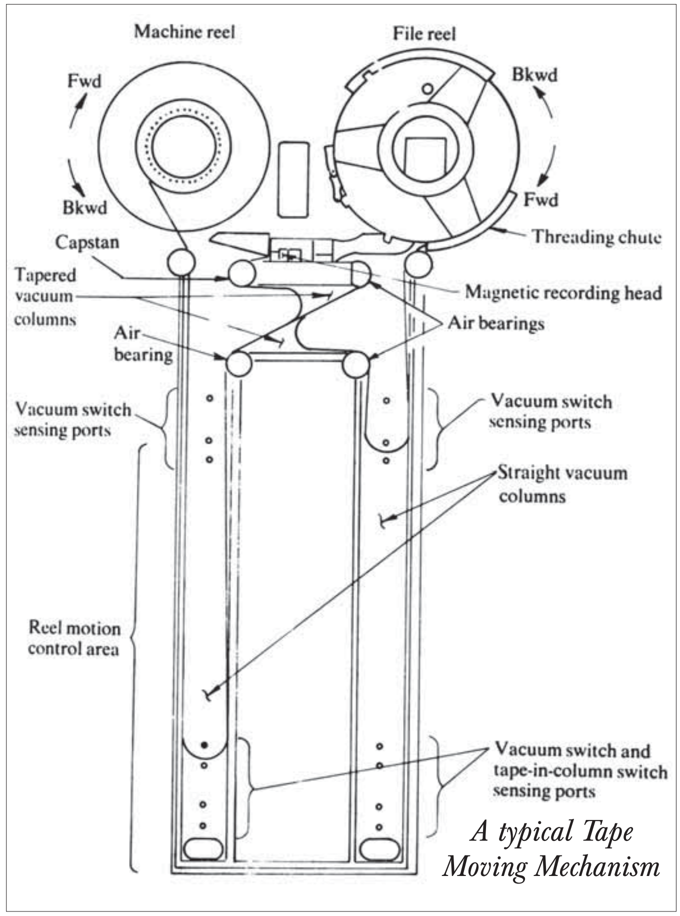
While I have marvelled at the wonders of the punched card machines with their relays and print mechanisms and have also been dazzled at the incredible advances as computers took over, I have always been amused at the role that air played in some of these devices. As a student, for a summer job I worked in a print shop. I remember that most of the printing machines in those days operated on individual sheets. Feeding rolled paper into printers and then chopping the paper to the right size was just coming into being in the 1950's although it had been used in high speed newspaper production for some time. In the meantime, handling individual sheets was tricky. Most printing machines had a device with several suckers providing a slight suction across the top sheet in the paper feed mechanism. To help separate the top sheet from the next sheet, compressed air was also blown under the top sheet as it was picked up ensuring that only one sheet at a time would be fed into the printing mechanism.

This concept of using air in the computer world quickly found many uses. I have already referenced the 084 sorter that used air suction to hold the last few cards down in the card hopper so that they would feed properly without the use of a card weight.

Tape drives also used air pressure. As the tape drives need to start and stop the magnetic tape very rapidly, there was a danger that if you had the reels pull the tape directly across the read/write head, it would be stretched.

Therefore nearly all tape drives were designed with two air columns which pulled the tape down before it reached the read head and did the same on the take-up side. This provided some slack and effectively got around this problem.

However air was to become indispensable in disk storage units. While the read/write head moved across a disk, it would be disastrous to have the head actually touch the surface of the disk.

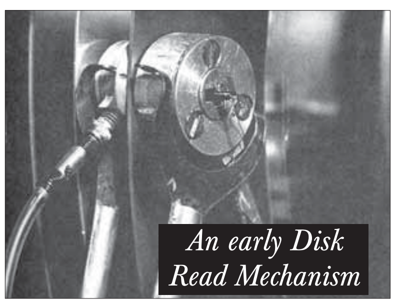


A typical Tape Moving Mechanism

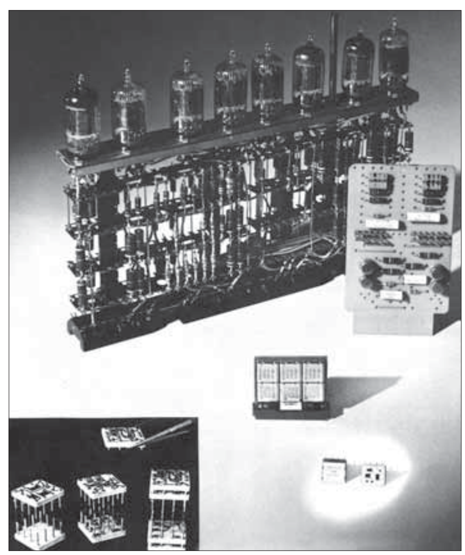
In the early 350's, the way the head was kept off the surface of the disk was by compressed air. In the earliest unit, the 350, the typical head-to-disk spacing was 800 micro inches. By the time of the 1311 disk system, this was reduced to 125 micro inches.

All of these devices were spring loaded to retract if the air compressor failed. Having a 'head crash' was therefore rare although not unheard of.

I just described systems such as CYPRESS that moved its cartridges around with compressed air.


An early Disk Read Mechanism

I also referenced the fact that large computer systems such as the System /360 Model 85 were water cooled. The reason for this was that the /360 systems still did not use fully integrated circuits. The circuits were called Solid Logic Technology (SLT) and were still installed on raised pins. A system such as the Model 85 generated so much heat that the amount of air pressure that would have been required to cool it could literally have blown the components off the substrate. It was this that led to the necessity of water cooling.


Tubes, Transistors and SLT

All of this is relevant to nothing in particular except to indicate that even the most modern computers still use some electro-mechanical components. Fortunately, the demise of the disk drive is not far off. The end of mechanical access devices will certainly not be lamented. They will soon go the way of punched card systems.

III.
Facedown, Nine Edge First

A Dignified Demise

The Punched Card lasted as an input mechanism for computers for some years. We will all remember the decks of FORTRAN programs.

However real time access from remote keyboards was soon to spell the end of this approach.

The Massachusetts Institute of Technology (MIT) Project MAC was perhaps the best known on-line interactive time sharing system. It was designed to allow primarily scientific users to develop their own programs on-line with direct telephone line access to the mainframe. This required a totally different type of thinking from the batch processing that had been common up to that point. Clearly the amount of dead time created by a user on a terminal between key strokes or while thinking or doing something else meant that a large computer had plenty of mainframe time to process multi users. It did require however a new type of Operating System that could monitor each terminal, accept input only when needed, do whatever processing was required and then check the next terminal.

IBM developed such an operating system call the Time Sharing System (TSS) which was intended to be its major entry in the time sharing business on a model of the /360 series called the 67. I did some investigation into this system as I thought it might be of interest to the National Research Council.

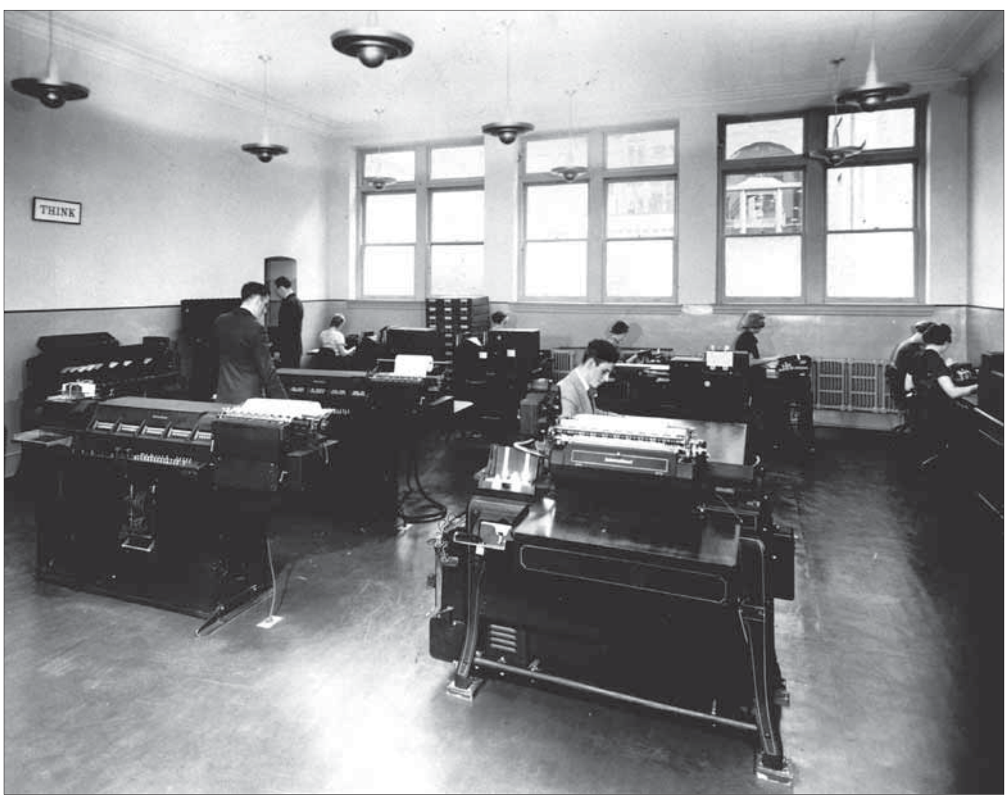
The concept was that a virtual /360 would be assigned to support each active terminal. Unfortunately it turned out to be a highly expensive and none too successful project. TSS was not compatible with the Operating System for the /360 (OS/360). The 67 was announced in August 1965 with the first system shipped in May 1966. After some investigation, NRC decided the system was far too expensive for its needs and many others found much the same. The system had a very short life.

However interactive on-line entry was truly the way of the future for many uses – the Internet is testimony to this. At the University of Waterloo where Wes Graham, Don Cowan and others had installed a Model 75, they also developed an on-line FORTRAN program that could be used by students directly from a terminal located remotely from the mainframe. This project was called WATFOR (Waterloo FORTRAN). It became a Canadian classic and went through several upgrades. It was the standard for student use in its day. They also developed WATCO which did the same for COBOL.

The use of computers to control processes also bypassed input from Punched Cards. It was becoming increasingly common for computers to receive direct input from manufacturing operations, inventory control systems, point of sale recorders and other such systems.

By the late 1970's, the Punched Card had largely disappeared, even as an input medium. Unit Record accounting installations were also becoming rare.

There were some attempts to preserve some of these early machines. A young entrepreneur started what he called the Computerseum which displayed in a school gymnasium in Waterloo some equipment he had accumulated from various sources. It was very nostalgic to walk through a display of old tabulating machines, sorters and calculators. He even had a 305 and a 1401. I have no idea what ultimately happened to the project.



A typical Punched Card Installation

25 Turbulent Years

My involvement with IBM equipment lasted about 25 years from 1955 to 1979 when I moved on from SDL.

Punched Card thinking remained influential during the early days of Electronic Data Processing. When you think of it, the 1401 was really not conceptually different from the Card Programmed Calculator, i.e. a system that was able to perform multiple functions on cable connected units such as a CPU (Central Processing Unit), card reader, card punch and printer.

Magnetic tape files were initially just duplicates of the sequential Punched Card files transcribed to a faster medium.

The 305 RAMAC and its successors were conceptually not much different from a unit tub file.

Even the conversion of thinking from a wired control panel to early machine programming was not all that different. You still pre-planned the steps on paper and then executed these by hard wires in the one case and by programming in machine language or early basic translators in the case of computers.

Of course as the true capability of the electronic computer became more obvious, the old Punched Card thinking rapidly disappeared. The internally stored program allowed the development of higher level languages that vastly eased the programming and were intended to allow easy transition by recompiling for new computers.

The ultimate breakthrough of interactive processing through sophisticated systems such as Windows meant that the user no longer interfaced with the machine any meaningful way. Their entire access was through the operating system.

With all the advances the computer brought, the Punched Card could now be buried *Facedown, Nine Edge First*.

The IBM Country Club on Leslie Street, Toronto, in the 1950s

IV.
Parting Thoughts

Personal Observations

I was lucky to have been active with IBM during the peak of the Punched Card era and the beginning of the computer era. I was also fortunate to have been in Ottawa from about 1960 to 1968 where the computer systems in what was essentially an IBM town were so large that I was regularly making visits with members of the Federal Government to Poughkeepsie, Yorktown, San Jose and elsewhere. It was truly exciting to be at least on the periphery of many of the leading edge developments, some of which I have tried to describe.

Watson Research Lab at Yorktown Heights

While I have emphasized the machines in this book, it was really the people who made this field so exciting at the time. In the final section, *Big Blue*, I give some of my thoughts on IBM in Canada.

But before going there, it is fun to recollect a few of the inspiring people that I met over the years who were typical of the leaders in the field at that time.

At one point I had taken a group from the Federal Government to Columbia University's Watson Scientific Computing Laboratory which at that time was at 612 West 115th Street in New York. IBM worked with Columbia to install a range of leading edge computers starting with NORC through machines such as the 701 and continuing through such special purpose machines as the /360 Model 95.

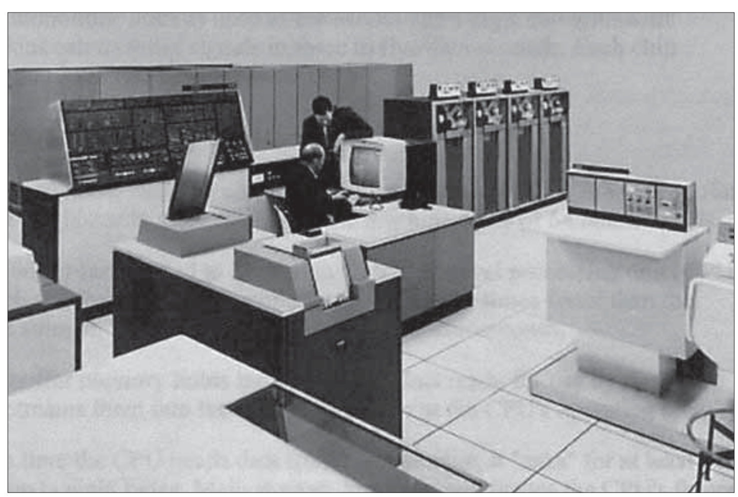
The 701 Defense Calculator with Dr. Herb Grosch demonstrating the machine to Ronald Reagan

Watson Lab at Columbia University

My main aim was to impress upon the Federal Government the leading edge thinking of IBM. We met with Herb Grosch, the lab's director at the time. Although not an employee, IBM could not have had a greater salesman than Herb whose anecdotes were myriad and humorous and whose enthusiasm was boundless.

Gene M. Amdahl

I state this only as a contrast in style. In 1970 while I was National President of CIPS, we had invited Gene Amdahl to speak to our annual meeting in Kingston. Gene had just left IBM to start his own company. He had had two careers at IBM (1952-55 when he became a leader in the design of the 704) and later (1960-70) when he was one of the chief designers for the System /360.



The last of the /360 line, the Model 195, which was about twice the speed of the Model 85

As Kingston was somewhat difficult to access, Gene was coming in the evening before and out of politeness I invited him to join me for dinner. In many ways, he proved to be almost shy but with one of those personalities with a passion for what he was doing. It was one of the most memorable one-on-one dinners I have ever had as he outlined his battles to get System /360 accepted as the single IBM line and then his plans for his own super computers.

Carl J. Conti (left) receives the largest award at an IBM dinner on May 21, 1968 for his work on the Model 85 Cache

As another example of the imaginative people who were working at IBM in those years, I met with Carl Conti who was working on the high end of the System /360 line at the time. In fact one of his major developments was the Cache concept for high speed memory in the Model 85, the model we subsequently installed at SDL. It was this concept of multi-layers of internal storage with increasing capacity that was pioneered for commercial use on the 85 and subsequently became the basis for the System/370 line.

At that time IBM was fighting hard with the CDC 6800, Amdahl and others at the top end of the computer field. One of the benchmarks that was normally used when a customer was evaluating such a computer was a 'matrix inversion problem'. I remember Carl outlining his proposal for incorporating in the System /360 90 series a special piece of hardware to improve the performance just for this benchmarking. The concept was called 'Conti's Kernel'.

I am not sure that it was ever actually implemented as I suspect that IBM Legal would have had concerns about the ethics of the process.

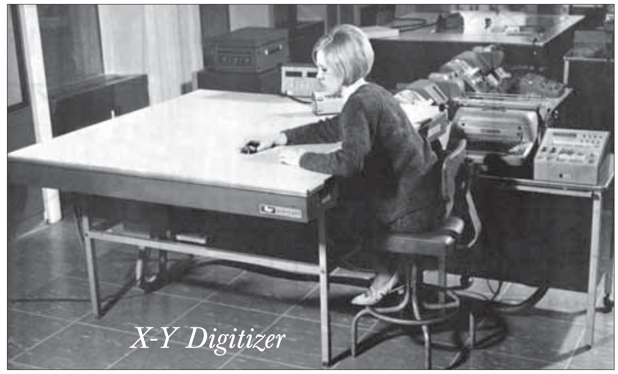
Dr. Roger Tomlinson

Not all of the imaginative people in the field were with IBM of course. The users of the equipment were equally innovative and were very stimulating individuals to deal with.

To reference only one, I should discuss Dr. Roger Tomlinson, sometimes known as the Father of geo-positioning systems in Canada. In the mid 60's he had put forward a concept of creating a computerized geo-information system for all of Canada.

Drum Scanner

This system was being developed for ARDA (the Agricultural and Rural Development Administration) of the Federal Government. IBM had undertaken one of its early systems contracts to develop a computer system on a /360 that would digitize maps containing the capability of the land in Canada for agriculture, forestry, recreation and other socio-economic developments as well as indicating the present use of the land. Approximately one million square miles was involved in the survey.



Maps would be created for each area for each use. They were then digitized on a special purpose scanner that IBM had built. In a separate operation, the characteristics of each area on the map were entered using an X-Y Digitizer. These two pieces of information were then matched.

Finally the computer could be used to overlay data so that one could determine very efficiently how much land there was in a particular area that would be suitable for recreation and within easy reach of road or rail for example.

Roger is an immensely imaginative man standing well over six feet and looking something like a modern Viking with a red beard. John Russell, Senior Systems Engineer at the time in Ottawa, Guy Morton, Systems Engineering Manager and others were working on this project and I was the sales representative. As outlined in *Finnie's Family,* it was this system that ultimately led the three of us to leave IBM in March 1968 to set up Systems Dimensions Limited initially to complete the programming of this job. But that is another story. Roger was simply an example of the many stimulating people that I have had the pleasure of being exposed to in the industry. These were truly heady times.

But perhaps there was more than just machines and even people that made IBM the dominant company that it was during this era. The final section will cover a few observations on this.

Big Blue

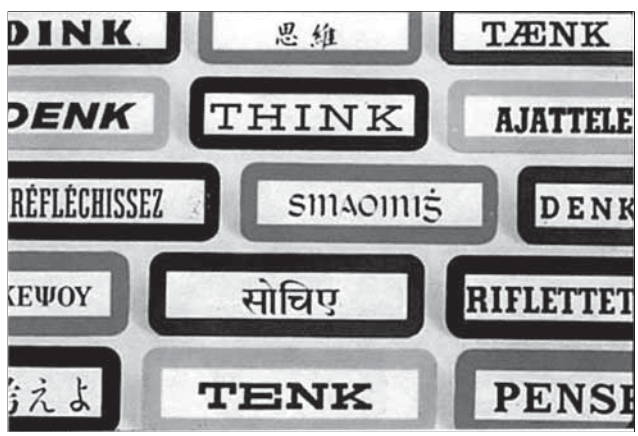
There has been much written about why IBM was so dominant in the Punched Card field and then in the computer era at least up to the 1980's.

Of course some of the reasons was its innovative equipment development. However at many points, IBM did not have the fastest equipment and was not always the first out of the gate. But what it did have was an astonishing attitude that "we are the best". Elitist though this may be, there was simply no doubt in the minds of IBM salesmen to say nothing of the Customer Engineers and Systems Engineers that we were the best trained, most dedicated and in our own opinion, the most imaginative group in the field.

To be selected as an IBM'er in the mid 50's in Canada involved passing a Programmer's Aptitude Test, at least one Psychological Test and being interviewed by three or four levels of IBM Management up to and including at least a Vice President.

We were somewhat the envy of our contemporaries as even during our training phase, we were better paid than most other professions at the time.

I think we actually believed that we were the 'Jesuits' of the Data Processing Industry, leading the development of this fascinating new field, armed with state of the art technology and unimaginable problems to solve.



Think Signs

This attitude had of course been engendered in the company by Thomas J. Watson. We all looked with some mild amusement at the THINK signs that were everywhere in IBM and were subsequently translated into most languages. However we did enthusiastically join in singing *Ever Onward* and *IBM Forever*. There was something of the Japanese dedication to the company that led to a fierce loyalty.

There was also an amazing camaraderie that seemed to have developed in the field and a feeling that everyone in IBM was behind whatever decision you made. The people at head office, in the plant or in the research labs would always go that extra mile to back up what you were doing.

The IBM'ers in their various offices were very close socially and parties and functions were usually with spouses.

100% Club in Quebec City with display of Systems Engineering Support:
Left to Right: George Richardson, John Atchinson, Wes Graham, Byron Borden, Elmer Talvita, Paul Golubovskis

We travelled to 100% Clubs together and I am sure any one would have a myriad of anecdotes to tell about those uplifting events to say nothing of the personal adventures that went along with them. To acknowledge only one, I can well remember attending a Club in Hawaii. Ron Stewart, who was with me in the IBM Ottawa office, and I decided to rent a Mustang convertible to explore Oahu having arrived a day or so early. We loaded it up with snorkelling gear and the two of us took off to drive around the Island. It turned out in those years there actually was not a completed road around the Island but this did not stop us. We nearly took the bottom out of the Mustang on the dirt road at the North West end of the Island. We had also forgotten to tell the car rental company that we were going to keep the car for a few extra days. They repossessed it and I could remember the two of us running down the street after the car which still had our snorkelling gear in it!

We dressed the part of missionaries. There was no doubt in those days that blue suits and white shirts were the order of the day. We even wore fedoras. It was all part of the image. This image somewhat changed with the advent of the computer era when many of our customers wore beards and desert boots. Gradually these dress regulations were relaxed as the formula was always to dress in the manner that would make your customer feel comfortable.

You Are What You Know

IBM valued education and sales training to a degree almost unknown in other industries. Not only did they try to hire the best but they made the investment to ensure that the end product was up to their standards.

Canadians attended the IBM Application School in Endicott, New York and subsequently a Sales School in Poughkeepsie, New York. However before attending the school to learn about the application of IBM machines, it was expected that the salesman would thoroughly understand the machines themselves. In Canada that was a rather haphazard training process until in 1956, Bob Beggs established the first class at the newly formed IBM Education Centre on Don Mills Road, Toronto. Bob was a top Customer Engineer and admitted to some trepidation when facing the first class of these egotistical young university graduates. Little did he know how little we knew about Punched Card machines and how grateful we would always be for the understanding and training he gave us. We all arrived in Endicott with a high level of confidence that we were 'at least the equal of our American counterparts'.

Application School was highly competitive. It lasted for an intensive five weeks and like the Harvard case study approach involved both individual and teamwork study and presentations. The aim was to learn how the equipment could be used to solve customers' problems. It had all the earmarks of an advanced business school which was very helpful as many of us had little if any formal business training.

The IBM Homestead was used for customer training but the 'students' were not invited to stay there. Instead we were put up at the Frederick Hotel. This had some advantages. IBM had a strict no drinking policy and at least when we were off premises at the Frederick there was some more flexibility (of which we made good use).

IBM Homestead, Endicott, New York

The course was rigorous and in the course of the course, some did not make it. They were politely returned home.

Between the Application School and the Sales School that was held in Poughkeepsie, there was an apprenticeship period served back in the local office. This is where many of us got to put our training to the test.

Hotel Frederick

Sales School was every bit as intensive. It was a bit shorter, i.e. four weeks instead of five, but it was where the budding salesmen were immersed in everything having to do with packaging ideas to make them attractive to the prospect and the whole IBM philosophy that it is the customer who is the absolute key to IBM's success.

The lessons learned in this almost two year period would last a lifetime. We were imbued with a sense of duty that would do a Marine proud. If we undertook an assignment, we saw it through no matter what. A promise made was a promise kept. Failure to make the 100% Club was virtually unthinkable.

Customer Relations

IBM Display at the Canadian National Exhibition where we all took part demonstrating a 305 and other new equipment

The real key to IBM's success was not only the trained army of 'experts' but the careful dedication to the idea that the most valuable knowledge IBM had was knowing how to meet the customer's need. This is why there was such intensive training on applications. IBM representatives really understood the insurance business, retail and wholesale processes, manufacturing operations and other industries. Later IBM would actually have specialized offices in major cities along industry lines. The competition might come out with faster or cheaper machines but they could not match IBM's understanding of the customer's need.

A second equally important approach was the relationship with management. Of course this started with the Data Processing Manager. The IBM salesman was trained to live, figuratively speaking, with this individual. The DP Manager knew that if he bought IBM equipment for a particular application, IBM and all its resources would stand behind the system making sure that installation worked. The DP Manager became an automatic hero. Heroes tend to remember how they got there.

IBM did an excellent job of working with industry associations such as the Data Processing Management Association (DPMA) and similar groups in the Electronic Data Processing field. This is just as they had done with the Association of Computing Machinery (ACM) and similar groups in the scientific computing area.

In a word we 'worked the system' with an intensity that made it difficult for the competition to be really effective. The U.S. Justice Department assumed in the early days that the reason for IBM's success was its refusal to sell equipment and only to rent it. However in my opinion, the real secret of success was the distribution and customer support program.

This program was fully backed by a wonderful group of Customer Engineers who maintained the equipment and as the complexity of the field grew, the Systems Engineers who provided in-depth support to the sales force. In fact they became one of the major selling features of the IBM approach.

The Payoff

High performance demanded and got high remuneration. When I first joined IBM (as I recall at $275.00 a month but still quite a sum in those days) salesmen were earning

$3.00 a point. A point was the U.S. dollar rental and so a 403 accounting machine that rented for perhaps $400.00 per month would lead to a commission of $1,200.00.

IBM plant at Don Mills Road and Eglinton Avenue, Toronto, 1950

As the value of the machines increased, this was gradually reduced to $2.50 and as I recall ended up at about a $1.00. It still however meant that IBM'ers were amongst the highest paid in the industry.

Nothing to Be Blue About

IBM in those days was something of a fraternity. Despite the competition within the company, there was an air of co-operation driven by the desire to see IBM succeed even if the particular challenge was not your own account. A loss to the competition was felt by everyone.

As noted above we socialized and partied almost endlessly. Perhaps this is why some 50 years later, the Punchcard Preservation Society still gets together to rehash the good old days at Big Blue.

There was certainly nothing to be BLUE about in those glorious days.

We Had Come a Long Way.

A Punched Card Installation in the 1930's

The NASA Nerve Center in the 1970's, Model 91

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Who is he anyway?

Mr. Fierheller graduated from Trinity College at the University of Toronto with an Honours Degree in Political Science and Economics in 1955. He joined IBM in Toronto that year and subsequently progressed through a number of positions in their sales organization. He was Marketing Manager for IBM's federal government business in Ottawa prior to founding Systems Dimensions Limited (SDL) in 1968.

Mr. Fierheller was President of SDL from the inception of the company until it was acquired by Crown Life of Toronto. SDL was one of the pioneering companies in the computer services industry in Canada.

In April, 1979, Mr. Fierheller moved to Vancouver as President and Chief Executive Officer of Premier Cablesystems Limited. In July, 1980, Premier merged with Rogers Cablesystems Inc. to form one of the world's largest cable TV companies. Mr. Fierheller was a Vice Chairman of Rogers Cablesystems Inc. and Chairman of Canadian Cablesystems Limited, as well as the President and CEO of Rogers Cable TV - British Columbia Limited.

During 1983, Mr. Fierheller led the team that was successful in winning the mobile cellular radio licences for Cantel. He was the founding President and CEO of Cantel Inc. In September 1989, he was promoted to Chairman and CEO of Rogers Cantel Mobile Inc. He was Vice Chairman, Rogers Communications Inc. until 1996 and now heads a private investment and consulting firm.

Mr. Fierheller has been actively involved in community affairs in Ottawa, and Vancouver and Toronto including: Chairman of the Board of Governors of Carleton University; Chairman of the Finance Committee of the Board of Governors of Simon Fraser University; Chairman of United Way Campaigns in Ottawa in 1971, Vancouver in 1981 and in Toronto in 1991, President of the Canadian Information Processing Society; member of the Executive Committee of the National Arts Centre; a Trustee of the Vancouver General Hospital Foundation; a Director of Vancouver Opera; and a member of the Vancouver Centennial Commission.

Since returning to Toronto, Mr. Fierheller has served as Chair of the Board of the United Way of Greater Toronto; Chair, Information Technology Association of Canada; Chair, Smart Toronto; Trustee of the McMichael Canadian Art Collection; President of The Toronto Board of Trade; Director, Ontario Exports Inc.; Chair of The Spirit of Leadership Campaign, Trinity College, University of Toronto; Chair of the Sigma Chi Canadian Foundation; and President of the National Club.

Mr. Fierheller currently serves as the Chairman of the Honorary Board of the Greater Toronto Marketing Alliance. He is currently Chair of the Sunnybrook and Women's College Health Sciences Centre Capital Campaign; a Director of The Canadian Institute for Advanced Research; Past Chair, Toronto Adventurers Club; is on the Campaign Cabinet of the Canadian Opera House Corporation; and the Board of the Council for Business & the Arts in Canada.

He has also served on a number of public company Boards including: Extendicare Inc., Falconbridge Inc., Telesystem International Wireless Inc., GBC North American Growth Fund and Rogers Wireless Inc.

Mr. Fierheller has received many awards including a Doctor of Laws degree from Concordia University in 1976; a Doctor of Sacred Letters from Trinity College in 1999; the Award of Excellence from the Canadian Wireless Telecommunications Association; is a Significant Sig from Sigma Chi Fraternity; and in March 1991, he received Toronto's highest honour, The Award of Merit. In 1998 he received the highest award from the United Way of Canada, the André Mailhot Award. In the Fall of 1998, he was admitted into the Canadian Information Productivity Hall of Fame, as well as receiving the Arbor Award from the University of Toronto.

In July, 2000 Mr. Fierheller was appointed a Member of The Order of Canada.

In May, 2001, he was honoured by the Association of Fundraising Professionals as the Outstanding Volunteer of the Year during The International Year of the Volunteer. In 2002, he received the Queen's Golden Jubilee Medal and the Salute to the City Award for service to the City of Toronto. In 2005 he was made a member of the Sigma Chi Hall of Fame.

In 2012, he was awarded the Queen's Diamond Jubilee Medal.

CHRONOLOGY

Period	Activity
1955	Graduated in Political Science & Economics from Trinity College, University of Toronto
1955 – 68	Various sales and marketing positions at IBM Canada - Toronto 1955-60 - Ottawa 1960-68
1968 – 79	President & CEO of Systems Dimensions Limited (SDL) based in Ottawa National President, Canadian Information Processing Society (CIPS) 1970-71 Chair, United Appeal Campaign 1971 Chair, Board of Governors, Carleton University 1977-79
1979 – 85	President & CEO, Premier Communications Limited based in Vancouver Chair, Canadian Cablesystems 1980-83 Chair, United Way Campaign 1981 Chair, Finance Committee, Board of Governors, Simon Fraser University 1981-84 Chair, Team BC 1982-83 President and CEO, Cantel 1983-85
1985 – 93	President & CEO, Rogers Cantel based in Toronto Chair & CEO, Rogers Cantel 1990-93 Chair, United Way Campaign 1991 Chair, Vision 2000 1989-91 Chair, Information Technology Association of Canada (ITAC) 1993-94
1993 – 96	Vice Chair, Rogers Communications Inc. based in Toronto President, Toronto Board of Trade 1996-97
1997 – Present	President & CEO, Four Halls Inc. based in Toronto Chair, Trinity College Capital Campaign 1996-99 President, National Club 1998-99 Chair, Greater Toronto Marketing Alliance 1997-2002

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