INTERNATIONAL BUSINESS MACHINES CORPORATION
DEPARTMENT OF EDUCATION
DIVISION OF GENERAL AND VOCATIONAL EDUCATION
ENDICOTT IBM SCHOOL

"THE STORY OF THE IBM CARD"

COURSE OUTLINE

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INTERNATIONAL BUSINESS MACHINES CORPORATION
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ENDICOTT, N. Y.

THE IBM CARD
Techniques of Development and Manufacture

"THE STORY OF THE IBM CARD"

J. P. Saxton
Sept. 16, 1946

One of the first bits of knowledge impressed upon us in early school days was the fact that "Great Oaks from little Acorns grow." We learned to speak this phrase long before we understood what it meant. As our scope of understanding increased, we began to realize what a marvel of natural development the transition of a tiny acorn, buried in the fruitful bosom of Earth, through years of heat and cold, rain and sunshine, wind, storm and peaceful calm, drew to itself the elements of nature, expanded, grew, spread its branches toward the sky until it became a mighty tree, strong and useful to all living creatures--most of all to Man.

In opening this school, I cannot refrain from drawing a comparison between the development of the acorn into the mighty tree and the fascinating "Story of the IBM Punched Card" which we are going to study during the progress of this school.

Let us realize now that the beginning of the Punched Hole Card is a much less tangible thing than the acorn. As a matter of fact, the Punched Hole in the card is actually nothing real or tangible! You can look through it but you can't see it! You cannot feel it, smell or taste it! The punched hole itself is nothing of substance at all. It is a vacancy surrounded by the material which is the card itself. The hole in the card does the work in our machines, but the card is the medium which makes it possible to assemble and relate the punched holes in orderly fashion, so the punched hole is correctly sized, in exactly the right place, at precisely the right split second of time to allow our machines to sense it, evaluate its meaning and put that evaluation to work toward an accurate end result or mathematical fact.

So here we start to learn how a tiny hole was put to work by the ingenuity of IBM Engineers and Craftsmen, and, under the inspiring leadership of our President, Mr. Watson, whose inventive conception and farsighted ability to apply those conceptions to the service of business, government and mathematical research, has grown into International scope, providing fruitful employment and happy lives for thousands of people throughout the world.

I want to outline briefly the growth of IBM's Punched Card usage since Mr. Watson took hold of what was, at the time, a stumbling enterprise in 1914.

In 1914, the punched card was manufactured in a small building in Georgetown Section of Washington, D. C. It was a comparatively simple card at that time. It had a capacity of 34 columns in what was called the short card, and 45 columns in the long card. The short card was $3\frac{1}{4}$" x 5 5/8" in size and looked like this. The long card was $3\frac{1}{4}$" x 7 3/8" same as the present standard IBM Card.

Production at that time was at an average rate of about 2,000,000 cards per day.

The machines used were a comparatively new creation for that time. These machines printed one side, cut the card to length and clipped one corner at a speed of about one card per second, 60 per minute, from reels of slitted paper. This was quite a rate of speed for 1914. Previous machines operated at about 30 cards per minute and had to be fed by hand after the cards were cut to size in guillotine cutters.

Since it was vitally important that the punched hole card be a perfect non-conductor of electricity, free from specks of carbon, tiny holes, or bits of metal from the paper machine, it was necessary to electrically inspect every single card manufactured before releasing to our customers for use in IBM machines. This was accomplished by specially rigged tabulator machines in which brushes for the entire column capacity, either 34 or 45 columns, had been wired in. The cards, after printing, were fed through this tabulator at a rate of about 75 cards per minute. If a card contained a hole, carbon, metallic or other conductive particle, and if the particle or hole were located just right to be sensed by the electrified brushes, the tabulator would stop.

The person operating the speck inspection tabulator would then remove the cards remaining in the feed hopper, empty the stacker, clear the feed chutes of all cards, throw away the top card on the stacker pile and all the cards removed from the feed chutes; reload the feed hopper with new cards and press the button to start the machine, then sit back and wait for the next stop. This happened very frequently and you can well imagine the waste of material as well as the cost of such an inspection operation.

Here, then, was a problem for IBM Engineers,and Mr. Watson speedily assigned this problem as a project for engineering solution. Mr. C. D. Lake was the man who developed the best solution. The reel fed card machines required a slitting and rewinding machine which converted the large mill rolls of paper, $26\frac{1}{2}$" wide, into $3\frac{1}{4}$" wide reels. Mr. Lake studied the problem for a time and then developed a device or attachment for the slitting machine. This device, called a Speck Detector, consisted of a double bank of brushes which pressed the entire web of paper against a contact plate as the web started into the slitting knives on the slitting machine.

A potential or electric pressure higher than that used in the Accounting machines was applied by the brushes to the paper web. Any conductive particle or tiny hole was sensed by these brushes. A device containing a knife blade would be actuated by such sensing and the knife would dart out and into the paper web just ahead of the defect and would slit the paper right in the middle of the $3\frac{1}{4}$" slitted width. This knife slit would run past the defect and then automatically withdraw. The paper web would continue at full speed, about 90 feet per minute, without stopping. Later on, the slitted cards in which defect occurred would be removed by the operator during the inspection operation on the card machines.

You can readily grasp the cost reduction and improved efficiency of this automatic speck detecting development.

We cite this development to show how Engineering & Research coupled with skilled mechanical ingenuity has in the past, and will continue in the future to solve problems and improve manufacturing operations.

The demands for punched card accounting caused expansion of card producing facilities until in 1920 the daily output averaged 3,500,000 cards.

In 1923, part of the Georgetown plant was moved to the Endicott factory and added to the existing Time Card Manufacturing Department.

This was for the primary purpose of meeting continued increase in demand for IBM cards, which by that time equalled the total capacity of the Georgetown plant. Secondly: The move added to security for our customers by having two plants in separate locations able to produce cards--a security against interruption in source of supply caused by fire, flood, accident, or other interruptions. This also provided an advantage for many of our customers in transportation costs from our factory to their offices.

By 1930, production had risen to 4,500,000 daily.

By 1935, production had risen to 7,000,000 daily.

In 1940, just before entering the World War II era, card production had advanced to 6,350,000,000 yearly. The growth shown by preceding figures was met with production made possible through continued development of card manufacturing machinery and techniques by IBM engineers and craftsmen. Almost all of this machinery was designed and constructed right here in the Endicott factory.

Later on in this school, you will learn how card manufacturing machines have been and are now being improved upon--made more productive and efficient, easier to operate by our craftsmen. How accuracy is being constantly improved and how our present fine machines are repaired, adjusted, and cared for to maintain them at top level in quality production.

You will also be shown how improvements in machines and processes start with suggestions and ideas contributed by IBM people throughout the entire organization. Nearly everybody in the Card Manufacturing plants has made one or more constructive contributions toward advancement in card manufacturing operations. You can be sure that we will never stop improving our operations. making our jobs more pleasant, more satisfactory, safer and more profitable for each of us as long as we all continue to contribute our thoughts and ideas to make IBM better.

When the Pearl Harbor attack plunged us into World War II, Mr. Watson immediately turned IBM's resources over to the U. S. Government and the government called upon IBM in many extremely difficult and exacting projects. You already know what was accomplished by our Machine Manufacturing Departments on these projects.

The Card Manufacturing plants were at once called upon for a tremendous volume of standard IBM cards to handle the logistics of conducting the war. The IBM card served not only in the control of production plants, War Department, Army, Navy and Air forces, Transportation, Food and Munitions. It also went right into the front line battle areas on land, sea, and in the air with IBM Mobile Units, manned by IBM men, to do its vitally important work.

Several extraordinary IBM card projects which contributed so much to the ultimate Victory were: the War bond record card and its component assembly with War bonds; the Dependency Benefit U. S. Treasury Check which the Treasury commanded us to make in IBM card form, and the stencil card which made possible the efficient and accurate addressing and distribution of the Benefit checks.

We started the War Bond Assemblies project from scratch--without time to invent, develop and build the necessary special machinery. At the start, the work was done with such machines as we had available at the time coupled with hand operations. While machinery was being designed and built, we hired and trained over 800 people to produce the hand operations on the Bond assemblies. These assemblies were then turned over to the U. S. Bureau of Engraving where the assemblies were associated with the bonds.

Every Bond assembly was serially numbered and prepunched. Every assembly had to be correct, in sequence and with no missing or duplicate numbers--a most exacting job for anybody.

A few months after the start of this big project we completed the first model of automatic machines designed to eliminate hand operations of assembly and insure better accuracy.

Within another few months, we constructed enough machines to mechanize nearly all the hand operations and 600 or more people engaged in hand operations on bond assembly became availabe for other productive work on war projects in our factories.

During the War years, IBM produced over 1 billion Bond Assemblies for the U. S. Government.

One billion assemblies are equal to over 400 loaded freight cars.

We are still making Bond Assemblies--and right here is a good tip--keep on buying them.

When the Dependency Benefits for men and women in the Armed forces was set up by the government, the U. S. Treasury was called upon to produce many millions of Benefits checks along with a positive-control to account for each and every check. The Treasury found their resources inadequate for meeting this enormous requirement and they called upon IBM for a solution of the problem.

The production of a check, in punched card form, which equalled the high quality and precision demanded by the U. S. Treasury required the best skills of our IBM Craftsmen and Engineers and involved extensive research along with mechanical ingenuity and resourcefulness.

Again, new machinery and techniques had to be created and developed against time deadlines in step with the accelerating war schedule of the U. S. Government.

The problem of production of these millions of checks and the accounting for them was squarely met by IBM in an astonishingly short period of time.

During the War years, IBM produced over 600,000,000 Dependency Checks. Every check had to be accounted for--even those damaged in transit or handling by the recipients. Every check had to be perfect in quality. Every check had to be numbered and serially prepunched and then verified through Inspection Tabulators for correct sequence, accuracy of punching, numbering and dimension. Every check had to be produced within restricted, carefully guarded, and closely supervised areas in our IBM factories.

It is a matter of record that the job was performed in a thoroughly competent manner; that there were no failures to account for every single check while it was in the hands of our IBM Craftsmen. You can comprehend the enormous volume of this performance when you visualize over 100 loaded freight cars would be required to transport the 600,000,000 check cards manufactured up to December 31, 1945--and we are still producing them!

Distribution of Dependency Benefit checks required a speedy and dependably accurate method of addressing each check to its proper beneficiary. This problem was solved by IBM Engineers through the development of the Stencil card. This card was unique in that it provided automatic selection of the individual name and address and in addition to this feature the stencil card actually applied the name and address, automatically, on the right check. All of the machinery for performing this hitherto unaccomplished work was developed and built by IBM.

The stencil card is radically different from the usual punched hole card but like it in that, through the medium of the punched hole, it can be sorted and selected in IBM machines automatically and with accuracy. It eliminates any possibility of error in transcription and makes every name and address exactly correct time after time in use. The elimination of manual selection and control made the whole procedure of filling out and dispatching checks free from error. The right person always received the right check, made out in the correct amount. As long as the beneficiary's address remained the same, the same stencil card served to address each month's check. When an address was reportedchanged, a new stencil card was typed and supplanted the previous card.

The stencil card required radically different machines--all of which were invented, designed, and built here at the Endicott Factory. This job presented another production problem which was met effectively and on time.

Stencil card production totalled 60,000,000 cards.

In 1942, we had expanded our card production facilities at the Georgetown plant in Washington beyond the capacity of the buildings and ground area, so a new and much larger plant was purchased at 1818 New York Avenue, N. E., along with ample ground area surrounding it. This building was completely reconstructed to adapt it to our requirements and the Georgetown equipment was removed and installed in the New York Avenue structure. Additional improved machinery was built and installed and within a period of a few months, the transition was complete.

The Washington plant is a model of efficiency, comfort, and convenience internally and of fine appearance externally. It comprises a work area of approximately 80,000 sq. ft. in the present structures. It is completely equipped with light-color maple flooring, fluorescent lighting, and air conditioning. It has a fine cafeteria where regular meals are served to all shifts. It has fine lounge rooms, parking lots, and ground landscaping. You will see it anytime you ride the Pennsylvania railroad into or out of Washington. The plant is devoted exclusively to the production of IBM cards. Its production capacity is 30,000,000 daily.

In 1943, to improve our facilities to serve government and War agencies in the Far Eastern War Theater, Mr. Watson ordered a study made of the West Coast area to determine where a card plant should be located. This study was made, and it was decided to locate a new IBM card manufacturing plant at San Jose, California.

A site was selected, purchased, and prepared for our card manufacturing requirements at St. John Avenue and 16th Street, San Jose, California.

In August 1943, we dispatched a special train of Pullman cars to San Jose carrying the employees and their families from Endicott who were to pioneer the California plant. Among the families were new-born babies and some older youngsters--60 years of age or more. Throughout their trip across the United States, every safeguard for their comfort and happiness was provided by IBM. They arrived safely and in good health. Every facility for their home establishment was provided.

The San Jose plant is another model of efficiency, cleanliness and comfortable surroundings. It comprises approximately 40,000 sq. ft. It is similar to our Endicott and Washington plants in every respect, having the beautiful flooring, lighting, cafeteria, first aid, lounges, and even a small but lovely park adjoining the factory on our own property.

In September, 1943, the plant was officially dedicated to the War effort and to future service of IBM customers by Mr. Watson before a company of distinguished Californian guests and our own IBM people. Mr. Watson, himself, threw the switch which turned on the power to set the card machinery into its first productive operation in the new plant.

The San Jose plant has a capacity of 10,000,000 cards daily.

In 1945, our IBM card plants produced an average of 60,000,000 cards daily.

To assist you in comprehending what 60,000,000 cards represents, I offer the following comparisons.

60,000,000 cards require 360,000 lbs. of paper, or 9 freight carloads daily.

A solid carload of corrugated boxes is consumed daily to pack the cards for shipment.

The mill rolls of paper required for one day's production, if piled one on top of the other, would make a pile higher than the Empire State Building in New York City.

If the mill rolls were rolled out flat on the ground, one day's requirements would make a path 30" wide over 800 miles long.

The web of $3\frac{1}{4}$" wide paper flowing through IBM card manufacturing machines in one day, if connected end to end, would reach out from Endicott East or West to a point nearly 1/3 the distance around the world!

Understanding the facts presented in this little introduction to our course on "The Story of the IBM Card," we realize that we are examining one phase of IBM's production which has already developed into a great and strong, deep rooted structure like the mighty oak which grew from the tiny acorn. The manufacture of the IBM card is a mighty big operation now, and it is growing bigger and better every day. It will never stop growing while earnest, ambitious, and competent people like yourselves will try to learn more and more about your business, as you are doing by attendance at this school. As Mr. Watson has often said "The IBM is not merely an organization of men; it is an Institution that will go on forever."

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THE IBM CARD
Techniques of Development and Manufacture

PAPER AND PAPER RESEARCH

by
K. J. MacKenzie
Sept. 23, 1946

HISTORY

According to history, paper was first made from fibrous material by the Chinese in the 2nd Century B.C. The secret of paper-making apparently was successfully guarded by the Chinese until the middle of the 8th century A.D., when the Arabs were attacked by an invading Chinese Army. History records that the invasion was repelled by the Arabs and amongst the prisoners who were taken were some who were skilled in the art of paper-making. These prisoners revealed their knowledge to their Arab captors and thus the carefully guarded secret began to spread and its usefulness to increase. That the Arabs took advantage of this newly gained knowledge is borne out by the large number of early Arab manuscripts which have been preserved. Most of this early paper was made from flax fibers; although later as the demand for paper increased, the use of other vegetable fibers and rags was introduced.

Like many other things, the spreading of the use of paper toward the West was occasioned by martial conquests. Thus, we see the introduction of paper into Greece by the end of the 11th Century, into Sicily in the early part of the 12th Century and thence into Spain by the middle of that same Century, All of this early paper was made by hand in a rather crude manner. While most of the paper of modern manufacture is machine made, paper is still being made by the comparatively crude hand methods. Examples of such paper are drawing papers used by artists, and stencil tissue which is produced in Japan.

Paper continued to be made by hand for several centuries. In fact, it was in 1798 that the first paper-making machine was invented in France by Louis Robert, who was a clerk in the employ of Messrs. Didot of the Essonne paper mills. This machine was introduced into England in 1803 by Henry Fourdrinier who owned a paper business at Dartford, Kent. Since Fourdrinier is the man responsible for exploiting the paper-making machine, the name of Louis Robert has been lost and the paper-making machines of today still are known by the name Fourdrinier, and most of the paper made today is produced on Fourdrinier machines.

Like the early hand made-sheets, the paper made by machines during most of the 19th Century used linen and cotton rags as the raw materials. These materials are still used to produce some special grades such as writing paper and saturating felts that are used for roofing paper and laminated plastics. However, most of the paper which is made today is made from wood.

WOODS USED

The principal woods used in the United States for the manufacture of paper are Spruce, Balsam Fir, and Eastern Hemlock in the Northeast and Lake States;

Western Hemlock, Fir, and Spruce in the Western States, and Southern Yellow Pine and Gum in the Southern States.

METHODS USED

There are four principal methods of converting wood to pulp which may be used in the manufacture of paper. They are:

(1) The mechanical process of grinding wood with a large grindstone. The pulp thus produced is called groundwood pulp.
(2) The Sulphate Process
(3) The Soda Process
(4) The Sulphite Process

The four processes used in the preparation of pulp for paper-making vary, but the actual paper-making on the Fourdrinier machines is the same.

The ground-wood process, as the name indicates, is the grinding of the wood to a pulpy mass with little or no chemical treatment. The other three processes are chemical processes in which the wood chips are cooked in a chemical liquor. The sulphate and soda processes use an alkaline cooking liquor while the sulphite process uses an acid cooking liquor.

In describing the technical details of the manufacture of tabulating paper, we shall confine our description to the sulphite process for the purpose of brevity. Until comparatively recently, this process was used to produce all of our tabulating paper, but recently, we have used and are still using some paper produced by the sulphate (Kraft) process.

PREPARATION OF WOOD

The wood is brought to the paper mill in 2-to 8-feet lengths. The method of transportation from the forests to the mills varies with the location. Wherever the mills are located on rivers, such as most of the mills in the Northeastern and Northwestern section of the United States, the logs are generally floated down the rivers to the mills during the Spring floods. Motor trucks and railway flat cars offer the means of transportation of wood to those mills that can not be served by rivers.

Since the process of making paper from wood requires the use of only clean sound wood, the bark must be removed from the logs. Some of the bark is removed during the logging operation in the woods but most of it is removed as the first operation at the paper mill when the log starts on its way through the process which will convert it to a sheet of paper.

The debarking operation is accomplished by several means. One method consists of feeding the logs into a tilted revolving drum. As the logs tumble around on one another in the presence of a stream of water, the bark is loosened and is washed away. Another method employs a rotating disc in which knives are mounted. The logs are forced against the rotating disc and the bark is thus removed. Still another type of barker employs a hydraulic method where the bark is literally blasted from the log by a stream of water under high pressure.

After the bark has been removed, large knots are bored out of the logs on a machine called a knotter. Defective logs are split to remove rotten wood and ingrown bark.

The cleaned wood is then fed to the chippers, which are powerful machines that reduce the logs to chips about an inch long and half an inch thick. After chipping, the chips pass through a crusher, which further reduces their size.

Following the crushing operation, the chips are fed over screens which remove finely divided wood such as sawdust and long splinters.

The wood now having been cleaned free from bark, chipped, crushed and screened, is conveyed to the chip bins, which are located in the top of the building over the digesters.

PREPARATION OF COOKING LIQUOR (SULPHITE PROCESS)

The liquor which is used in the sulphite process to cook the wood chips is calcium magnesium bisulphite containing an excess of sulphurous acid. It is produced by bringing about a chemical reaction between sulphur dioxide, limestone, and water. The sulphur dioxide is produced by burning sulphur in a large rotary chamber with a controlled supply of air. The gas is conveyed from this chamber to a larger combustion chamber provided with dampers through which air is admitted to complete the combustion of the sulphur. There are several other types of sulphur burners in use, such as the flat-type and others. However, they all fulfill the same purpose--that of burning sulphur to sulphur dioxide.

From the combustion chamber, the gas is piped to the coolers, since it is necessary to cool it to about 80° F. before entering the reaction towers. There are numerous types of coolers in use, but they all are essentially a series of acid-proof pipes through which the gas passes, being cooled by circulating water or a combination of circulating water and a water spray. The cooler is located near the combustion chamber so that the cooling of the gas will be as rapid as possible. This is due to the fact that slow cooling tends to produce sulphuric acid, which is undesirable because of its corrosive attack on the metal components of the system.

The cooled gas is fed to the equipment which combines the sulphur dioxide with lime or limestone and water to form the sulphite liquor. There are two types of equipment in which this reaction is brought about. They are the milk of lime system and the tower system. Since the tower system is now used almost exclusively, it will be the only system which will be described.

The earliest forms of the tower system were high wooden towers filled with lumps of limestone. The gas from the sulphur burner entered at the bottom of the tower and rose in an irregular manner, its passage upward being intercepted and broken by the limestone. Water sprayed into the top of the towers flowed down over the limestone, covering it with a film of water. The engineering difficulties attendant to the building and maintenance of these towers was so great that they were abandoned in favor of the milk of lime system. However, with improved construction methods, the tower system has again gained favor and has almost completely replaced the milk of lime system.

The towers are now constructed of reinforced concrete lined with acid-resisting tile. Towers are operated in pairs which allows one tower to be charged with limestone while the other is operating.

The finished acid or cooking liquor is pumped to a storage tank from which it is supplied to the digesters as needed.

COOKING PROCESS

The digesters in which the wood chips are cooked are large steel tanks with a dome-shaped top and a conical bottom. The size of the digesters varies but a typical size is 15 feet in diameter and fifty feet high. They are lined with an acid-proof tile to prevent attack of the steel shell by the acid. The digesters are usually located immediately underneath the chip bins in order that the chips may be fed by gravity into the top of the digester.

After the digester has been charged with chips and the acid cooking liquor, steam is introduced and pressure built up until the temperature reaches about 285°F. This temperature is maintained for about 8 to 12 hours, it being necessary to relieve the pressure during the cooking period in order to maintain the proper temperature. The exhaust gases are collected and returned to the liquor storage tank to be used in subsequent cooks.

At the end of the cooking period, the wood still retains its original shape although about 50% by weight has been dissolved by the acid. In order to break up the cooked chips into a pulpy mass, the charge is blown from the digester through a blow pipe into the blow pit. The blow pit is a vertical tank, of wooden or concrete construction strongly reinforced. Since the charge is under steam pressure in the digester, it is blown with considerable violence against a cast-iron target in the blow pit. This breaks up the chips, they lose their woody appearance, and a pulpy mass is formed. The steam is allowed to escape through the vomit pipe which is a chimney-like opening in the top of the blow pit.

The spent or used sulphite liquor containing the dissolved portion of the wood is a great industrial waste. Some of it is used today, however, in the manufacture of synthetic vanilla, in fact, most of the vanilla on the market today is made from this black, smelly waste produce. It is also used to produce linoleum cements, road binders, and plastics.

REFINEMENT OF THE PULP

The pulp is washed with water in the blow pit until it is free from acid. It is then diluted with water and pumped to the stock chests, which are equipped with agitators in order to blend the pulp from several cooks and thus assure uniform quality.

The pulp is then pumped from the stock chest and goes through a number of screening operations where undigested knots, fiber bundles and dirt are removed. The undigested knots and fiber bundles are removed by the knotter screens while other heavy particles and dirt are removed by devices called rifflers. The pulp then passes over transportation screens which have slots only .007" wide, which allows the finely divided fibers to pass through; and that portion of the pulp which does not pass through goes to the screening chest and is later made into coarser grades of paper. The pulp that passes through is now in the proper condition for further processing. At this point if a white paper is desired, it is bleached by the use of chlorine. If no bleaching is done, it is usually pumped to a wet machine, which consists of a wire-covered cylinder partially immersed in the pulp slurry. Water is removed through the cylinder causing a deposit of pulp to form on the screen, and a thick web of crude paper is thus continuously formed. Press rolls remove some of the water so that the crude sheet or lap contains about 50% moisture as it leaves the wet machine. This web of partially dried pulp is folded in convenient-sized piles and are stored for further processing.

BEATING

The manufacture of paper, as distinct from the manufacture of pulp, starts in the beater room. It should be kept in mind that pulp is but one of the raw materials used in making paper. Some of the other materials which are added to pulp to produce sheets of distinctive quality are clay, rosin or wax size, and dyes. These materials are added to the pulp in the beater. The beaters are large oval tank-like machines which are used to break up the wet-lap before it goes to the paper-making machine.

The wet lap with the proper amount of water is added to the beater and the mass is beaten by passing between a rotary cylinder and a stationery bed plate upon which heavy metal bars protrude. The cellulose fibers are beaten or pounded until their physical structure changes from smooth, stiff rods to soft irregular structures.

If the beating continues long enough, the pulp becomes a gelatinous mass with indistinct fibrous structure. A sheet of paper made from unbeaten fiber would be coarse, porous, and weak as it would be held together merely by interlocking fibers. After beating, there is not only an interlocking of fibres but a cementing due to the gelatinous characteristic of the mass. The length of beating is controlled and depends on the type of sheet that is desired.

As previously indicated, certain materials are added to the pulp in the beater. Starch or sodium silicate are added to increase the strength. Synthetic resins may be added to give strength when the paper is wet with water. Dyes or pigments may be added to produce a colored sheet and clay added as a filler. Rosin or wax size are added to give some water repellancy.

After the proper additions have been made and the pulp beaten to the proper consistency it is pumped to the stock chests which feed the paper machines. Further refinement of the pulp may be done in what are known as Jordan machines. These machines consist of a cone-shaped plug rotating in a conical shell. The cone and the shell contain bronze bars and as the pulp passes through the machine it is given additional beating.

After the pulp leaves the Jordans, it is diluted to the proper consistency and is again screened to remove any coarse particles. At this point the pulp suspension contains only about ½% of solids, the rest being water.

THE PAPER-MAKING MACHINE-FOURDRINIER

It will be recalled that the first machine to produce paper was introduced into England by Henry Fourdrinier and that this machine with the improvements which have been made to it still bears his name. There are other machines used for making paper but most of the tonnage is produced on Fourdriniers and it is the type of machine used in the production of tabulating paper.

The Fourdrinier machine consists essentially of a device for allowing the carefully prepared and screened pulp of constant consistency to flow on to a vibrating horizontal wire screen, made in the form of an endless belt and travelling constantly away from the point where the pulp flows onto it. The water in the pulp drains through the wire, this drainage being assisted by suction boxes applied under the wire at certain points. At the end of the wire farthest from where the pulp flows on to it, is a pair of rolls between which the newly formed sheet of paper passes. The newly formed sheets contain considerable water, part of which is removed by passing it between felt-covered rolls which squeeze out part of the water.

The sheet then passes through a long series of highly polished steam heated cylinders being supported through the rolls by an endless felt web which travels with the paper. Most of the moisture is removed from the paper as it passes over the steam-heated cylinders, the moisture content of the finished product being carefully controlled. The paper finally passes through a stack of highly polished calendar rolls which iron the paper to give it the desired finish. It is then wound on large reels and finally slit into the conveniently sized rolls which are used in our plants to produce the cards.

This short description of the final paper-making process on the Fourdrinier machine hardly does justice to the machine itself. The size of the machine and the careful attention which must be given to its operation can not be described adequately by words. The machine is huge and attention to minute details in its operation are absolutely necessary.

We have thus traced the manufacture of tabulating paper from the forests to the finished sheet of paper. Some of the details have not been mentioned, but the process in general has been delineated and, as pointed out previously, while the details of the sulphite process has been described, the other processes are different only in the method of preparing or cooking of the pulp wood. It can be readily seen that the making of tabulating paper consists of a rather complex process in which constant refining and purification of the raw material takes place until we finally arrive at the end with a sheet of paper which has the characteristics and physical properties so necessary in making the tabulating card which is a vital operating unit in our machines.

PHYSICAL PROPERTIES

The most important physical properties which affect the quality of the card are:

(1) Hygroexpansivity
(2) Freedom from conductive particles
(3) Moisture content
(4) Freedom from curl
(5) Coefficient of friction
(6) Freedom from fuzz and dirt
(7) Aging quality
(8) Printability and Writeability
(9) Bursting strength
(10) Ash content.

Following is an explanation of these terms and the reason for their importance.

HYGROEXPANSIVITY

This term refers to the expansion and contraction of the paper in varying conditions of relative humidity. As the relative humidity increases, paper expands and contracts as the relative humidity decreases. It is, therefore, important that the paper produced for us exhibit the lowest expansion or contraction possible.

FREEDOM FROM CONDUCTIVE PARTICLES

It is obvious that the paper from which tabulating cards are made must be free from particles which will conduct electricity through the paper since such a condition would act the same as a hole in the card. Extreme care must be exercised throughout the pulp and paper mill to produce paper which does not contain conductive particles. Such particles may be carbon or iron scale.

MOISTURE CONTENT

The moisture content of the paper is highly important in order that the cards will not expand or shrink too much after they have been produced on the card manufacturing machines. Cards produced from paper of too high moisture content will shrink when exposed to 50% relative humidity and cards produced from too dry paper will expand under like conditions.

FREEDOM FROM CURL

Freedom from curl is also very important since badly warped cards give feeding difficulty in machines. This quality is controlled by keeping both sides of the paper with as nearly the same surface condition as possible.

COEFFICIENT OF FRICTION

The coefficient of friction affects the handling and feeding quality of the cards. In feeding the cards it is important that their resistance to feeding or moving across the adjacent card be of such value that the cards feed easily. It is equally important, however, that the cards not be so slippery that they are difficult to handle in packs. The coefficient of friction can be controlled by the type and quantity of sizing materials added to the paper.

FREEDOM FROM FUZZ AND DUST

The paper should be as free from fuzz and dust as possible. The brushes of the machines will pick off loose particles and cause an undue accumulation of dust within the machine and thus cause both mechanical and electrical difficulties. This quality is controlled by the additions which are made to the pulp and the degree of heating in order to produce a sheet with the cellulose fibers firmly bonded.

AGING QUALITY

Since it is required that a great many of the cards be stored in files for use over a long period of years, it is important that the paper retain its high physical properties during this long period. The excellent aging quality which is obtainable in our IBM Card Stock is maintained by careful control of the acidity of the pulp. Stock which is being produced today will retain its high quality for many years.

PRINTABILITY AND WRITABILITY

These are perhaps coined words but they express important qualities since they indicate that the surface of the paper must be of such quality that it can be printed upon and written upon both with pencil and ink. This quality is controlled by the surface sizing as well as the degree of calendering which the paper received.

BURSTING STRENGTH

The bursting strength is important since it gives some indication of the durability of the sheet. It is a property not too easily controlled except by the meticulous attention paid to the details of operation throughout the entire papermaking process. Since it is affected by the character and quality of the wood itself, it means that careful selection and use of only high-quality wood can be permitted.

ASH CONTENT

It is important that the ash content be controlled since it indicates the amount of filler such as clay that is used. The fillers usually detract from the strength of the paper and for that reason should be kept below a definite established value.

There are other physical properties which are of less importance, but are controlled since they contribute somewhat to the quality and performance of our cards.

It can be understood from the foregoing description of the manufacture of IBM Card Stock that it is not a simple operation but consists of many technical details which must be rigidly followed.

RESEARCH

No product is improved without research. While the cards which are being produced today do an outstanding job, their excellent performance is the result of research both on the part of the laboratories and manufacturing departments of our paper suppliers and also our own Paper Research Laboratory.

We are equipped with apparatus with which experimental hand sheets can be produced and fine instruments with which these hand sheets can be tested and evaluated. It is the goal of the Paper Research Laboratory to discover ways of making paper or discovering other materials which will produce the ideal card. By "ideal card" we mean one which will perform all of the many functions which are necessary and will embody all of the desired properties. It is beyond the scope of this discussion to indicate the many approaches which are being used to solve the problems that exist today. We have confidence, however, that carefully planned work and intelligent thinking will be fruitful in the development of better materials for cards. Mr. Watson has often referred to research by quoting Mr. Kettering's definition "Research is finding out what you are going to do when you can no longer do what you are doing now."

Within the Paper Research Laboratory, research on types of paper other than that used for cards is carried on. This is necessary since practically every machine which we produce uses paper, and it is important that the paper used in every application meets the service requirements.

While research on paper is a major activity in the Paper Research Laboratory, many other research problems are also handled by this laboratory. These are problems that are closely associated with paper such as various types of inks, pencils and adhesives.

It is hoped that this description will create a clearer understanding of paper and the complexity of problems with which it is surrounded as well as the scientific approach to the solution of those problems.

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INTERNATIONAL BUSINESS MACHINES CORPORATION
DEPARTMENT OF EDUCATION
DIVISION OF GENERAL AND VOCATIONAL EDUCATION
ENDICOTT IBM SCHOOL

THE IBM CARD
Techniques of Development and Manufacture

IBM CARD STOCK TESTING

H. O. George
Sept. 30, 1946

Two weeks ago, Mr. Saxton told you of the remarkable growth of the IBM card business. You were shown how the production of cards expanded from about 2,000,000 per day in 1914 to 60,000,000 per day in 1945. Much of this increase in volume resulted from new applications of our cards. These new applications in many cases demanded qualities in the cards which were not previously required. The change from a 45-column card to an 80-column card made accuracy of dimensions and of registration assume a new importance. Some of the applications required cards which would run through the machines several hundred times and which could be stored for many years without deterioration. This increase in the rigidity of requirements has made it essential to exercise control over the paper which goes into the card. Use of poor-quality paper is costly in more ways than one. It may result in rejections of cards, in which case we lose not only the paper, but also packing materials, labor, transportation, and machine time. A more serious loss is the confidence and goodwill of our customers. Poor-quality cards can result in serious delays in getting out important reports. It would be a poor business that exercised no control over a material on which it spends $20,000 to $30,000 per day.

The first modern and well-equipped paper laboratory was constructed in 1933, though even before that time there were a few testing instruments which were used to compare the quality of shipments of paper. Now we have a completely equipped paper testing laboratory in each of the three card factories.

The first requisite of a paper laboratory is close humidity control. The physical properties of paper are affected to such an extent by atmospheric conditions that specifications must be based on tests conducted under controlled humidity and temperature. Our laboratories, like those of nearly all major paper mills throughout the country, are maintained at 50% relative humidity and 73°F.

It is not practical to test every roll of paper that comes to our factories; so we have made arrangements with our suppliers to furnish samples from every 10th roll of paper that comes off their machines. These samples are supplemented by others taken within the IBM factories. In this way, we are able to test a cross section of all the paper received in our factories.

Before the paper is tested, it is fully exposed to the humidity controlled air of the laboratory for a period of at least two hours. This permits the paper, regardless of its previous exposure, to come to an equilibrium with the standard humidity under which tests are to be conducted. The testing methods which we use are for the most part procedures which have been standardized by the Technical Association of the Pulp & Paper Industry. In some cases, due to our specialized requirements, we have had to create our own testing procedures. We have brought with us to the classroom many of the instruments we use for paper testing so that we can give an actual demonstration. In a few cases, however, we shall have to content ourselves with a description of the test.

BASIS WEIGHT

The simplest of all tests, yet one of the most important, is the determination of weight. The weight of papers is spoken of as basis weight and is the weight of a ream of paper. To the uninitiated this is a very confusing expression, for the size of the ream and number of sheets to the ream is different for different grades of paper. A standard ream of bond paper consists of 500 sheets 17" x 22", while a ream of wrapping paper is comprised of 480 sheets 24" x 36". A ream of book paper consists of 500 sheets 25" x 38". Thus, a 20-pound bond paper is actually heavier than a 40-pound book paper. The IBM card stock weight is 75 pounds per ream of 500 sheets 22½" x 28½" or 101 pounds per ream of 500 sheets 24" x 36".. The tolerance in weight is plus or minus 5%. While we can permit a variation of 5% on individual samples, the average weight must be held very close to the optimum. A two percent increase in average weight could raise our paper costs as much as $150,000 in a year like 1945. A 2% decrease in average weight could result in a very substantial saving, but it has never been the policy of IBM to sacrifice quality in order to affect a saving.

Even basis weight determinations are affected by the relative humidity at which the paper is weighed. Thus, weighing made at 40% relative humidity would indicate basis weights about 1% lower than if the test were conducted at 50% relative humidity. Basis weight is most conveniently determined by means of a direct-reading scale. With this type of scale, we weigh one sheet of paper, but the scale indicates the weight of 500 sheets or of 480 sheets. If the sheet of paper weighed is 24" x 36", the weight indicated is for a ream of this size. To determine the basis weight of IBM card stock, we would weigh one sheet 22½" x 28½" or several sheets having an equivalent total area. Since we frequently must determine the basis weight of IBM cards or of odd-sized sheets of paper, we usually make use of a gram scale and through the use of charts convert the weight in grams of a single card to pounds per ream.

THICKNESS

The thickness of paper is measured by means of a dial micrometer reading to 1/10,000 of an inch. There are three important requirements of a paper micrometer. The anvils must be 0.56" to 0.65" in diameter, they must be parallel within 0.0002", and they must apply a pressure of 7.0 to 9.0 pounds per square inch on the paper. The standard thickness of IBM card stock is 0.0067" and the tolerance is plus or minus 0.0005".

BURSTING STRENGTH

The bursting strength of paper is determined by means of an instrument known as the Mullen Tester. Hence, bursting strength is often referred to as mullen. The instrument provides a means of applying uniformly increasing pressure to the paper through a rubber diaphragm until the paper breaks. During the test the paper is held firmly between parallel circular clamps having an opening 1.200" in diameter. Gauges indicate the pressure required to rupture the paper. For accuracy of result there must be no slippage of the paper in the clamp and the pressure must be applied at the proper rate.

This is one of the most useful, rapid, and convenient tests which can be applied to paper. A high bursting strength indicates good wear resistance and clean punching in IBM card stock. It is, however, possible for the paper manufacturer to affect adversely other properties of the paper in an attempt to gain a high mullen; so in evaluating paper one cannot rely on bursting strength alone to indicate paper quality.

FOLDING ENDURANCE AND AGING QUALITY

The folding endurance of paper is determined by folding the paper repeatedly in the same spot until it breaks. Two different types of instruments are used in making the test. The one we use in testing IBM card stock is known as the M. I. T. folding endurance tester. In this instrument a strip of paper 15 mm wide is clamped in a vertical position under a tension of 1 kilogram. The lower clamp has a rotary oscillating movement of 135° to each side of center. As the clamp oscillates, the paper is folded over the edge of the clamp. A counter records the number of double folds; and when the sample breaks, the machine is automatically stopped. A high folding endurance indicates that the paper is strong, tough, and durable. Samples for test are cut both in the machine direction (with the grain) and in the cross direction (across the grain). As a rule, strips cut in the machine direction have a higher folding endurance than strips cut in the cross direction, but sometimes the reverse is true.

In testing the folding endurance, it is very important that the samples be conditioned at 50% relative humidity. A 5% variation in humidity will have a very pronounced effect upon the result. The folding endurance increases with increase of humidity and decreases as the relative humidity decreases.

In some applications, EAM cards must remain in use for many years. We must, therefore, have a means of measuring the aging quality of the paper. As paper deteriorates with age, the most pronounced physical change is a reduction in folding endurance. We have seen in papers with poor aging quality a drop in folding endurance from 1000 double folds to one or two folds in the course of a few years under unfavorable storage conditions. To obtain an accelerated aging test we cut strips of paper from the sample to be tested. Half of these are placed in an oven at 212°F. for 72 hours and then reconditioned in the testing laboratory for 24 hours. We then compare the folding endurance of the oven-aged samples with that of the samples kept under normal conditions. In the case of our present card stock, we find that at least 50% of the original folding endurance is retained by the oven aged samples. A few years ago, manila card stock after being aged in the oven would break on the first fold.

TEARING RESISTANCE

To measure the tearing resistance of IBM card stock, we use an instrument known as the Elmendorf Tearing Tester. In this instrument strips of paper $2\frac{1}{2}$" wide are clamped in a vertical plane. One of the clamps is stationary while the other is attached to a movable pendulum. A knife attached to the instrument is used to make a vertical slit in the bottom edge of the paper leaving 1.69" between the upper edge of the slit and the top edge of the paper. By releasing the pendulum, the strips are torn in two in line with the slit started at the bottom edge of the paper. The distance the pendulum swings is governed by the tearing resistance of the paper. The pendulum carries a pointer which indicates the distance the pendulum swings. The instrument is so calibrated that when 16 sheets are torn at one time the scale indicates the tearing resistance in grams for a single sheet. With a strong paper like IBM card stock, we tear only four sheets at a time; so the result must be multiplied by four in order that our reading be in grams per single sheet.

Tearing tests are conducted both with the grain and across the grain. Generally, the paper offers more resistance to tearing across the grain than along the grain. In an IBM card, a high tearing resistance prevents jammed cards from becoming torn, a crumpled card being more easily reproduced than one which has to be pieced together from torn scraps of paper.

TENSILE STRENGTH

The tensile strength of IBM card stock is determined on strips of paper 1" wide and is expressed in terms of pounds per inch of width. The strips are held between a fixed and a movable clamp. Tension is applied until the strip breaks and a gauge indicates the maximum tension required to break the strip. As in all physical testing, the rate at which tension is applied must be kept constant in order to obtain reproducible results. Tests are conducted on strips cut both in the machine and in the cross direction. The tensile strength of strips cut in the machine direction is generally about double that of strips cut in the cross direction.

STIFFNESS

IBM card stock must meet certain stiffness requirements. A flimsy card is difficult to handle and will not give good service in IBM machines. Stiffness tests are conducted on an instrument known as the Taber V-5 Stiffness Tester. In this instrument, strips of paper 1½" wide are bent first to one side and then to the other. The instrument measures the amount of work done in bending the strip. The result is expressed in gram centimeters, a gram centimeter being the amount of work done in lifting a one-gram weight through a vertical distance of one centimeter.

Tests are conducted on strips cut both in the machine and in the cross direction, the stiffness being about twice as great in the machine direction as it is in the cross direction.

SIZING

Paper is treated in a number of ways to make it water repellent. Without some special treatment, it would be absorbent like blotting paper. This water resistance of paper is known as sizing. It is generally obtained by use of rosin soaps and alum or by wax and rosin emulsions. Sometimes, these treatments are supplemented by running the partially dried paper through solutions of starch or of gelatin.

We measure the sizing of IBM card stock on an instrument known as the Carson Curl Size Tester. The paper to be tested is cut into a strip 1½" wide with the grain running across the width of the paper. One end of the strip is cut diagonally to a point. The square end of the strip is held loosely in a clamp while the strip spans a 0.6" wide slot in a light-weight aluminum pan. The aluminum pan is then floated on water so that the area of paper over the slot is in contact with the water. As the water penetrates into the paper, the paper curls. Finally, as the water penetrates through to the upper layers of the paper, the sample begins to straighten out. By means of a stop watch we measure the time from the instant the paper contacts the water until the paper begins to straighten out. This time interval is a measure of water resistance. Since this time interval is also affected by the thickness of the paper, we divide the time in seconds by the square of the paper thickness in mils to give us what we call the curl size factor. Thus, if the test result were 98 seconds and the thickness of the paper were .0070", the curl size factor would be 2.0.

There are a number of other tests which we sometimes use to evaluate the sizing of paper. One is to write on the paper with pen and ink and observe whether or not the line feathers. Another is to sprinkle a mixture of finely powdered sugar, starch and dye on the surface of a piece of paper and then float the paper on water. The mixture of sugar, starch, and dye is practically white as long as it remains dry. As soon as water comes through, it dissolves the dye and colors the mixture, thus indicating the end point of the test.

POROSITY

Another property of paper in which we are interested is porosity, as this affects the absorption of printing ink. Porosity is measured by means of an instrument known as the Gurley Densometer. In this instrument, the paper is clamped over an opening. Air is then forced under constant pressure through the paper. Porosity is reported as the number of seconds required for 100 cubic centimeters of air to be forced through the paper. A high reading indicates a relatively non-porous paper while a low reading indicates a porous sheet.

GLOSS AND SMOOTHNESS

Both gloss and smoothness are measures of the surface finish. Gloss is an optical property and is measured by means of the Ingersol Glarimeter. With this instrument, light is reflected from the surface of the paper at an angle of 57.5°. The instrument determines what percentage of the light reflected at this angle is polarized by the paper. If the paper is glossy, a high percentage of the light is polarized. Both surfaces of the paper are tested. Uniformity of result is important since excessive variations between the two surfaces can result in serious curl.

Smoothness is probably more important to us than gloss though it is a more difficult property to measure. One instrument which we use for this provides a means of clamping a folded piece of paper with a constant pressure. Air is introduced between the folds through a hole in one layer of the paper. The instrument measures the time required for a definite volume of the air to escape between the two paper surfaces. If the paper is smooth, air will escape slowly. If the paper is rough, the air escapes rapidly. We find that smoothness of paper has an important bearing on control of card length on the card manufacturing machine.

COEFFICIENT OF FRICTION

Another surface characteristic of paper which we try to control is the coefficient of friction. This is a measure of slipperyness of the paper and seems to have little or no relationship to either gloss or smoothness. If the IBM card stock is too slippery, it becomes difficult for machine operators to handle the cards and may result in slippage of the cards in the machines. On the other hand, If the cards are not sufficiently slippery, an excessive strain is put on the cards as the cards are fed in IBM machines.

It would be simple to measure coefficient of friction if it were not for the fact that this property is very easily changed. A second test on a piece of paper always shows a lower result than the first. The most accurate way we have found to check this property is to use a sensitive, horizontal spring scale. This is attached to the top card of a pile of 5 cards. The lower four cards are clamped so that they cannot move. A weight of 200 grams is placed on the top card. With a steady pull on the spring scale, we determine at what point the top card, with the 200-gram weight resting on it, begins to slide over the adjacent card. If a pull of 100 grams is required, the coefficient of friction is 0.50. If a pull of 80 grams is required, the coefficient of friction is 0.40. The test is never repeated between the same two surfaces. To check the results, two new surfaces are brought into play.

ACIDITY OF PAPER

As previously mentioned, IBM cards must last for many years with the minimum deterioration. Rapid deterioration can usually be traced to excessive acidity, since acid salts are used to precipitate rosin sizing on the fibers of the paper. In order to prevent rapid deterioration of IBM card stock, we have definite tolerances on acidity. To determine acidity we boil 2.5 grams of the paper in 125 cubic centimeters of distilled water. After an hour, the water is drained from the paper and cooled. The acidity of the water is then determined on special electrical equipment called a pH electrometer or a pH meter.

PERCENT ASH

Paper frequently contains substantial quantities of mineral filler. In some papers there may be large quantities of clay, chalk, or other minerals added to improve the printing quality or to cheapen the stock, for clay is much less expensive than wood fiber. Excessive quantities of clay result in a weaker paper and may result in excessive wear on our slitters and, worse yet, on the punches and dyes of the machines we send out to the field. To determine how much mineral matter has been added to IBM card stock we weigh out 2 grams of paper. This is cut into strips and burned to a white ash in a platinum or alundum crucible. When all carbonaceous material has been consumed, the ash is weighed on a very sensitive balance to 1/1000 of a gram. We permit up to 5% ash in IBM card stock and find that our suppliers stay conscientiously within this limit.

FLATNESS

Probably the most important requirement for an IBM card is that it remain flat. Curled cards can cause more feeding trouble than cards low in strength. Cards may remain flat at one humidity and curl badly at another. For this reason, tests for flatness are conducted at 20%, at 50%, and at 75% relative humidity. The test is made by laying a pile of 10 cards printed side up and another pile of 10 cards printed side down on a table at each of the three humidities. After the cards have come to an equilibrium with the atmospheric conditions of the room, the amount of curl is measured by placing a light-weight gauge across the two high points of the pile of cards and measuring the vertical distance between the gauge and the low point in the cards.

HYGROEXPANSIVITY

All paper changes dimensions with changes in relative humidity. Since

IBM cards must remain accurate in dimensions at all times, it is important to us to have a dimensionally stable paper. We determine the expansion and contraction of IBM cards by measuring the cards first at 20% relative humidity, then at 50% relative humidity, then at 75% relative humidity, and finally again at 20% relative humidity. These readings are made with a very accurate and sensitive card gauge which measures both length and width of the card. Before measuring the cards, they are allowed to condition for at least two hours at the humidity under which they are to be measured. Though cards are more than twice as long as they are wide, the change in width is greater than the change in length. This is because paper expands or shrinks more across the grain than along the grain. This is true even to a greater extent in lumber. A board will shrink and swell in thickness and width but will show little change in length. In the case of both paper and wood, this is due to the fact that the wood fibers change appreciably in diameter but change little in length.

FIBER ANALYSIS

It is frequently desirable to find out what kind of pulp has been used in the manufacture of paper. This can be done by means of a microscope and chemical stains. Fibers removed from the paper are mounted on a glass slide and stained with complex chemical stains. These stains are so designed that they will stain one type of fiber one color and another a different color. Thus, one of the stains we use will give a red color to rag fibers, a blue color to kraft fibers, a grey color to unbleached sulfite fibers, and a yellow color to ground-wood fibers. Various kinds of fibers also show different markings which are useful to the analyst. In many cases it is possible to tell one species of wood from another by the shape and distribution of pits in the fiber wall.

MOISTURE CONTENT

This discussion would not be complete without some mention of moisture content of IBM card stock. Paper always contains a small percentage of moisture. Upon exposure to air, the paper changes its moisture content to correspond with the relative himidity of the air. Thus, at a relative humidity of 40% the paper will have about 5.5% moisture. An increase of relative humidity to 50% will raise the moisture content to about 6.5%, whereas a change to 20% relative humidity would result in a decrease of moisture content to about 3.6%. These changes in moisture content are accompanied by dimensional changes. IBM cards are accurately slit to the right width and are accurately cut to the right length on the presses. If, however, the moisture content of the paper is high at the time of slitting and printing the cards will dry out under normal humidity conditions and will shrink both in width and length. If the paper is too dry at the time it is converted into cards, the cards will later absorb moisture from the atmosphere and will become too wide and too long for proper functioning in the machines. To maintain close control over card dimensions, it is necessary not only to do an accurate job of cutting the cards, but it is also necessary to control the moisture content of the paper. We consider the ideal moisture content of IBM card stock to be 5.5%. No paper mill can assure us of paper at this moisture content but we can and do insist that the moisture content be held between 4.5% and 6.5%.

Moisture content is determined by weighing a sample of the paper, drying it out and weighing it again. The loss in weight times 100 divided by the original weight gives the percent of moisture in the paper. In sampling the paper for this test, extreme care must be used to weigh the paper before it has a chance either to lose moisture or to pick up moisture from the atmosphere. After the sample has been dried, care must be used to weigh the sample before it has had a chance to reabsorb moisture.

We also make use of a quick electrical test to determine the approximate moisture content. As the moisture in the paper varies, its electrical conductivity varies. Thus, by comparing the electrical resistance of the paper with known resistances, we get an indication of the moisture content. We can use this type of test, which is rapid and simple, by leaving a wide factor of safety. If the electrical test indicates a moisture content near 4.5% or near 6.5%, a recheck is made using the other more accurate method. Before an electrical test of moisture content can be made, a calibration curve must be worked out for each type of paper which is to be tested. There are factors other than moisture which affect the electrical conductivity; so any change in type of paper requires a new calibration.

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INTERNATIONAL BUSINESS MACHINES CORPORATION
DEPARTMENT OF EDUCATION
DIVISION OF GENERAL AND VOCATIONAL EDUCATION
ENDICOTT, N. Y.

THE IBM CARD
Techniques of Development and Manufacture

PREPARATION OF IBM CARD STOCK FOR MANUFACTURE
Unloading, Storage, Handling, Slitting to Width, & Superedging

Arthur Lane
Oct. 7, 1946

The paper that is used to manufacture EAM cards comes in roll form in various sizes. The two most common sizes used are 26¼" and 45 3/4" and are made to special specifications for IBM. The large rolls weigh 1,300 pounds, the small rolls, 700 pounds, and every roll is protected with a waterproof wrapper.

Some years ago, it was the paper manufacturer's practice to load freight cars with the rolls standing on end, in tiers two rolls high. When they were unloaded from the cars at our plant, each roll had to be handled separately. This method made it necessary that each roll be tipped to a position lying on its side with a hand crow bar, and then rolled from the car. After the rolls were taken from the car, they had to be tipped upright in tiers again, so as to conserve storage space. Tipping rolls caused unavoidable damage to edges by crumpling due to weight concentrated on corner.

To get them piled two high, one roll would be tipped upright on a skid; then the second roll would be raised on a hand-operated machine, called a revolvator, and then tipped upright on roll that had been placed on skid. After two rolls were on skid, they were taken to storage with a hand truck; then a third roll was raised and rolled on top. By this method, sixty tons of paper could be unloaded a day.

As you can readily perceive, this was a slow, hazardous method of unloading, handling, and storing paper. So this job was being constantly studied for ways and means of unloading and handling paper quicker and easier and safer. When electric powered trucks appeared on the market, a truck was purchased and applied to this important job.

Even after putting the new truck into use, it answered only part of our problem; so after a careful study by our IBM Engineers, a representative of the electric truck makers was called in and a special truck was designed. When the improved power truck was put into use, it was possible to load 26¼" wide paper in tiers three high in the freight car. The boom or "Pick up" on this truck was in the shape of a half barrel so that when it was tilted back, three 26¼" rolls would lie in it securely in an upright position as the load was moved. This boom could be tilted forward and backward as well as raised and lowered, and could also be rotated to a horizontal position with a full load of rolls. At the bottom of the boom, there was a knife-like plate which was used to pick 26¼" rolls off the floor of the freight car three at a time and place them on skids ready to be moved into storage. This pickup plate is interchangeable with a set of specially designed forks which will reach under skids, pick up three 26¼" rolls, tip them in a horizontal position, and lay them gently on the floor ready for production. At this time, all rolls were of the small size. The larger rolls were not used until 1942 when new Kidder slitters were put into use.

Even with the improved mechanism of this new truck, we had to find a better way of handling the heavier 45 3/4" rolls that were required on the new-type slitters; so, with the help of the mill people, tests were made by having rolls loaded in cars lying on their sides in a horizontal position. This method proved to be better as the rolls had fewer crinkled edges than the rolls standing on end. The rolls are piled two high in a nesting position and are kept in place with triangular blocks so they will not shift in car. When blocks are taken out, rolls are let down and rolled on electric trucks and then taken to storage. There are approximately 30 tons of paper in a car, and with the present method 150 tons of paper a day can be unloaded. We have, thereby, improved our methods of handling paper from a standpoint of safety, less damage, and providing means for our material handling workmen to accomplish more with much less effort.

A sufficient amount of paper is kept in storage at all times in the three card plants, Endicott, Washington, and San Jose to keep each respective plant running for approximately 2 months.

When rolls are placed in storage, they are piled in rows according to size and color. Even though rolls have a waterproof wrapper, they are placed on planks four inches high. This is for additional protection against water in case of leaking or broken water pipes. The rolls are stored in the same position as in the car, only, instead of being two high, they are three high, as you can see in this picture. In addition to card stock rolls, there are many other different kinds of paper kept in storage for other IBM paper products, about which you will hear more in future lectures.

As rolls are needed in the slitting room, they are taken down from storage location by the special electric truck equipped with fork "pickups." The forks are placed under the bottom roll, then tilted back slightly so that,when the truck backs off, it takes the roll with it and lets the second and third rolls down to floor level gently and without any damage to the paper. The truck then carries the roll to the Slitting Department.

Each roll has two identifying paper slips attached showing roll number, weight, color, and size. These slips are used for inventory purposes. One slip is detached from the roll when it is taken from storage and the other slip is detached when it is placed on the slitting machine. At the end of each work day, these inventory slips are compared, counted, and sent to the Accounting Department for recording their actual consumption on the day's production.

One of the most important requirements on card paper is that it be totally free from any conductive particles or holes that would permit the electrified brushes in IBM machines to pick up an electric impulse through the card at any point other than where a tabulating hole is punched in the card.

All $26\frac{1}{4}$" rolls are converted in $3\frac{1}{4}$" wide reels on slitters such as the one in the picture on my right. This type of slitter has a device called a Speck Detector, which was developed by Mr. C. D. Lake, one of IBM's Engineers. It consists of a double row of brushes firmly pressing against the entire web of paper. When holes or any electrically cnnductive particles pass by the brushes, a contact is made through the paper to a steel plate on the opposite side of the web. The electrical impulse in turn actuates a cam projecting a ripping knife into the paper, making a rip slit in the center of the $3\frac{1}{4}$" slitted reel right at the point of the defect.

This Speck Detector is wired with a circuit of brushes and one ripping knife for each individual reel so that a conductive defect will be caught and ripped without affecting the other reels on either side of the defect.

* Cards with speck detector rips would occasionally get past visual inspection later on and go out with good cards in the field, causing trouble. Here again, our research engineers found a solution to the problem by replacing the ripping knife with a dye cup and wick which would stripe the defect with colored dye instead of ripping it. This stripe identifies the card as being defective. You can also see part of a speck detector stripe in this picture.

After the paper web passed by the Speck Detector, it was slit in $3\frac{1}{4}$" widths and rewound on individual spools at a speed of 90 feet per minute. There are two sets of knives which are circular that slit paper into $3\frac{1}{4}$" strips. In this picture, you can get some idea of how the knives are mounted. The bottom knives are mounted solidly, while the top ones have a spring tension holding them against bottom knives. By having a spring tension on one set of knives, we get a much smoother edge on the slit reels. These knives are set with an overlap of about 1/32d of an inch. They are spaced apart a few thousandths of an inch under $3\frac{1}{4}$". The reason for this is to help compensate for the normal expansion of paper as explained to you in a previous lecture.

As demands for IBM cards kept growing, more slitting capacity was needed, so our electrical engineers worked out a solution to this problem by installing individual motors on each machine, increasing speed of paper from 90 ft. to 150 ft. per minute. When the speed of slitters was increased to 150 feet per minute, we were confronted with the problem of the Speck Detector's not actuating fast enough, thus allowing conductive particles to pass by the dye cup before it could dart out and stripe the paper. You can well imagine that with this increase in speed from 90' to 150' per minute, the Speck Detector had to actuate very much faster. After some intensive research, the first electronic unit was built by IBM. This unit consisted of tubes and transformers instead of relays and coils. The unit proved so successful that all of our slitters were equipped with it. It was so sensitive and fast that slitter speeds were again increased from 150 ft. to 250 ft. per minute, with perfect speck detection.

In 1940, IBM Engineers were assigned to exhaustive study of slitting methods to develop faster and better machinery for meeting heavily increased card demands.

In conjunction with a specialty machine company a new, larger slitter was built and installed on trial at Endicott in 1942. This machine could slit and rewind a 45 3/4" roll of paper into $3\frac{1}{4}$" slitted widths at speeds up to 1,800 feet per minute. At first this machine was not too successful. But after three years of continued intensive research and development by IBM Engineers, the new slitter was improved to a point where it was placed on full-time production. If you will look at this picture, you will see how the 14 reels are rewound on a single shaft with a drum-type rewind. That is, these drums that the paper is resting on.

One of the original difficulties on this machine was due to interweaving of reels caused by variable tension on the web of paper, while being slit.

In 1945, two more of these machines were installed with a specially designed electrical drive which kept a uniform and constant tension at all times during slitting of roll, and interweaving troubles were overcome. This special drive alone was installed at an approximate cost of $15,000 per machine.

By looking at this picture and seeing how fourteen reels are rewound side by side, you can visualize how the reels could easily weave together if the paper web would move even a few thousandths of an inch from side to side as it wound after slitting.

These machines have some very fine advantages over other types of slitting machines. Due to using 14-reel wide rolls instead of 8, edge trim scrap loss of paper was reduced 50%. With constant and uniform tension on the paper web at all times, reels are wound firmly and soundly without damaged edges. I have here two reels of paper, one each from the two different types of slitters just described. I should like to give you a comparison of the firmness of these two reels--you will notice that when I tap them with this rod, the reel from the old-type slitter sounds soft or "punky," while the other gives a firm, ringing sound.

The knives are mounted on these machines in such a way that the outside blades are set at an angle to the back blades thus giving them a shearing effect which produces a very smooth edge and little paper dust. Paper dust is detrimental to our slitting machines as well as the IBM machines in the field.

With these newer machines slitting paper up to 2100 ft. per minute, the blades require regrinding only once on an average of every 1000 rolls slit. Then only the back set of blades is reground. The front blades are self-sharpening; and when worn out, are discarded for new ones.

I should like to add here that at the present time, IBM is building ten of these big slitting machines at an approximate cost of $35,000 per machine. This construction is being done in the Endicott factory by our own people through arrangements made with the slitting machine company due to the fact they could not deliver more slitters as fast as we need them.

After rolls are slit into $3\frac{1}{4}$" reels, they are taken to the Super Edge machine where they are sprayed with a special Edgecoating solution. This solution penetrates into and toughens the edges of paper thereby increasing the potential use of the card $2\frac{1}{2}$ to 3 times more than the untreated cards. Here the reels are mounted on a conveyor and are taken into the spray booth automatically. When each reel on the spray booth conveyor reaches coating position inside the Spray Booth, the reels are revolved and sprayed automatically with four spray guns.

While reel is being sprayed inside the booth, a sprayed reel is outside in position to be taken from conveyor and an untreated reel is mounted on conveyor arm where the finished reel was taken off.

Two spray guns are set on each side of the reel of paper; and because of the greater area to be sprayed on the outside edge of reels, the two outside guns are adjusted to spray 2 ounces of liquid as compared to 1 ounce by the inside guns.

The liquid is pumped to the Super Edge Booth from a storage tank and the pump runs 24 hours a day the year around, constantly circulating the solution through the storage system.

Inside the booth, a wall of water is continually falling, through which all fumes and over-spray are taken by a fast vacuum exhaust fan and discharged high above the roof of the factory.

The spray booth is surrounded with every safeguard and convenience for loading, unloading and handling of reels - with a minimum of manual labor.

After the sprayed reels leave the Edgecoating booth, they are slipped into special carrier trucks and dispatched to the card manufacturing machines ready for use.

10/24/46 D.S.

INTERNATIONAL BUSINESS MACHINES CORPORATION
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ENDICOTT IBM SCHOOL

THE IBM CARD
Techniques of Development and Manufacture

I. B. M. CARD ORDER CONTROL

by
P. H. Kennedy and L. B. Miller
Oct. 14, 1946

Order control is one of the vitally important functions of IBM card manufacturing.

Regardless of how perfectly a card is manufactured, it does not serve our customer satisfactorily unless it arrives at his office in good condition and at the right time.

We take great pains in maintaining order schedules and in giving the very best service. Requests for card deliveries sometimes are of an emergency nature, requiring perfect coordination and cooperation between Order Department, Etching Department and differenct sections of Card Manufacturing.

One delayed card order might hold up a payroll, inventory setup, or important report, involving serious delay in some customer's business. We often do the impossible to give this important service, breaking down jobs, changing working schedules and procedures. Hardly a day passes without several emergency requests by long distance telephone or telegram.

I believe the best way to explain our system is to trace one order through our plant starting at the time it arrives from the Order Department. All IBM Card Orders are prepared on IBM Business Machines. Procedures in the preparation of orders down to this point will be explained in a later lecture by the Heads of our Order and Machine Accounting Departments.

We receive from the Machine Accounting Department an invoice order showing the form number, quantity, color, and special features of the card to be produced, along with the schedule date, the production cards and the identification cards. Each order card showing the same information as the invoice is accompanied by a duplicate to be used as a label or identification tag on our shipping containers.

Also, a salmon colored card with the same information which is later used for accounting purposes. Also, a white striped location card with the same information which is used for checking and locating orders in our Shipping Department.

The first operation is to check our production cards against the original invoice to make sure all the specifications conform. At this time, our electrotype file is checked to see whether electro is available. The orders are then placed in a file by schedule date sequence.

I might add that each production card automatically tells us how to pack the order at the presses. One type of card calls for packing in 10M regular-unit containers. Different color and stripe indicates boxes of different capacities.

If everything is in order up to this point, production tickets with their duplicate identification cards and type cylinder are released to our presses. The invoice is moved to our Shipping Department files together with salmon card. The location card is sent to a special tray along our conveyor line to await the arrival of boxes of cards from card manufacturing machines as they are produced. The machine operator, as he produces each box of cards, pulls out one production card and the duplicate identifying card and attaches the duplicate to the box of cards together with two samples of the card form in the respective box being printed. Production card is held at the press until the end of the shift, at which time it is sent to the Accounting Department for production records and preparation of reports which show us status of finished and unfinished orders.

STANDARD IBM CARD MANUFACTURE

The first IBM card was manufactured on a machine known as a job press or a hand-fed platen press which operated at a speed of about 30 cards per minute. Cards were first cut to length and width on a guillotine paper cutter and then fed by hand, one at a time, into the job press. Cards were of 34-and 45-column length or 3¼ x 5-5/8 and 3¼ x 7-3/8 sizes.

In 1906, a specially built flat-bed machine came into use. This machine imprinted and cut to length from a roll or web of paper which had previously been slit to card width. First the imprint on the card was made, then the card was cut to length and deposited in a hopper. In order to do this, the web had to come to a complete stop as each card was imprinted and cut off. This machine operated at a speed of 60 to 70 cards per minute.

In 1911, an improved card manufacturing machine came into use. The principle of operation was practically the same as the earlier roll-fed machine with the speed increased up to about 160 cards per minute. These machines all required flat electrotypes.

Because of the rapid growth of the Electric Accounting Machine business under our great president's leadership, Mr. Thomas J. Watson, it became necessary to find a better and faster method in which to manufacture cards.

This job was given to our very capable engineer, Mr. Fred M. Carroll. By 1925, Mr. Carroll had developed a rotary card machine which produced cards at the rate of 400 per minute. This machine was known as the rotary card machine, 400 series. A cylindrical type was developed for this machine. With this new rotary machine, the web of paper did not have to come to a complete stop or even slow down in order to make a cut-off of the card as it had on previous machines used.

Then in 1928, the 80-column machine and card were developed. This development nearly doubled the capacity of the 45-column card.

By 1936, Mr. Carroll had developed an improved rotary card machine known as the 650 series. This machine had a capacity of 650 cards per minute. In 1938, this same 650 series card machine had been improved to produce 800 cards per minute.

In 1944, the 650 series card machine was further improved to produce a higher quality of cards at the rate of 1000 cards per minute.

The IBM rotary card machine is a precision machine which manufactures cards to a length of 7.375 + .003 - .005 at the rate of 1000 cards per minute.

As each improved machine was developed; closer accuracy and added features such as automatic paper straightener, speck eliminating device, and quick-change adjustments were designed and added. Our present rotary card machine is certainly a most wonderful piece of production equipment and one to be proud of.

SETUP AND OPERATION OF THE ROTARY CARD MACHINE

First, Production Tickets and type cylinders are dispatched from the type room to each machine operator.

A reel of paper is placed on the spindle and locked into place; the paper web is then threaded into machine.

Operator must first check the type cylinder for proper form number as called for on production ticket. The type cylinder is then placed on type arbor of the machine and locked into place in proper registration.

Machine is then started by power and a check is again made to see that card is in proper registration, length, corner cut, distribution of ink, and a good clear imprint.

There are a series of guide rollers enroute to the dryer wheel.

The first guide roller compensates for any side wobble of the reel. The next roller is of small diameter and guides web to next roller, which is connected to the brake hub and provides even tension on the web at all times.

The next roller guides web to the flangeless striping roller where stripe is applied if called for on order. Next is the paper straightener. Straightening is done by drawing the paper web under tension around a hardened and ground piece of steel which has an ironing effect to the web and removes the curl in the paper. The degree of straightening action is automatically and constantly readjusted from the amount of curl in the card itself.

The next two rollers are the "come along" rollers.

The first is a beryllium copper roller or speck detector roller. There are two sets of closely moulded brushes that touch the entire width of the web; and when a carbon spot or any metallic substance is sensed, it completes a circuit from the brushes through this spot to the roll and out through the common brush to the other side of the line. This energizes a magnet which sets a pin, which in turn opens a clip in dryer wheel and allows the defective card to drop in discard receptacle.

The next "come along" roller helps to feed paper to the guide shoe. This guide shoe insures that the paper enters the feed rolls properly. These feed rolls are ground to very close tolerances, and are adjusted for parallelism. The feed rolls must grip paper firmly to insure accurate and uniform feeding of the web in order to produce close dimensioned cards. Next is a guide which slightly buckles or tends to stiffen the paper as it enters between type cylinder and platen. The type cylinder or electroplate is engraved according to customer's requirements. It is inked through the inking unit which evenly distributes ink over the entire surface of type. The platen provides the pressure of the paper against the type cylinder to give a good clear print. Care must be taken so as not to have too much impression which will crease the paper.

The paper is fed through another guide to the cut-off blades. These blades are so designed that the card is cut off with a shearing rotary action. The cut-off blades cut the cards to a length of 7.375 +.003 - .005. This close tolerance is maintained through the accurately ground and adjusted feed rolls. Card now enters the gripper unit. The purpose of this unit is to guide the card under the clips on the dryer wheel. The gripper unit is timed so the following card enters a different slot or guide in the roll. These rolls revolve so that the following card will not strike the tail end of the preceding card.

As the card enters the clip on the dryer wheel, the clip closes to hold the card enroute to the corner cut unit. The closing of the clips is controlled by an adjusting block which opens the clip to receive the card and closes soon enough so as not to mark end of card. The dryer wheel is geared down one revolution to 50 revolutions of the feed rolls. The reason for slowing up the dryer wheel is to allow the ink to set before the cards are stacked.

The corner cut is a separate unit of rotary action. The unit is designed so it is possible to cut any corner desired.

As card enters the rear card guide, clip opens and allows card to position.

Card then enters the cornercut area, the clip is again opened; and as the corner-cut knife comes into cutting position, a positioner or pusher locates the card in the bottom of clip to insure a uniform corner cut.

The next station is the stacker unit; and as cards enter this area, clip holding card to dryer wheel is released, allowing card to drop into stacker.

When stacker becomes filled, machine is automatically indexed to the next pocket. Operator then removes cards from stacker, joggles cards for evenness of length, checking cards for length in card length and registration gauge.

Operator inspects cards for size and evenness of corner cut. Riffles slowly through both ends of cards to inspect for good imprint, ink offsetting, damaged or devective cards.

After cards have been thoroughly checked as to customer's requirements, they are placed in cartons ready for shipment.

One of the marvels of the rotary card machine is that, with a piece of flexible paper, the machine prints and cuts cards to very close tolerances at speeds of 1,000 cards per minute. Our average production on the rotary card machine is 57,000,000 cards per day in our three card plants. About 3,500 reels are used daily.

To give you an idea of the daily production in our card plants, if all the cards produced on the rotary card machines for one day were stacked one card on top of the other, they would reach to a height of 33,250 ft. or over 4,000 feet higher than Mount Everest.

The card machine operator accumulates on the spur conveyor at his machine as many boxes as possible of the same item before releasing to main conveyor. After release to main conveyor, boxes travel through an automatic stapling machine where the two samples of the imprinted card and the identification card are affixed to box so that they can be pulled out later on. The next operation is to paste a sample of the imprinted card together with the identification card to the outside of the box, leaving one printed sample under card flap.

These boxes move on to another location where they are checked against the white file card which was sent out at the time the order was released from the type room. The location is marked on this card to enable the distributor to place all boxes with this particular order number in same location on shipping room floor. Orders of five boxes or more, are placed in some definite premarked spot on the floor. If under five boxes, they continue to end of conveyor where they are checked and marked ready for shipment.

As each order is completed, location card is referred to our stencil cutter, who pulls out the invoice, and cuts the address stencil according to address and routing typed thereon. This is given to a checker who takes address stencil with invoice and compares identification card on finished boxes against invoice, making sure all specifications are met. The address stencil is then marked on boxes, invoice stamped with date of shipment, and order is routed to shipping platform. One copy of invoice is placed in one box of each shipment and is used as a packing list for the customer to check shipment on arrival.

We ship by various ways: by freight, truck, express, parcel post, etc. As each order is routed to the respective carriers, they are again checked out, making sure they are loaded into the right freight car or truck, and bills are signed and shipment is complete.

When bills have been signed, the salmon card which has been held in the Shipping Department's file, is pulled out and forwarded to the Accounting Department as a shipped order. One copy of shipping order is retained in the shipping department for further reference and the remainder of the copies are sent to the Order Department for proper billing, etc.

This example has shown what happens to an order with one item. Most of our orders cover from 2 to 15 items. These are all accounted for in the same manner. This constitutes the regular procedure for standard work.

In cases of partial shipments, amount of cards shipped is noted on salmon card and this is retained in shipping department until order is complete. However, we do make out a duplicate salmon card with same information every time a part shipment is made and this is immediately sent to Accounting for their records.

Whenever a partial shipment is made, the invoice is sent to Order Department for billing and is later returned to shipping for use in shipping remainder of order.

At the end of each day, all invoice copies that have been shipped are separated and forwarded to Order Department.

Also,we prepare a listing of orders shipped and these are sent to Order Department with the invoices. This listing is used for quick checking on inquiries as to date of shipment.

In case of special production such as numbering, prepunching or work calling for additional operations, a slightly different procedure is used. These special orders are segregated in the type room and are routed to card machines according to operations and machine load at time of schedule.

The number of orders handled averages about 350 per day and require approximately 5,500 to 6,000 packages.

Production tickets which are sent to Accounting Department each day are sorted and a report is made on all orders that have been shipped and status of orders complete. This record is used for quick reference on inquiries and is also used to check to see that orders are not held dormant in Shipping Department, and is a guide in checking any discrepancies.

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INTERNATIONAL BUSINESS MACHINES CORPORATION
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THE IBM CARD
Techniques of Development and Manufacture

SPECIAL CARD MANUFACTURING

by
Mr. P. H. Kennedy
10/21/46

When we say "special" cards, we are referring to cards that have other than standard features or cannot be manufactured on our rotary standard card machine. This takes in multi-colored imprinted cards, serially numbered cards, serially prepunched cards, creased cards, notched cards, scored cards, and cards of various lengths other than 7-3/8".

The first cards manufactured were of two lengths: 5-3/8" used by the city of Baltimore, and 6-3/8" cards used for U. S. Census work.

Later on, as our business developed, a longer card was needed and a length of 7-3/8" was decided on, which is still our main standard length.

With the exception of the census cards, which were numbered on a special imprinting and cutting machine, cards were manufactured without any of these special features up until 1923.

By this time the use of cards had spread to more and more different applications, and it was necessary to change our manufacturing procedures to keep pace with changing requirements.

Before we go on with the discussion of the various-type machines used in special card manufacturing, I should like to point out that all of these machines were developed and built for IBM's particular manufacturing requirements.

The first major change was to serially number and prepunch cards.

In 1923, a prepunch device was developed here at Endicott which enabled us to manufacture numbered and prepunched cards.

The serial punching device was located at a point on the card machine ahead of the imprinting and cutoff. The numbering machine had to be included in the same head as the imprinting plate. This was not wholly satisfactory because it limited the position of the number on the card and it was necessary to provide space in the imprinting plate for the numbering machine.

In order to overcome some of these difficulties and limitations, two of the original flat-bed machines were combined, making a doublehead machine. The prepunching device was incorporated with the corner cut and length cutoff in a single long die on this machine.

This combination was a big improvement over the single-head machines. Some of the improvements were:

1. Numbering in any position on card.
2. Numbering machine did not require any space in imprinting head.
3. Numbering in different color from imprinting on the card.

4. Gave better registration on prepunching.
5. Made it possible to do back and front imprinting in one operation by twisting the web between imprinting heads.
6. Possible to imprint two colors on one side of card also in one operation.

These machines are still in use. There have been many more improvements made on these machines from time to time. The average speed of these machines is 80 cards per minute.

After numbering and punching features were in use, requests for stub cards necessitated the following additional changes in our card manufacturing equipment:

Wider imprinting heads.
Special scoring units.
New-style corner cut.
Punch and die base.
Special ground feed and draw roll which controls card length.

We now cut approximately 25 different length cards ranging from 4.852 (51-column card) to 15¼"--each one for a different customer's special application.

With the use of the punch and die base, better punching registration was achieved. Accurate length on stub cards was made possible and more uniform corner cuts maintained.

This was accomplished by doing punching, scoring and corner cutting in die base adjacent to cut-off knives.

Another new card requirement was the use of punched hole cards for bank checks.

With the increased demand for these various types of special cards, it again became necessary to improve and expand our equipment further. These included:

(1) Use of M-24 imprinting machine to do overprinting and back imprinting and other additional features. The M-24 imprinting machines are used for doing additional operations on special cards. These presses are very flexible and are capable of imprinting work of high quality. They are used mostly for short-run jobs, and to finish work that requires more operations than our other card manufacturing machines are able to do. The speed of these imprinting machines is approximately 85 cards per minute. The imprinting surface is 7 by 11-5/16, although a longer card can be fed through machine. These machines do not cut cards to length, and are used only for imprinting on precut cards.

(2) Re-designed 1/0 flat-bed card manufacturing machines enabling us to manufacture cards from 4.852" or 51-column cards up to and including 8-15/16 over-all in length. These machines have an imprinting head and a numbering head.

Among the special features this machine can perform are:

1. Number.
2. Prepunch in one or more fields.
3. Score and perforate.

4. Punch holes in stubs.
5. Crease for folding.
6. Dye stripe.
7. Overprint.
8. Tint.
9. Cut out tab and stop cards.

The speed of this type of card manufacturing machine ranges from 180 to 250 cards per minute.

(3) Special Rotary Card Manufacturing Machine

This machine was purchased primarily for bank check manufacture. It requires cylindrical plates and consists of three rotary imprinting heads and one rotary numbering head.

This machine will produce cards or checks of standard length only as follows, complete in one operation.

1. Number
2. Prepunch.
3. Crease.
4. Tint on front.
5. Imprint on front.
6. Imprint on back or overprint on front.
7. Cut corner.
8. Stripe.

This was the first rotary-type special machine used in manufacturing cards.

This rotary special machine has several extraordinary features. In order to number consecutively, two numbering machines are used, one with odd numbers and one with even numbers. This allows the action of numbering machines to work at $\frac{1}{2}$ the speed of the imprinting heads, insuring greater accuracy in numbering. The 2d imprinting head uses the dry offset principle; that is, the image from the type is first transferred to a rubber platen roller which in turn is applied against the paper, transferring or "offsetting" the imprint on the card.

This principle is used for several reasons: to obtain more uniform imprint on delicate designs, the rubber platen compensating for unevenness in paper; for quicker drying and better appearance. Increases production life of plate because finely etched lines on plate do not contact paper.

A reciprocating motion actuates the die base which does the pre-punching, scoring and cut off. This back and forward movement allows the web of paper to move, without stopping its forward motion as the work is performed on the card.

It is possible to disconnect quickly any individual printing head merely by throwing out a clutch.

This press is ideal for small runs as a complete setup of all heads can be made in a comparatively short time. It was a great improvement over previous special card manufacturing machines doing similar work because of improved imprinting quality, higher speeds and eliminating extra operations. The speed is 125 cards per minute.

(4) Rotary Gravure Card Manufacturing Machine

As the use of bank checks expanded it became necessary again to increase our machine capacity.

The next special IBM card manufacturing machine developed was the Gravure Rotary machine.

This machine had six imprinting stations in addition to the numbering head. The die base is similar in action to the Special Rotary machine just described.

The principle of imprinting used on this type machine was entirely different from anything done in our card manufacturing departments before.

This new method is known as the gravure process. All previous imprinting done by us was called the letterpress process.

The letterpress process imprints from raised characters. The Gravure method uses a smooth surfaced plate with the imprinting characters being recessed or etched into this surface.

In letterpress imprinting, ink is applied to imprinting surface by means of inking rollers. In Gravure imprinting, ink is applied over the entire surface of the plate. Then surplus ink is removed from the smooth surface of the plate leaving ink only in recessed areas. This is done by what is called a doctor blade.

After ink has been removed from smooth surface of plate, paper is pressed against the plate by means of a rubber platen roll and ink is transferred to the paper.

Some of the advantages of using this method are: greater speed and almost instant drying of inks, eliminating offset and thus speeding up clearing of orders through our departments for shipments.

The speed of these machines ranges from 240 cards per minute on punched and numbered cards, up to 300 cards per minute on unpunched and numbered cards.

At the beginning of the war we started manufacturing government checks in large quantities, and this additional check business made it again necessary to increase our equipment to manufacture such cards.

By this time a new tinting machine had been developed. This was a gravure-type machine capable of tinting one or both sides of a paper web simultaneously.

By using tinted paper from these machines, we were able to manufacture checks on any of our special card manufacturing machines.

The method proved so practical that a 1/1 card manufacturing machine was developed making it possible to use tinted paper and print front and back of cards, and number and prepunch cards of various lengths from 4.852 to 8-15/16 at one operation.

These machines are of the letterpress type and do work of a high quality.

The average speed is 200 cards per minute.

Soon after the start of the war, we started manufacturing a new type of card for government use. This was called the stencil address card.

It is used in preparing checks by electric accounting machine methods for distribution.

At the start, these cards were manufactured entirely by hand because we could not wait for automatic machines to be developed.

Our engineers started working on developments to mechanize the production of this new type of card immediately.

With these new machines a more accurate and higher quality card was manufactured, resulting in increased combined efficiency of over 500%.

One subject I have not mentioned before is the special operations performed by our finishing department.

These include: brass eyeletting, fibre re-inforcements, stringing, and wiring cards, collating cards and slips into pad form. Some pads are held together by staples, others by special adhesives; cards assembled in sets with carbon sheets for duplicate work, various size holes punched in stub cards, etc.

Examples of these various operations can be seen on the exhibit board.

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THE IBM CARD
Techniques of Development and Manufacture

INSPECTION AND VERIFICATION OF QUALITY

by
F. J. Kizale
10/21/46

I shall begin my part of this session by presenting and explaining some of the gages used for measuring cards in the early days of card manufacturing. First, I shall describe what is known as a bar length gage, dating back to 1926. This gage was used exclusively for measuring card length of 7 3/8", 5 5/8", and card width of 3 1/4". To measure a card with this gage, the card is placed between two points on the gage 7.375" apart, which is the mean dimension of the card. The same holds true when measuring a 5 5/8" card, or the width of 3 1/4". This method required keen judgment on the part of the machine operator, but of course, cards manufactured in those days were of the round punched holes, with only a capacity of 45 columns in a 7 3/8" card and 34 columns in the 5 5/8" card, thus allowing a wider machine tolerance.

I might mention at this point that one of the employees connected with card manufacturing enhanced the value of this gage by suggesting that two notches be cut in the gage to measure the full card tolerance, plus or minus .005". Cards cut longer than 7.380" would not enter the gage, while cards cut under 7.370" would fall inside the second notch. This holds true when measuring 5 5/8" cards and the width of 3 1/4". Not only did this eliminate the guessing of measuring cards, but also increased the efficiency of operation.

Since the bar gage could measure only card length or width, another gage was necessary to measure corner cut of the cards. The gage I have here was the one used, designed to measure 1/8", 1/4", 3/8", 1/2" and 1 inch depth corner cuts with a 45-or 60-degree angle. To measure corner cut size with this gage, you merely place the corner cut end of the card on the gage to whichever size is desired, and depth of corner cut on the card must conform to notch depth on the gage or within the 1/32" tolerance shown on the gage. In 1936, various depths and angles of corner cut were eliminated, and the corner cut was standardized to a 60-degree angle, 1/4" depth, with a tolerance of plus or minus 1/32".

It is important, from the standpoint of the customer, that the registration of imprinting be in correct alignment to the card. Therefore, still another gage was needed to align imprinting registration. This gage was designed similar to a card, flat rectangular, with round punched holes. For proper registration, the numerals imprinted on the card should show clearly through the round holes in the gage.

From this description, you can readily see that three separate gages were necessary to measure cards completely. There is no question in my mind, as to the problem we would have today if cards had to be measured with three separate gages with the tremendous volume of cards produced each day.

With production steadily increasing, the necessity of more efficient methods for gaging cards was never greater. The engineering department was searching to devise better means for measuring cards, and then in 1930, a gage was developed which is known as the glass-top, dial length gage. The gage consists of a dial indicator, which measures card length in thousandths of an inch, with a glass top for imprinting registration, and also shows the corner cut size and tolerance. To measure cards with this gage, you merely insert the card in the gage; and the dial registers the length of the card in thousandths of an inch on either the plus or minus side of the length. The imprinting is lined up to the glass top on the gage, for proper registration, also showing 60-degree angle, 1/4" corner cut, tolerance of 1/64", located on any corner of the card. The accuracy and efficiency of this gage is a great asset to card manufacturing.

With production still increasing, and cards becoming more complex, the demands increased for reducing card tolerances on card manufacturing machines, and it became necessary to further improve the glass-top, dial length gage. The improvements were the results of past experience with the first dial gage. Suggestions received from employees, working in the card manufacturing department, contributed greatly to the following improvements: the gage was lined with carboloid inserts to resist wear, a standard shock proof indicator and the gage itself mounted on shock proof brackets. These features aided in maintaining high accuracy of the gage, with a minimum amount of attention. The gage is used in the same fashion for obtaining length, registration, and corner cut, as the original dial gage.

Each machine operator is equipped with one of these high-precision, glass-top, dial length gages, and the accuracy of these gages is checked by a process inspector with a master plate 7.375" in length, scribe lines 3/16" from the bottom and also 7/32" on either end of the plate.

With master plate inserted in the gage, the dial should line up on zero, scribed lines on the glass top gage should conform to those on the master gage, for proper imprinting registration. The width was not mentioned since the width is measured at the time of the slitting operation.

The process inspector maintains a record of all the gages for location and repairs, by date. I might mention here that every gage is completely gone over for wear and general cleaning once every two months.

Becuase of the required close tolerances on card length, it is important that all gages measure cards accurately and it is desirable in close relation with one another. To control variation among gages, the reading of each gage is compared to a newly developed five-dial master gage. The line gage reading must be within .0005" of the master gage reading, before it is assigned to any operator.

To describe in detail the master gage, two dials measure the width of the card, one dial measures the length, and two other dials gage the squareness. The gage can be used only for measuring length and width; and if the squareness is required, you merely press a button and the squareness dials come into play. This was designed by the Engineering Department of card manufacturing. This gage is the final word on card length, width and squareness used by the inspection department.

The machine operator continually checks the length of cards during operation, and, therefore, it is important that each machine isequipped with one of these high-precision, glass-top dial length gages. The accuracy of the gage is checked by the process inspector with a master plate 7.375" in length, scribe lines 3/16" from the bottom and a scribe line 7/32" on either end of the plate.

With master plate inserted in the length gage, the dial should line up on zero, and lines on the glass-top gage should conform to those scribe lines on the master plate for proper registration.

With card manufacturing length tolerances reduced, it was also necessary to reduce squareness tolerances to .0035". A gage was developed which can efficiently and accurately measure card squareness in the production line.

To measure squareness with this gage, you place one end of the card under a magnifying glass which enlarges the actual size 4 1/2 times. If both top and bottom of card are visible in the gage, the card is within the .0035" tolerance. Once the machine is set up to cut within this tolerance, as a rule it seldom changes.

The process inspector who cares for the gages, also checks for correct machine operation, checks for proper length of cards and the actual operation, by comparing the shop order for correct form number, color of paper, corner cut, imprinting and appearance in general.

Located at the end of the standard card production conveyor, another inspector reopens and inspects completed boxes for length, corner cut and general appearance of cards. Of these, four boxes are checked for count and weight, as well as the thickness of the cards. Each container should hold approximately 2M cards, of an average weight of 5 lbs. 5 oz., and an average thickness of .0068".

All during this talk, I have not mentioned any specific points about width of the card. The reason is that this operation takes place at the time of slitting.

The slitting department has been provided with a dial width gage, which measures width in thousandths of an inch. The gage is designed with a small hinged lid which presses the paper against the gage to obtain a true reading. The width tolerance is -.005" to + .000", for slitting operation.

Samples are taken once each shift from each of the machines, to insure correct width tolerance.

The edges of the cards play an important part in machine operations in the customers' offices, and, therefore, it is important that rolls are slit with a keen edge. Samples taken from each machine on a daily basis are checked on a comparator for smoothness of edges. The comparator is a Jones & Lamson Comparator, which amplifies the actual size of the edge fifty times. This reflection is thrown on a screen showing the established tolerance of .0024". Machines which are found cutting outside of this tolerance, are shut down and necessary repairs are made.

Process inspection procedures of special production are similar to those explained for standard production, with the exception of an additional operation involved in manufacturing special cards and checks serially numbered and punched.

The process inspector of the special production line continually checks for proper length, legibility of serial numbers, punching information and registration, imprinting and tinting operations of each machine.

Completely manufactured special cards and checks are moved in card drying racks to the inspection department for final inspection.

The inspector starts his work by first comparing the invoice to cards or checks for form number, front and back proper imprinting and registration, color, watermark paper stock or plain, tinting, length, and general appearance. Also compares the not numbered or punched cards provided by the card manufacturing department with each separate job. These cards are used to replace any cards found missing or damaged.

In groups of 500, the cards are inspected for legibility of serial number, and imprinting and tinting appearance. Any defective card found during this process is replaced by the inspector, by hand stamping the serial number, and prepunching the serial information on an electric key punch, on the make-up card. The inspector checks the make-up card to see that it is exactly and properly made up.

Then in groups of 500, cards are verified for correct punching on the variable-length tabulator. The machine was specially built for the inspection department, and verifies card or checks with lengths varying from 5 5/8" to 15 1/4". The machine is equipped with electrical circuits to control numerical sequence, missing cards, or cards having more than one punched hole in any one column. The machine has three adding counters: two are used to add and compare punching information taken from the cards as they pass the brushes, and one counter is used to count cards.

If, during machine operation, a card is missing, out of sequence, or double punched, a red light located just above the start key is flashed on and remains on until turned off by the inspector. The light is in the motor circuit, and when this light is on, the motor relay is dropped out, stopping the machine at that exact point.

In cases where an error occurs in a group of 500 cards, the inspector, after making correction of the error, re-runs the group for final checking. By so doing, the errors of the human element are reduced to an absolute minimum.

If both adding counters have correct answers at the end of a 500 run, and no red light has occurred, the inspector proceeds to band the cards in groups of one thousand, with a top and bottom protection card. Two groups of one thousand each, are placed in unit containers with the beginning and ending serial numbers marked on the outside of the box. Container is then placed in a large 10M-size box. The outside of the 10M box contains the information referring to the order number, form number, beginning and ending serial numbers, and color of paper, which is used for the customer's identification.

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THE IBM CARD
Techniques of Development and Manufacture

IBM IMPRINTING PLATES

by
R. E. Frederick
10/28/46

CYLINDER IMPRINTING PLATE

The copy and photographic work having been completed, it is now necessary to superimpose the image from the negative on to a cylinder that will ultimately be used for imprinting the IBM cards.

The material used for making type cylinders is "S.A.E. 74 Brass Tubing." The raw material is first rough turned, bored, and annealed at 500°F. for one hour. A finish turning and boring operation follows to bring the cylinder to correct dimensions.

The outside diameter is turned with a diamond tool to a surface finish that measures between 1 1/2 to 4 micro-inches.

The cylinder is scoured and washed preparatory to the coating and printing operations. The surface must be absolutely clean before applying an emulsion, otherwise the emulsion will not adhere to the metal. The scouring operation is accomplished by placing the cylinder on to an electrically driven arbor and rubbing the surface with an Aluminum Oxide powder and water.

An emulsion of Bichromated Albumen is applied while the cylinder is still wet and as it is taken from the scouring sink. This emulsion, which is sometimes referred to as the coating solution, is light sensitive similar to the photographic emulsions found on camera films.

To provide a uniform coating, the cylinder is placed on a specially designed coating machine. The arbor holding the cylinder revolves while the coating is applied over the entire surface, then the machine whirls on its vertical axis throwing the solution towards each end. The centrifugal force resulting from the whirling motion causes the solution to be evenly distributed. A small electric stove built into the machine is automatically turned on while the machine is in operation, heating and drying the emulsion.

The coating operation takes approximately 4 minutes.

When the coated cylinder is thoroughly dried, it is placed in an exposure machine in contact with the film negative that was reproduced from the six-times copy. An arc lamp is used as a source of light for the exposure.

The exposure machine has a vertical spindle upon which the cylinder is located. The negative is placed into a moveable rack which moves in synchronism with the spindle. As the cylinder rotates, the rack moves in a linear direction, the negative being held in contact with the cylinder at all times. The light enters the machine through an aperture 9/16 of an inch wide.

As the negative passes in front of the light, the sensitized solution on the cylinder undergoes a chemical change. Where the light or transparent openings in the negative have allowed the light to pass through on to the cylinder, the solution has become fixed and insoluble in water. That portion of the solution that was protected from the light by the dark areas of the negative remain soluble in water and will wash off readily when later developed. The time for exposure will vary from 12 to 15 minutes depending on the color of the negatives; that is, whether the black areas are definitely opaque or on the grey side and whether the white areas are perfectly clear.

Upon completion of the exposure, the cylinder and negative are removed from the machine; the negative is filed away and the cylinder is rolled up with a photo-engravers ink. An electrically driven arbor is used in the inking process, and the ink is applied with a hand inking roller.

To develop out the print that has been exposed, the cylinder is immersed in cold water and the surface washed lightly with soft cotton. The areas that were affected by the light and which became insoluble during the exposure will remain on the surface covered with black ink. The other areas not affected by the light will wash off, taking the film of ink with them. When completely developed, the image on the cylinder will be a card size reproduction of the six-times-size copy. Metallic surfaces will be showing where the ink and solution have been washed off. It is these areas that will be attacked by the acid and etched away.

The print is now inspected for breaks and is touched up if necessary before going to the etching operation.

The ink print is dusted with an asphaltum powder and the cylinder is heated to burn the powder into the ink. The combination of the ink and powder when burned in creates a hard protective acid-resisting coating which protects the image on the metal from etching.

Next the cylinder is positioned on a special arbor in an Electric Etching Machine and allowed to etch for approximately five minutes. The depth of etch will be .002 to .0025 of an inch.

Electric etching is accomplished by immersing the cylinder into an electrolyte solution of "Sodium Chloride" and "Ammonium Chloride" and passing a current of 65 to 70 amperes through the cylinder with 8 to 10 volts.

When the desired depth of the first etch is obtained, the type is thoroughly washed and dried in preparation for a re-inking operation.

The re-inking machine is now used to apply a thin coating of special photo-engravers ink on to the top surface of the characters. An asphaltum powder is dusted over the inked surfaces and the type is placed in an oven where it is heated for 7 minutes at a temperature of 400° F. It is then quickly cooled by a cold water spray.

The heat from the oven causes the ink to run down the sides of the characters and also the powder and the ink to blend into a hard resisting surface as protection against the next etching operation.

The type cylinder is now placed in a chemical etching machine where it is revolved in a bath of Ferric Chloride and etched to a total depth of .010 of an inch. The etching time may vary from 10 to 12 minutes depending on the strength of the acid.

If the type has any large open areas, it is necessary to deep etch such areas further until a total depth of .020 of an inch has been obtained. The time required for deep etching is usually 3/4 to 1 hour. The characters and all fine detail are painted with an asphaltum shellac for protection against the acid.

At the completion of the deep etch, the type is trimmed to length, cleaned and sent to the plating department.

All cylinder type are chrome plated for twenty minutes to provide a hard surface which increases the length of life.

Plating is the final operation and from here, the type are prepared for shipment against the orders that were originally sent in from the field.

FLAT IMPRINTING PLATE

The production of flat plates follows the same procedure as outlined for cylindrical type with the exception that different equipment is used.

We do not electrically etch the flat plates but instead use the four-powder method all the way through. When using this method, a special resin powder known as "Dragons Blood" is used. The powder when banked against the four sides of the characters, burned in, and heated forms a strong resistant coating as protection against etching.

GRAVURE IMPRINTING PLATES:

A "Gravure Cylinder Type" is processed in a similar manner as the "Letter-Press Cylindrical Type."

The difference between the two is that in letter press the characters are raised and in gravure the characters are etched down into the surface of the type. The depth of etch for gravure is .0025 of an inch.

Gravure cylinders are printed from a film positive rather than a negative. The positive contains a gravure screen in the background which has been put there by photographically processing the first negative through a screen on to another piece of film.

Letter press cylinders are used for imprinting the numerals and letters on to the card.

Gravure cylinders are used in the majority of cases for imprinting a tint or design into the background of a card.

The Photo-engraving business as it has been outlined is one in which much skill is required. There are many problems to be solved from day to day because of the critical and precise conditions that are so essential for successful operations. As an example, the humidity of the atmosphere and the temperature of the room have a great effect on the coating, printing and etching operations. The speeds at which the machines operate are very important and may vary from one job to another.

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THE IBM CARD
Techniques of Development and Manufacture

IBM CARD DESIGN

by
R. V. Flynn
10/28/46

One of the points at which those who are interested in the production of IBM cards marvel is the hundreds of thousands of new forms designed over the years. They are all different, and a study of them would show the history of our people both from a social and an economic viewpoint.

In their early uses, they took the form of census cards for our government to find the facts upon which both government agencies and business could make future plans. Then as their application became more general, they were used to give detailed help to individual enterprises such as railroad accounting and studies for our great insurance companies in their early years of development. In the past fifteen years, the course of all of the social legislation, which has affected the lives of all Americans for all time, can be followed in the design of the IBM cards called upon to do all of this vast detail of work. Social Security is firmly embedded in the IBM card, both from the point of administration in the Federal Government through all of the phases of state participation down to their use by our commercial customers in caring for the contribution of the individual employee.

In the IBM card, we have seen the development of huge public works programs such as the Public Works Administration and the Tennessee Valley Authority. We can follow the course of the recent World War II through the National Defense Program of 1940-41 and our participation in the war itself. The IBM card played a very vital role in our war effort in the control of our men and material. The Lend-Lease Program was made more effective by the use of IBM cards. Cards were designed for the armed forces during the war which were classified as top secret documents and more recently, there have been cards designed to work for the United Nations Organization to do their part in making a lasting peace.

We have other cards which are used in the study of our public health problems looking forward to the future when they will have played their part in the elimination of a great amount of sickness and disease. So you can see my point in that a study of card designs, as they go by, could well be a study of current events.

Card design must, of course, have for its origin the specific need of a card to perform a given operation in an installation of electric accounting machines. Take for an example, a customer needs a material requisition as part of his control of stock and supplies. This need is recognized and then either a representative of IBM Sales Organization goes into consultation with our customer, or in the case of a larger installation, the customer's supervisor of machine accounting operations will lay out the designed card on one of our twice-size diagrams. This is then forwarded through the channels of the Sales Representative and the Sales Office to our Endicott Factory together with a purchase order from the customer which will authorize us to produce the necessary type from which the cards may be printed.

The subsequent operations which are performed to bring this new card into being are those that were portrayed in the movie which opened this series of instructions. You will remember that the diagram was given a form number which would give us control of its schedule and location for all of the years that this card may be an active form. The diagram with a proper order is entered in the Photo-Engraving Department and here the actual process begins which will transfer an idea sketched on paper into a precision printing plate from which millions of finished cards may be reproduced.

At this point it perhaps would be well to review the different kinds of cards which are produced. First, we have the regular card which has no other features except a choice of card stock colors, the use of a stripe of any one of various colors and the choice of location of a corner cut if one is desired. This first style of card may be produced from a cylindrical imprinting plate on the IBM cylinder imprinting machine. The second style of card is a regular-length card that may have a scored corner, prepunching, serial numbering or more than one color used in the design. It is necessary that these cards be printed from a flat type. This is also true of all cards that require the use of a stub on either end attached to the card by a perforation. Thus, you will see the necessity of knowing the type' of card to be produced before we begin to make the printing plate.

At the time when an order for a new card form arrives in the Photo-Engraving Department, it is assigned a work jacket which carries its form number and gives its schedule as to when it is to be ready for photography. This then places it in its proper sequence with all other work on hand. The order, in its proper turn, is taken up by a person whose part is to order all of the words necessary to compose the large copy. The copy writer is equipped with type charts which are the same size scale as the diagram and in this way he is able to select the correct size and style of type to fit a given space.

The order for words is then transferred to a file of stock words, and this is made up of hundreds of different words in a number of different sizes and styles of type. Here all of the common words are drawn from the files and checked from the order. The balance of special wording is then ordered from a printing section where all of the special words are set in type and proofed on a power proof press. These proofs are dried in hot air ovens and when dry are added to the words already taken from the files. This then gives us a complete set of words with which the large six-times-size copy can be composed.

During the time that the wording is being prepared by one group of people, the diagram of the new card is passed to the layout section. Here we make use of a large master form which has all 80 columns of body figures printed in correct registration.

By referring to the diagram the draftsman is able to put all of the necessary rules and registration on this large form in pen and ink to produce the rules and lines on the finished card. It is here that we assure the accurate registration of the card in its use with the various kinds of printing business machines such as the 60-column interpreter. The card must fit the registration of these various machines.

Now that we have the large six-times-size copy with all of its lines drawn in ink, it is only necessary for it to have all of the wording added to it to be complete. This is done by a girl working on a drafting table with the use of a straight edge and rubber cement. Each of the words is pasted in position on the large copy to agree with the original diagram. When this is finished, all of the work is checked by a proof reader to see that we have reproduced the design as wanted.

The copy is now ready for photography. This step is of utmost importance because the reproduction of all the aforementioned steps on to a sheet of film is dependent upon the degree of accuracy of the photographic process.

Photography, as used in Photo-Engraving, is a vast field in itself and is the subject used to fill many textbooks. Our use of photography at this point is reduced to an operation which is fixed in its use and results. Our camera is set for an accurate six times reduction. The large copy is held in a glass-covered frame always in the same place. The film is held in a special plate holder which is equipped with a vacuum chamber to insure the sheet of film's being held flat for each picture. We use a process film which requires a 35-second exposure under four 35-ampere carbon arc lamps, this film being developed in a slow-process developer which gives us a very sharp image with a dark black background. This is an ideal negative from which to produce a line engraving.

11/13/46 mk

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IBM CARD
Techniques of Development and Manufacture

MAINTENANCE AND REPAIR OF CARD MANUFACTURING EQUIPMENT

by
W. S. Granger
Nov. 4, 1946

The responsibility of any maintenance department is to keep production equipment in good running condition at the lowest possible cost. The card manufacturing maintenance department at Endicott in addition to maintaining equipment for the Endicott plant has the following responsibilities:

1. Builds new card manufacturing equipment for all plants.
   a. High-speed slitters
   b. Card manufacturing machines
      (1) high-speed rotary machines
      (2) special purpose flatbed machines
   c. Tinting machines
   d. Special machines and all necessary tools.

2. Works in close cooperation with the Engineering Department in connection with building and testing new designs of card manufacturing equipment.

3. Maintains records and arranges for periodic overhauls, at Endicott, of equipment from all plants. At this time all the latest improvements are added to each machine.

4. All card manufacturing equipment shipped to our foreign branches is reworked to their specifications at the Endicott plant. Also, at this time, all the latest improvements are added.

5. Maintain a stock of replacement parts and ship on demand to any of our plants --- domestic and foreign.

The job of maintaining our card manufacturing equipment is constantly becoming more complex and important. Some of the factors contributing to this trend are listed below.

1. Reduction in manufacturing tolerances brought about the increased demands upon our accounting machines.

2. Constantly raising quality standards of our product.

3. Increased output per production machine.
   a. Original flatbed machines produced 40 to 50 cards per minute.
   b. Improved flatbed machines ran 120 cards per minute.
   c. Present flatbed machines run 200 cards per minute.
   d. Original rotary machines operated at 400 cards per minute.
   e. Improved rotary machines increased production to 800 cards per minute.
   f. Our present rotary machines operate at 1000 cards per minute.

The increased production speeds result in:

a. Heavier bearing loads and more wear.
b. Increased vibration loads.
c. Increased paper dust and chip troubles.
d. Lubrication requirements are more exacting.
e. Adjustments must be made with greater care.
f. Adjustments require more frequent checking.

4. Increased complexity of our production equipment such as:

a. Development of the electronic speck detector.
b. Incorporation of this speck detector as a completely automatic feature on individual machines.
c. Growing use of electronic speed control such as now used on our slitters and tinting machines.
d. Introduction of multi-state printing, numbering, pre-punching, scoring and punch scoring.
e. Introduction of new printing materials and techniques.
  (1) Gravure printing
  (2) Fast drying inks
  (3) Safety inks for check printing
  (4) Registration on multi-colored jobs.

The administration of a maintenance department is divided into two fields. One is to prevent machine breakdowns; the other is to repair a machine which has broken down. We will first discuss the preventive measures taken by our maintenance department.

1. Of prime importance is the selection and training of men who meet the following qualifications. He should ---

a. Fully appreciate the importance of his job.
b. Be willing to learn and practice the best and safest ways of doing jobs. Experience shows that most accidents could have been prevented by the exercise of greater care on the part of the worker.
c. Work toward promotion through study, gaining experience and the performance of consistently high-quality work.
d. Have a feeling of conscientious responsibility.
e. Be unceasingly vigilant and constantly alert to see that everything possible is done to keep the machines running on production and the repair costs held to a minimum.
f. Strive for a habit of neatness, a very desirable quality. It pays a better return than any other investment. Neatness applies not only to the care of machines but also to tools, equipment, working areas and safe working habits.
g. Recognize that the ability to be a good maintenance man cannot be obtained from books alone. The top ranking maintenance man has a wide range of practical knowledge gained through experience and association with managers and engineers who themselves have been first rate maintenance men.

2. All equipment scheduled for periodic overhauls.

3. Standardization of repair procedure.

4. Correction of weak spots through close cooperation with the engineering department.

5. Encourage maintenance men and operators to turn in suggestions for machine improvement.

6. Encourage training programs such as this and others offered by the school, which will provide opportunities for both operators and maintenance men to learn more about their jobs.

A second field of administration of a maintenance department has to do with repairing a machine which has broken down. The organization of the department to meet this situation is outlined below.

1. Experienced maintenance men are immediately available.

2. All necessary special tools are supplied to the maintenance men, as well as safety equipment (safety glasses and shoes, special hoists).

3. A well-equipped machine shop, operated by skilled machinists, is ready to repair or rebuild worn parts in cases where replacements are not available.

4. A stock is kept on hand of parts and assemblies most frequently needed.

5. Any maintenance man is free to ask for help from his fellow workers, his department manager, or the development engineering department.

6. Experience gained in any of our plants is standardized and distributed to all plants through the medium of engineering memoranda and inter-plant visits of factory managers.

7. A reference manual is being prepared with illustrations covering the working parts of the machines. The use of these illustrations will greatly reduce the time required to identify the defective parts and secure replacements. In addition this manual will assist less experienced men to more quickly understand the operating principles of the machines.

OPERATION AND MAINTENANCE PROBLEMS

High-Speed Rotary Card Machine

This card machine is a carefully engineered and precisely built piece of equipment. The side frames are bored on a jig bore, the gears are the very best that can be obtained. Every effort should be made to operate and maintain this machine in the best possible manner. Some of the problems that confront the operator and maintenance man are listed below.

BRAKE

The brake on the reel of paper is a simple but important part of the machine. The leather washers must be soft, smooth, and well oiled. The fibre washers must be smooth and free from dirt or iron chips. The brake hub nut must be adjusted so that:

1. Brake will prevent reel from unwinding when press is stopped.

2. To hold the hub sufficiently to allow the reel to lock in position when loading a new reel.

3. Provide a uniform tension on paper web while machine is running.

PAPER STRAIGHTENER

The paper straightener is controlled automatically by the action of the cards against the feeling rod. A curl in the cards will move the feeling rod, which will close an electrical contact, energize the paper straightener motor and remove the curl from the paper. This motor is reversible and its direction is controlled by the way in which the cards curl. The straightener blades must be sharp and adjusted to an opening of .012 inches. The feeling rod should be formed so as to rest on three cards; this will prevent the straightener motor from hunting. Overtravel is prevented by mercury limit switches located on the shaft of the paper straightener.

FEED ROLLS

Feed rolls are very critical and are manufactured with the utmost precision. Each feed roll is ground concentric on its own shaft to a tolerance of .0002 inches. A change of as little as .0001 in the diameter of the feed rolls will result in a change of .001 to .003 inches in card length.

Any foreign substance on the feed rolls such as dirt, ink or paper will cause excessive card length variation. Our machines are equipped with felt wipers designed to keep the feed rolls clean. To do a good job these felt wipers must be kept clean.

In order to get the longest bearing life the feed roll pointer should be set at the lowest figure which will produce correct length cards. With the pointer on number (1) the feed rolls should be paralleled using a .005 steel shim.

PRINTING PLATEN

The printing platen must be adjusted for a light even pressure for the full width of the paper. A properly adjusted platen will have a long life and little or no effect on the card length.

The most common printing difficulties are listed below:

1. Type cylinders oversize for feed roll.
   a. 2.350 + .001 - .000 for machines with 2.3422 diameter feed rolls.
   b. 2.345 + .001 - .000 for machines with 2.3430 diameter feed rolls.

2. Platen not correct size for type used.

3. Worn platens, require heavy pressure.

4. Platen tight on shaft due to lack of oil.

5. Bind in oscillating mechanism.

6. Dirty platens, card dust, oil, ink.

7. Worn type results in a loss of sharpness in the printing.

8. Excessive printing pressure. A properly adjusted platen can be turned by hand with paper in printing position.

CUT-OFF

A properly adjusted set of cut-off blades will produce cards with a clean square and straight cut-off.

The removal of dull knives and assembly of sharp knives is the most important single operation on the card machine. The procedure is as follows:

1. Leave the type cylinder in place.

2. Remove both blade holders.

3. Crank machine until bleed line is in line with centers of knife shafts.

4. Assemble wing knife holder and blade so that the blade lines up with bleed line on the paper.

5. Assemble solid knife and holder on their shaft so that blades press together lightly.

6. With paper between the blades turn the machine slowly; if the blades hit or drag, stop the machine and back the set screw slightly. The set screw referred to is a 10-32 screw which controls the pressure between the two knife blades. The movement of the wing blade should be between 1/64 and 1/32 of an inch.

7. Check the overlap of the blades. This should not exceed .018 inches. If the overlap exceeds .018 inches the blades will shear against each other, cut fuzzy cards and push cards crookedly into the gripper unit.

The recent adoption of cemented carbide blades has greatly reduced the number of knife blade changes.

GRIPPER GUIDE UNIT

The purpose of this unit is to guide the card from the cutoff into the drier drum. The unit is timed as follows:

1. Turn press until top of card is even with top of fluted guides.

2. Loosen the set screw in the rotary guide drive gear.

3. Rotate the guides until the top of the card is 1/32 removed from guide plate.

4. Tighten set screw in rotary guide drive gear.

5. Position the four individual guide brackets so that the card moves freely and squarely into the drier drum. Under no circumstances should these four guides be ground or mutilated.

DRIER DRUM

The drier drum is a conveyor which carries the cards from the cutoff to the stacker. The fanning action of the cards while in this drier drum helps the ink to dry and reduces offset when the cards are stacked. There are approximately 37 cards in the drier drum at all times which allows 2.22 seconds for the ink to set on each card. To time this unit proceed as follows:

1. Turn the card machine until the card has just cut-off.
2. Position drier drum so that any one of the "V" slots is 1-9/16 above the gripper unit casting.
3. Lock drier drum in place.
4. Move loading cam foreward until the clip opens approximately 3/16 in.
5. Turn card machine until "V" notch is now 1-21/32 above gripper unit casting.
6. Adjust loading cam up or down so that drier drum clips just close.

DRIER DRUM CLIPS

These clips must rest evenly on the face of the drier drum with no rocking. The lever on the side of the clip should extend exactly 7/8 inches. The clips should also be kept clean of oil, dirt and ink. If the above requirements are not strictly adhered to the cards are apt to be marked on the ends.

DRIER DRUM CLIP RELEASE CAM

The purpose of this cam is to open the drier drum clip when the card is in a vertical position. This will allow the card to drop against the clip hinges, thus positioning itself for a corner cut. The cam should be assembled with long end up and set to open clip to fullest extent.

CORNER CUT UNIT

The purpose of this unit is to cut any corner of the card. The usual angle is 60°. Special angles require special knives. The proper size of corner cut is etched on the face of the standard card gauge. To time this unit proceed as follows:

1. Check to see that drier drum is in time.
2. Turn machine until moving blade is at its closest position to stationary blade. Loosen screws and move stationary blade with sufficient pressure to result in a clean corner cut. Secure in this position with clamping screws.
3. Turn card machine until knife just starts to cut corner on card.
4. Corner cut auxiliary cam opens drier drum clip 1/32 to 1/16 inches.
5. Move the card bumper as far from card as possible.

6. Adjust card support bracket so that card is held with as little sag as possible.

7. Move the bumper until it just bumps end of card.

8. Adjust for size of cut by moving entire unit toward or away from machine.

CARD STACKER

The completed cards are stacked through the action of a platform scale in groups of 850 to 900 cards. This stack of cards trips index mechanism which turns stacker table. Platform scale returns to empty position in readiness for more cards. During this index operation the cards are temporarily stored by action of "Card stacker shutter."

In earlier model machines considerable damage was done to the index mechanism if a jam occurred during the index cycle. To overcome this the spring overload release was developed as now found on the index pull rod of all machines.

Adjustments:

1. Platform scale spring adjusted so that 850 to 900 cards will trip index mechanism as follows:
   a. Index latch must drop into notch on top of platform scale.
   b. Movement of index latch releases index dog causing the "Card stacker shutter," to spring into position to receive card. At the same time the stacker indexes one pocket.
   c. The card stacker shutter is returned to its latched position.

The present construction of the platform has necessitated considerable repairing. As a result of a suggestion on the part of a maintenance man the construction has been considerably simplified, reducing repair time to almost nothing.

SPECK DETECTOR

The purpose of this device is to automatically reject all cards containing electrically conductive spots such as carbon or iron particles. This device consists of:

1. Electronic cabinet containing a thyratron tube.

2. Electrical interlocking relay preventing operation of machine unless the speck detector is in operation.

3. Contact roll and brushes which sense the presence of the conductive particles in the paper. A second interlock on this brush assembly prevents turning machine over unless brushes are making contact with the paper. These brushes must be located so that there are seven card lengths between the brush and the card ejector pin. Brushes must be kept free of paper dust.

4. The brushes are held against the paper by action of a two-coil solenoid.

5. A conductive particle in the paper passing brush and contact roll will ionize the thyratron tube which in turn energizes the pin set magnet causing this defective card to be ejected.

6. Twice each shift the action of the speck detector is checked to see that it is working properly and will detect spots the full length and width of the card, and actually eject defective cards.

CARD EJECTOR MECHANISM

The purpose of this mechanism is to throw out defective cards as sensed by the speck detector brushes. This mechanism consists of:

1. Electromagnet, armature and micro switch.

2. Pin set gear.

3. Card ejector plunger.

The timing of this mechanism is as follows:

1. Before assembling mechanism into the press, check to see that the armature when attracted to within 1/64" of magnet core will open micro-switch in the thyratron tube circuit and set pins for card ejection.

2. Adjust assembly to press. Care has to be taken to have circuit polarized.

3. Then adjusted to suit press for proper card ejection.

Ball bearings have been added to late models to reduce oil drip on micro switch which has caused burned points and operation failure in the past.

In conjunction with this speck detector unit a slime spot detector is being developed.

AUTOMATIC PRESSURE LUBRICATING SYSTEM

This system is operated by a direct drive from the main shaft of the card machine. The oil is piped to all principal bearings of the machine where it is metered according to the demands of the individual bearings. With the present machine speed of 1000 cards per minute, oil is forced into all bearings once every eleven minutes. This time interval can be set for any value between $2\frac{1}{2}$ minutes to five hours.

The copper oil pipes should be inspected to see that they are not damaged, thus cutting down on the oil to one or more bearings. The filter in the sump of the pump should be renewed at least once a year.

ELECTRICAL SYSTEM

This consists of 220-volt, three-phase AC power, and 220-volt DC power.

AC Power

1. Main drive motor

2. Speck Detector

3. Straightener motor

4. Drive shaft brake.

5. Belt tightener solenoid

6. Motor control box

DC Power

1. Speck Detector

2. Speck detector brush solenoid

Electrical Safety Interlocks

The following safety interlocks are mechanically connected to a control contact in the motor control circuit:

a. Feed roll, type cylinder, cutoff safety cover.
b. Ink unit cover.
c. Frame cover.
d. Stacker overload.
e. Stacker index safety stop.

The following safety interlocks are electrical:

a. Paper end and jam stop.
b. Platform stacker jam stop.

Push Button Control of Paper Straightener.

1. Push buttons are located in stacker table switch box.

2. Proper setting of paper straightener at start of each reel is controlled from these push buttons.

Manual and Power Switch (toggle DPDT)

1. Located in stacker switch box.

2. On "Manual" the speck detector brushes are energized and the brake is held on, allowing the press to be turned by hand.

3. On "Run" the speck detector brushes are raised away from the contact roll to allow threading of the new paper web. At this time the brake is on and prevents turning the machine. This is necessary because the speck detector brushes are raised in order to allow threading the machine.

Start and Stop Switch

1. Located in stacker switch box.

2. In order for the start switch to be operative all safety and jam contacts must be closed and the toggle switch set to "ON" position.

3. The action of this start switch is:

   a. Starts drive motor.
   b. Brings speck detector brushes down against the paper.
   c. Releases brake on drive shaft.
   d. Energizes belt tightener solenoid.

The actual starting of the card machine is accomplished by tightening the drive motor belt after the motor has been started by the start switch.

If at any time the running circuit is broken by the stop button, jam contacts or cover safety contact, the machine will stop instantly through action of the magnetic brake on the drive shaft.

In order to produce cards with special features, new devices had to be invented and developed. Among these are the combination die base, prepunching die and head, corner cutting unit, Scoring device, hole punching device, creasing devise and a special printing station to provide for serial numbering. After these devices were developed and put into use, it became the function of the card maintenance department to keep these units in proper working order and set up procedures for periodic check-ups to prevent lost production time due to breakdowns. Repair and maintenance cost on these devices can be greatly reduced through their proper setup and handling.

The basic unit of these special devices is the combination die base which holds all of the other special devices which have been developed. This combination die base, in which the dies, prepunch heads, scoring unit, and corner cut unit are held, should be handled carefully to see that none of these devices when placed in die base bottom, so heavily as to put an excessive strain on shafts and levers causing them to shear pins or break shaft. A large number of units in die base can cause a very great torsional strain on shafts and an excess of impression can cause them to be broken, causing a large die base maintenance.

Prepunch head is used for punching holes in numbered sequence and is used with the prepunch die. We have special numbering heads to number backward reverse, skip numbering and odd and even numbering. We also can gang punch.

Prepunch Die repair--when die no longer cuts a clean hole in the card, the die is repaired by staking in the hole and grinding the die plate. If die plate is worn,a new plate is installed and punches fitted. Then die is broken in so that it will work properly. At the time of repair die is looked over for worn bushings and leader pins, broken springs, and general line up of the die itself.

These machines are delicate and should be handled with great care. Pinching on Detent Rod with fingers will cause rods to bend and stick. Prying around rods with screwdriver does the same thing. Hitting a side frame will put it out of alignment causing it to bind and one or more of these things will cause the tools to function improperly and will cause double punching or wrong punching. It should be kept free and clean from paper dust and dirt. It should be oiled with a light oil and then blown off with air. Make sure that it fits die base proper and no shim is put under one side or the other causing it to bind. This causes Leader pin to wear on dies and punches to stick.

Corner cut unit is used to cut the corners of cards. This unit should be set up square in die base, without shim and punches adjusted to cut off corner. The die is ground and punch is ground to a good sharp cutting edge. When these parts are worn, a new punch is fitted and new dies are put into unit to fit punch to keep unit in alignment. This unit should not be hammered on, to move in die base.

Hole punch die for piercing holes in tab cards is run at a close tolerance and has to be in perfect alignment otherwise edge of punch is sheared, very often ruining die and punch. A fixture has been made to line up these punches to avoid these faults.

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IBM CARD
Techniques of Development and Manufacture

ENGINEERING

by
R. H. Holmwood and K. E. Anderson
November 11, 1946

To provide machinery for the high-speed, economical, and efficient production of quality cards and other printed forms is the responsibility of the Engineering Department of the Card Manufacturing Division.

Engineering advancements must keep step with ever-increasing production demands. Manufacturing improvements, of course, are sought out and developed continually. As new product requirements arise, machinery must be invented and developed to make the new product. Also, new machines are being created from time to time to more efficiently produce standard items through improved machine design principles.

Such engineering undertakings originate in the company and may or may not be worked out in collaboration with specialized machinery manufacturers. The new electronically controlled high-speed slitting machines, mentioned in an earlier talk on Preparation of Card Stock for Manufacturing, represent an example of an outstanding engineering achievement made possible by the cooperative efforts of the engineers of the Kidder Press Company, the Reliance Electric and Engineering Company, and our own department.

Standard production equipment, such as the Rotary Card Press, is continually being improved. Mechanical and electrical features added to the machine are designed for increasing production and bettering product quality.

Our work, as compared to that of other engineering departments, is unique in that it centers around the design of highly specialized machinery and the development of manufacturing methods used in the actual making of the IBM card. The product we make is the operating unit by which our company's business machines function. The efficiency of these machines is greatly dependent upon the accuracy of that operating unit. In turn, the accuracy of the IBM card is completely dependent upon the engineering soundness and precision built into the machines used to produce it.

Specifically, the work of the Engineering Department includes:

1. The technical analysis of all matters pertinent to the production of printed forms.
2. The development of new processes of card manufacturing and printing.
3. The design of checks and special forms.
4. The calculation of manufacturing cost estimates.
5. The handling of all engineering changes relative to any equipment used in our manufacturing division.
6. The handling of departmental design and development projects.

Our analyzing work covers the study and recording of the life of machine parts, the study of the characteristics of various types of papers, inks, and dyes and their effects upon machine design and operation, investigation into production methods in the interest of improving efficiency or economy, and the responsibility for recommendations regarding card production equipment and techniques within our plants in this country and in plants of foreign countries.

Among our contributions to the card manufacturing business have been the development of such new processes as continuous paper tinting, fabrication of the stencil card, the over-and-under printing press, and the high-speed slitters.

We design checks and other printed forms for various branches of state governments and the federal government and for all types of industrial concerns.

Calculations made by the estimating staff of our department are used in establishing the basis for the selling prices of all printed forms.

As mentioned, we control all engineering changes made on any of the card manufacturing division equipment. Changes originate in many different ways, but, with rare exceptions, a standard procedure for handling them is followed.

An engineering change may be brought about by a departmental development. A new machine feature may be designed to be added to existing machines in the form of a universally adaptable unit. A part or a unit may be redesigned for the purpose of improving machine operation or permitting closer control of card quality.

There is also the case where a completely new machine is released by an engineering change. This machine may have been developed for performing new functions or for more efficiently performing the present functions of existing machines.

Engineering changes may originate through the reports of machine operation or adjustment difficulties experienced by operators or repair men. Machine Repair Department records serve as an information center for facts relative to parts or units giving trouble, requiring excessive attention, or needing frequent replacement.

Suggestions from employees, of course, have accounted for a great many engineering changes which have provided for improvement in operation, maintenance, and quality.

Frequently, the Tool Engineering Department will request a change to facilitate tooling or manufacturing. Recommendations regarding the usage of common parts are forwarded to the Engineering Department by the Standards Department for engineering change action.

When a request for a change is received, the recommendations are studied and discussed. If it is apparent that the time required to carry out the work involved is appreciably long, a project is set up and assigned to a member of the department.

A member of the Engineering Department then investigates and makes a thorough study of the situation. Any tests considered advisable are conducted. If necessary, a model, incorporating the new or revised feature, is built and tested under actual production conditions.

If the change appears advisable, it is approved and an Engineering Change Notice number is taken out and assigned to the project. Once a change number has been taken out, reproductions of all drawings involved are withdrawn from the factory blueprint room and filed in the Engineering Department.

Prints of all parts and bills of material affected are then marked and filed. When the blueprint room receives requests for prints of such parts, the requests are referred to the Engineering Department where prints, marked with changes, are furnished.

The change notice is then written, checked, and approved. Copies are forwarded to the Production Engineering Department and the Tool Engineering Department. Should it be essential that the actual change in the machine be made effective before the time ordinarily required for completion of routine clerical change notice operations elapses, a letter of advance notice is written to the Production Department.

When a printed copy of the change and prints of the corrected drawings are received from the Production Engineering Department, it is an indication that the master drawings have been revised and new reproductions made. Original reproductions in file are then destroyed and the project is closed out.

Development projects begin when a need for machine improvement becomes apparent. The improvement may be brought about by design changes in the present unit or by development of an entirely new unit to perform an operation not incorporated in the present machine design.

A study is first made of the present unit to determine possible means of improvement or of the machine itself, if a new unit is being developed, to determine possible location for the new unit, depending upon function, powering, operating convenience, safety, and expected space requirements.

A discussion is usually held between the department supervisor and the designer on the merits of various design proposals. A layout of the design then follows and necessary assembly and detail drawings are made. A model unit is then built and installed on the machine for testing.

Following observations and results of the test, the unit is redesigned for practical production and released on an Engineering Change Notice.

An example of such a departmental development project to be considered is the new Corner Cut Unit on the Rotary Card Press.

The original corner cutting device was found to have such disadvantages as uneveness of cutting, high maintenance costs, and corner chips sometimes getting in with stacked cards. In starting upon the development of an improved unit, a new principle of operation was designed. Sliding, or shearing, action of two knives in constant contact replaced flying rotary blades.

In making the model unit, the primary interest was the testing of the new theory of knife design. The method of corner chip removal was purposely neglected temporarily, with a vacuum system being rigged up to suit at the time of assembly. While the unit was under test for corner cutting, various types of chip chutes and vacuum take-off systems were tried.

The knife design having proved satisfactory, the unit was redesigned for production. When redesigned, various improvements and refinements were incorporated.

Life expectancy of the knives was increased by the changeover in material from tool steel to solid tungsten carbide. Wear on moving parts was reduced through installation of bronze bushings on the bell crank studs, and adopting a more rugged knife post lift pin design.

The weight of oscillating parts was reduced by the use of aluminum for castings. Accessibility to knife parts for adjustment and replacement was obtained by making the entire knife unit demountable through the removal of one screw. All necessary vacuum intakes, hose line and connections, and the chip chute became part of the unit design.

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THE IBM CARD
Techniques of Development and Manufacture

CARD ORDER ENTRY AND HANDLING

by

H. E. Williams & J. E. Cummings

Nov. 18, 1946

Mail is received in the Card Order Department four times daily, bringing Card Orders from all parts of the World. At the present time, we are receiving well over 300 of such orders daily. The first step in entering a card order is checking type file for plant location and verification of customer's name. Orders are then arranged alphabetically and in groups of 20 to 25 orders. A control sheet is also attached to each group. (Slide) Control (Samples) sheet purchase order, Branch Office Order.

The orders then go to the Pricing Clerks. The Pricing Clerks, incidentally, are the hub of this operation. Their operations are as follows: Checking purchase order against Branch Office Order and sample cards. This is done primarily in an effort to correct any transpositions, which may take place in the branch offices in editing the work sheet or branch office order from which we work, once the checking operation has been completed. The next operation is checking the jacket card, which is included in the tub file for verification or correction of quantity discount to which a customer is entitled and for any special instructions pertaining to that customer. At the tub file, the Master Address Deck is also pulled. The pricer then returns to a pricing desk, which contains prepunched cards for the various colors in which are prepunched color, quantity and unit price. These tickets are made up according to required packing, that is 2 M Small Wood Boxes or 10M Corrugated boxes. On the first ticket of each type number is mark sensed the following information: 1) Item number, 2) Corner cut, 3) Electrotype number if special routing is required. A prepunched routing card is also pulled from file, also prepunched quantity discount cards, which are made up for various discounts and quantities. A complete deck then, as worked up by the pricer, is as follows: 1) Master Address Cards, 2) Routing cards, 3) Item cards, 4) Quantity discount cards.

Decks and orders then go to Printing Punch, where a header card is punched, which contains the following information: date of purchase order, purchase order number, requisition number, schedule date of order and invoice number. This information is also reproduced through mark sensing reproducer into all other cards in the deck with the exception of address decks.

The orders then go to the Machine Accounting Department. The complete decks on orders to be invoiced are received from the Card Order Department, and are immediately listed on a thirteen-part invoice form, one of which each person in the class has on his desk. This form is printed on an IBM Accounting Machine, using a special platen and extra-heavy springs on type bars. As you will notice on your sample invoice, the thirteenth copy is very legible. After the invoices are prepared, all cards and invoices are returned to the Card Order Department.

The 13-part invoice is prepared and returned to the Card Order Department, where invoicing and shipping address is manually checked against the order, and any local taxes added to invoice on a facsimile typewriter. As soon as this operation is completed, the last two copies of the set are released, namely, acknowledgement to customer and acknowledgment to Sales Office. Order is filed, remaining 11 parts of invoice set to Production Ticket Clerk. Deck cards then go to Interpreter for interpreting information on top of production tickets, then to sorter for sorting yellow cards. Address decks, production tickets and miscellaneous cards, are returned to Pricing Clerk for refiling in the tub file. Decks are used over and over. Three additional control cards are also prepared, two to Department 950, 1 to Accounting Department. Production tickets are then matched against invoice. When a group has been completed, two control cards for each order, shop tickets and Nos. 6, 7, 8 & 3 Bills of Lading go to Machine Accounting Department.

The Production Tickets and Shop Orders as received from the Card Order Department are now ready to prepare the Identification Ticket, which is applied to each carton of cards shipped from this plant. Using the IBM Interpreting Reproducer, Type 519, we reproduce from the Production Tickets to this Identification card, picking up all necessary information and interpreting on the first line the Customer Invoice Number. These cards are passed through this machine the second time for a lower interpretation of the Card Electro Number. These identification cards are then passed through the 552 Alphabetic Interpreter and the information across the top is printed. We now merge the Production Tickets and the Identification cards by the use of the IBM Collator. This facilitates the handling of orders and necessary cards in the Card Manufacturing Department. After the cards are merged, all cards and copies of the Shop Orders are given to the Control Clerk in the Card Manufacturing Department. The identification card with the large type makes it much easier for the Shipping Department employees in IBM and also the employees in the customer's Receiving Departments to identify each box of cards. Along with the Identification Card, a sample of the card form is applied to the outside of each packing case.

The yellow cards and Accounting Department Control card are accumulated until the end of day at which time a listing of orders entered for the current day is prepared and sent to Department 950 and to the Accounting Department with control card. The first five copies of the invoice are placed in Card Order Department Open Invoice File and yellow header cards are placed in control file from where a weekly schedule list is prepared each Friday. The cards are sorted by schedule date and the Printing Department furnished a listing of those schedules, which can be printed.

A Control Header Card is received from the Order Department and reproduced to our Accounts Receivable Card. The information punched is interpreted across the top of the card to facilitate matching the cards against customer invoices. From a copy of the invoice, all necessary information such as card revenue, page number, miscellaneous items, etc., are punched by the Keypunch Section of the Machine Accounting Department. After the punching and verifying, these cards are sent to the Tabulating Room, where all cards are balanced against control totals, and a listing showing all necessary data is prepared for transmittal of the necessary information to World Headquarters for use on their Accounts Receivable File. This accounts receivable procedure is completed the day after shipment of cards.

The Production Tickets have another use in preparing the quantity produced on our EAM Card Production and Inventory Report. This report is made from the original Order Control Card along with the detail Production Tickets. This report is used by the Accounting Department and Card Manufacturing Department for the control of inventories and shipments of cards to customers on a pre-determined schedule date. This also facilitates a minimum of storage space in the Card Manufacturing Department for cards printed, but not shipped.

When production starts on an order, the Production Tickets go daily to the Accounting Department, where they are accumulated and tabulated until the salmon cards are received indicating final shipment, at which time the Accounting Department waits for the listing of the billed orders from the Card Order Department (Shipping list) is then matched against Production.

When shipment is made in Dept. 950, shipping notice is released to office originating order, packing list is placed in one of the boxes and three bills of Lading signed, carrier takes one copy, one copy becomes permanent shipping room record and one copy returned to Card Order Department with shipping order, which is our signal to invoice customer.

If no alteration has been made to invoice, we simply pull five copies from open file, date them, attach bill of lading to first three copies, which is customer's invoice. Page number 4 and 5 copies, which is New York Accounting Department copy and Accounts Receivable copy respectively. Pull yellow header card and send to Machine Accounting Department, where a shipping list is prepared (alphabetically), and yellow cards are reproduced. Additional information is punched on this Accounts Receivable Card such as page number card revenue and miscellaneous items. Register or spread sheet is then run from Accounts Receivable Cards and Accounts Receivable cards, two copies of invoice and register sent to New York, the day following shipment.

The yellow card now becomes quantity discount card and is accumulated until end of month at which time an accumulative discount report is run which is necessary so our offices can be advised on the status of customers' yearly card contracts at any time.

(Shipping list)

(Entry list)

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THE IBM CARD
Techniques of Development and Manufacture

ACCOUNTING OF IBM CARD MANUFACTURING

by
G. C. Emmons
November 25, 1946

GENERAL INFORMATION

Cost accounting is defined as that branch of accounting which has to do with recording and analysis of expenditures, study and interpretation of the data thus obtained, the use of such information in the management and direction of the enterprise. In a narrower sense, the term "Cost Accounting" is applied to accounting in a manufacturing enterprise and the accounts would, therefore, cover production or factory activities.

The purpose of cost accounting is to furnish information which will make possible intelligent and efficient administration of a business enterprise. For example--the cost accountant should have information available which will:

1. Point out where costs are going out of line
2. Improve processes
3. Secure low costs
4. Reduce spoilage and waste
5. Total cost of cards sold
6. Cost per thousand
7. Comparison of costs of three card plants
8. Etc.

It should be pointed out and emphasized that the Accounting system must be molded around the production system and layout. Reports resulting from the system must not only fit, but also reflect the operations clearly and effectively. However, there are certain accounting fundamentals which exist which must be recognized by production personnel.

The elements of cost are as follows:

1. Direct Labor, which is labor spent in actual production of the product or labor which is immediately identifiable with product costs.

   Examples: Slitter Operator
   Carroll Press Operator

2. Direct Material, which is material forming a part of the finished product. Generally speaking, materials present in the finished product.

   Example: Paper

3. Expense (often referred to as Overhead or Burden) includes labor and material which cannot be charged directly but are necessary to the manufacture of the product.

Examples: Wages of Managers, clerks, truckers, maintenance repair men. Materials including repair parts, oil, grease, stationery.

Expense would also include fixed charges such as Depreciation, Taxes, Group Insurance, Unemployment Insurance, Vacation and Holidays, Country Club, Occupancy expense.

The term depreciation may be but a technical accounting word to you, so we shall take this opportunity to explain it in detail:

Machinery and equipment used in the Card Plant is either purchased as a unit or manufactured and assembled by the IBM. This equipment has an expected length of life or service for a period of several years and the cost is, therefore, prorated over that period.

For example--a machine used in the slitting department may cost $1,000; and if this cost were charged immediately to operation costs, it would seriously distort costs because a ten-year cost is included in one year's operations. Therefore, the cost of this machine is prorated or depreciated over a period of 10 years or $100 per year.

Expressed in accounting terms, the machine has been capitalized and depreciated based upon obsolesence and deterioration over a period of years.

This type of expense is usually referred to as fixed, since the expense exists regardless of operations. If the plant should remain idle or work at capacity, the expense of depreciation would remain the same.

COST FINDING

This subject would be very simple if we could divide the total cost of operating the Card Plant by the quantity of cards produced to derive a cost per thousand. This calculation would indicate trends but would not be specific in detail to be of value to management.

Therefore, a schedule of accounts must be created which will include the three elements of cost mentioned above. It is also necessary to break up the charges to these accounts by cost center (referred to as Burden Centers, cost pools, departments).

Accounts are divided into three sections:

1. Major Accounts
   910 - Plant #1
   912 - Plant #3
   913 - Plant #4

2. Minor accounts are divided into the following groups and would be applied to the three Major accounts:

a. 10xx Direct Labor
b. 11xx Maintenance
c. 12xx Depreciation
d. 13xx Office and Supervision
e. 14xx Occupancy
f. 15xx Variable
g. 16xx Non-Variable
h. 17xx Direct Material
i. 18xx Shipping Expense
j. 19xx Cost of Shipments

3. Burden Centers are assigned to major operations performed such as:

a. 001 Handling and Storing
b. 010 Slitting
c. 550 Edge Coating
d. 190 Carroll Press
e. 750 Shipping
f. 910 Direct Labor Redistribution
g. 920 Press Impression Redistribution

The complete account would be written as follows - Carroll Press Operator at Plant #1:

Major		Minor		B. C.
910	-	1000	-	190

All direct labor and Indirect expenses are charged to a burden center. If it is not possible to charge to operating burden centers, general Burden Centers are charged. The expense so allocated is redistributed to operating burden centers on a Direct Labor or Press Impression basis.

Accuracy of Cost finding depends upon the preparation of the detail labor and material cards in the Card Plant itself. If the department time keeper is not aware of transfers from one job to another, the first job will be overcharged and the second undercharged. Errors of this nature are not easily identified during the course of the check of labor and material charges each week and invariably our first indication that costs are out of line is after the books are closed and we are preparing the Card Cost Statement. Discovery of errors at this point tends to delay publication of Cost Statements.

To determine the cost of production of one thousand cards on the Carroll Press line, we must know the costs of:

1. Handling and Storing
2. Slitting
3. Edge Coating
4. Printing Development
5. Carroll Press
6. Shipping Expense
7. Paper

The cost of 1-2-3-4 are known as "Common Costs", since they would apply to production of cards regardless of the type of press used.

PAPER COST CONTROL

Paper cost includes the Invoice and freight charges. Since freight on paper is a large expense, it has been our policy to include it in the total paper cost rather than show freight on paper as an expense item.

Cost of paper per thousand of cards is the largest item of the total. Therefore, it necessarily follows that this cost must be accurately controlled and recorded. The key to accurate control is the weight per M cards. This figure is calculated by dividing production into the total pounds of paper used. A deviation upwards from an established average would indicate an error in poundage used, or the production figure used would be in error or the scrap accumulated is unusual. The reverse or a deviation below the established weight per M would indicate that an error exists in pounds of paper recorded as used. Production figure is too high or scrap is abnormally low.

Paper usage, weight and money, is determined by the following simple formulas:

	Pounds	Value
On hand		
+ Received		
- On Hand		
= Usage		
or		
Beginning Inventory		
+ Receipts		
= Available		
- Usage		
= Inventory		

Since various types of paper are used separate, controls are necessary for:

Manila
Colored
Etc.

Each roll of paper received at the plant is numbered. Receiving reports or packing slips received with each shipment list the serial numbers of the rolls received. Cards are received in the Accounting Department from the vendors which represent the rolls delivered and invoiced. After a check for accuracy is made and receipt of the shipment is verified, these cards are added to the perpetual inventory file.

As paper is consumed in the slitting department, the roll numbers are listed and forwarded to the Accounting Department daily. Withdrawals from the inventory card file is based upon these transmittals. A tabulation of these usage cards at the end of an accounting period will provide the Accounting Department with the total number of pounds of paper which has been slit.

All paper slit during an accounting period is not necessarily processed through card presses. The slit reels on the floor at the end of an accounting period are inventoried and deducted from the total paper slit to obtain the number of pounds used. An accurate inventory of slit reels on the floor is most important, since errors would penalize the usage figure which would in turn distort the total card costs.

Rolls of paper are slit for foreign shipment. The cost of handling and storing, slitting and the paper value is credited to plant operations and charged to a separate inventory account. The value of this paper must be relieved from the total paper slit to obtain the value of paper used in the manufacture of cards.

Scrap paper, including edge trim, cards, chips, etc. is sold to scrap dealers. The sale of scrap is, therefore, a reduction in operating costs but never offsets the money which was originally spent for the paper. The cost of scrap handling, collection and baling, is one factor which tends to decrease the credit realized from the sale.

Packing Costs - Most industrial organizations do not recognize this expense as a direct cost but as Shipping Expense which would be charged to a selling account. Our policy has been to consider container costs, stapling, storing and handling, record keeping in the shipping department as a part of the cost of cards. However, the expense of delivery to customers is not charged to card costs but to selling expense.

Control of quantity and value of containers follows the same pattern as outlined for paper. Assembly of the #10 box, placing the 5 #2 boxes inside and the complete unit on the conveyor on the first floor, stapling the box, identification and storing in the shipping room, trucking to the rear platform is all considered packing cost. Packing cards in containers at the press is considered as a part of the Press operation costs, since it would be impractical to attempt splitting time to two operations.

PRODUCTION AND INVENTORY CONTROL

At Plant #1, we have an excellent control of production. It is really quite simple to operate. The reasoning is the quantity ordered must be produced and shipped. The production tickets which are distributed to the press operators with each order represent the quantity of cards ordered by a customer for a certain card form. The production tickets are usually for a quantity of 10M cards. However, in some instances they may be for a quantity of 1, 2, or 20M.

As each container is filled, a production ticket is used to record this production. At the end of the work day these tickets are turned in. You have probably noticed that the tickets are punched. The holes in these cards give us the information necessary to build up the production figures for a day and also to give a progress report or status of each order entered. Over-runs on orders should be avoided, since no credit for production of this nature is allowed. Duplication of orders caused by issuance of duplicate production tickets should be avoided. Only quantities ordered are allowed in production.

You will recall that paper is the major cost factor in the total card cost. Over-runs, duplication of orders, etc., tend to increase the cost of cards shipped.

In some instances over-runs, and errors in production such as making the wrong corner cut, putting the stripe in the wrong position, etc., does not necessarily mean a loss in production. These cases are taken up with the customer who may choose to overlook the error and accept the cards as is. In this case, production is allowed. However, such contacts with customers should be avoided and his acceptance of errors should be discounted, as he cannot be considered as a "satisfied customer."

The inventory of finished cards in the shipping department is available from this daily report. At all times, the report reflects the number of cards printed but not shipped. This quantity multiplied by the cost of a thousand cards gives us the value of the finished card inventory. This value is then credited to operating costs for the period, leaving a balance in the accounts representing the cost of cards shipped.

A year ago, we had to count card boxes in the shipping department and other locations in the Card Plant to get this inventory quantity. This was a chore which necessitated overtime work on Saturday, which was usually a good hunting day. The daily tabulated report has proved so accurate that it has replaced the tedious labor which was formerly required. As a matter of fact, it has been proved the machine report is more accurate than counters and checkers ever were.

This report of production and inventory also gives the vital figure of the back-log of orders; meaning the orders which have not been started in production but have been entered in the Order Department or the total of cards yet to be produced on orders in production plus quantity of cards on orders not placed on the Card Plant. This back-log figure is constantly on the move, since production is subtracted from it and orders entered are added to it each day. This back-log figure must be accurate, since management uses it as a guide in forming certain policies.

This report is also used to follow up on orders which are behind schedule. A daily check on old listed items by the shipping department properly followed up will insure better service to the customers.

The plants at Washington and San Jose have similar routines established to insure that production credit is properly recorded and follow up is promptly made on aged orders. However, neither plant's reports are on electric accounting machines as yet.

SPECIAL PROBLEMS

A. Department 953 under W. S. Granger's supervision is known as the Repair and Maintenance Department. This department does more than the title implies. Following is a listing of functions performed, each of which, are separate accounting problems.

1. Regular maintenance
2. Rebuilding machines
    a. For use in Domestic Plants
    b. For the foreign division
3. Assembly of New Presses
4. Assembly of New Kidder Slitters
5. Keeping stock for use at Plant #1
6. Filling orders for maintenance stock for Plants 3 and 4.

Each of the six functions mentioned must be accurately accounted for. Once again, the accounting department is dependent upon accurate recording of data at the source. Maintenance and rebuilding are considered as an expense of operations. Rebuilding machines for foreign shipment is charged to the Foreign Division. Assembly of Presses and Slitters is a major part of the capital value of this equipment. Keeping stock and filling orders for the other plants is considered as departmental expense.

B. Printing Development under the supervision of Messrs. Ross and Holmwood is divided into two groups, namely, process development and equipment development. Management is interested in knowing how much has been spent on each project; so another series of accounts and reports are necessary.

The account is set up as follows:

Major		Minor
971	-	lxxx

Different minor accounts are used for each project.

Development expense is considered as a part of card cost and is distributed to the three plants based upon production.

C. Electrotype Costs - A discussion on Card Plant Accounting would not be complete without some mention being made of cost finding in connection with electrotype.

The account code pattern is very similar to the one employed in the Card Plant. Major account 918 identifies the expense with electrotype production. The minor account series parallels those used in the Card Plant Schedule. Burden Centers are used to break down expense to operations.

The Electro Etching department produces Cylinder, flat (regular and special length) and rotogravure type. On new type, all operations (includes--Label Ordering, Layout, Copy, Label Printing, Photography, Coating and Printing, Etching, Trimming and Plating) are performed. Replacement type only coating and printing, etching, trimming and plating operations are performed. On remakes all operations are performed but the cost is less because some sections of the card are not changed.

Cost reports are made each month for each month's production and in addition show the costs based on expense and production for the year to date.

Customers are charged for the new type and any revisions which they may require. The cost of replacement is considered as a part of card costs. The distribution to the three card plants is based upon actual shipments.

Development work under Messrs. Corbett and Fredericks is absorbed into the cost of electrotype.

CONCLUSION

Naturally, I have not covered all details pertaining to this complex subject for that would be most unfair to you. I hope that we shall all receive some benefit from this paper and the discussion which has taken place.

I wish to repeat one single fact--accurate accounting begins in the shop and appears on reports to management as the finished product. The Accounting Department serves as the clearing point and acts as the middle man in this connection. Poor records are a reflection on both production and accounting departments, therefore, it is imperative that they work together with the best spirit and cooperation.

12/5/46 mk

INTERNATIONAL BUSINESS MACHINES CORPORATION
DEPARTMENT OF EDUCATION
DIVISION OF GENERAL AND VOCATIONAL EDUCATION
ENDICOTT IBM SCHOOL

THE IBM CARD
Techniques of Development and Manufacture

OTHER IBM PAPER PRODUCTS SERVING ITR, TEST SCORING, MARK SENSING, ETC.

by
George W. Streby
December 2, 1946

Test Score sheets are designed so they can be scored on IBM Test Scoring Machines showing the results of a choice of from two to five questions, a true or false quiz or a percentage of rights against a percentage of wrongs.

It is possible to have up to 150 different questions with a choice of 5 different answers on one side of a sheet of paper and the same on the other side.

By this means of scoring, it is possible to find out the exact knowledge one may have on a given subject or of what value this knowledge may be in selecting people for different types of occupations depending on the pattern used for scoring.

The scoring positions on the sheet are held in close tolerance so they will align with the contact points in the Test Scoring Machine and an electrical current will flow across these points where a heavy lead pencil mark is made on the paper in the scoring position chosen by the person taking the test.

The carbon in the lead of a lead pencil being a conductor of electricity it is necessary to use a soft lead pencil so a heavy deposit of lead will appear on the paper. It is also necessary to use a type of paper that will take off a good amount of lead easily.

Another factor in choosing the right kind of paper is to find one that does not change with expansion or contraction easily due to atmospheric conditions. The best paper containing all of these qualifications is a high-grade mimeograph paper which we have manufactured special for this type of work.

Also the ink used on imprinting these sheets must be free of carbon which most printing inks contain and this too is made special for these sheets.

We stock nearly 200 different kinds of forms which can be used on almost any type of examination, but most of our forms are for book publishers who sell these examinations to schools and colleges. Another very large user of our Test Score sheets is our own U. S. Government who uses these for Civil Service, and the Army and Navy tests.

We use electrotype forms to imprint these sheets which we buy from outside vendors who make these forms from copy that is sent to us by our customers.

Before a test score sheet can be scored in our Test Score Machine, we have to cut a stencil. This stencil has cut round holes that correspond to the right answers. We cut this stencil with a special die in a standard punch press. There must be a stencil cut for every test that is scored.

DIAL SHEETS

In the manufacturing of time clocks we have one which is known as the Dial Recorder. This clock differs from the Attendance Recorder which we use in our own factory here where each employee has his own time card for a complete week. In the Dial Recorder, we use only one sheet for all of the employees if it is a small factory, or one sheet for a department if it is a large factory or organization. This sheet may be changed daily or weekly, depending upon which type of clock the customer chooses.

This sheet then becomes a permanent record of a given group of employees showing the time registered in and out of work with the total hours worked, rate of pay per hour, and total pay per week with all deductions such as taxes, Bonds, etc.

While we have either the daily or weekly dial sheets we have also several sizes in both, known as 20 - 30 - 50 - 100 - 150 - 200 sizes. These different sizes limit the number of people that can ring on one clock.

In the manufacturing of these sheets, we first take a large sheet and imprint cross line rules in green ink across it depending on what ever spacing it is to be, from 20 to the 200 size. Then we take either a daily or weekly form and imprint in black ink between each space in the cross line ruling, the clock number of each employee so that his attendance time registered by the clock can be identified.

There are 19 different cross line ruling forms.

These lines must be very accurate in their relation to each other and also to the edge of the sheet so when this sheet is placed in the clock each registering postion will line up; otherwise one man's position on the clock would register on another man's position on the sheet.

We must have one of the daily overprint forms to fit each of the cross line ruling forms.

These figures represent each person's man number and are changed to whatever the customer's requirements may be. The width of the Daily Overprint varies some; the average being approximately 2-3/4 inches. We make up our form so that we can imprint 7 at one time and then cut them apart.

The Weekly Overprint form is made up special for each customer. With one of these forms we not only have to change the figures which represent each man's clock number but we have to change the headings on columns such as total hours and pay, and also the different deductions according to the customer's copy.

12/9/46 mk

INTERNATIONAL BUSINESS MACHINES CORPORATION
DEPARTMENT OF EDUCATION
DIVISION OF GENERAL AND VOCATIONAL EDUCATION
ENDICOTT, N. Y.

THE IBM CARD
Techniques of Development and Manufacture

ITR TIME CARD MANUFACTURE

by
J. C. Miller
Dec. 2, 1946

(Picture 1) At the turn of the 20th Century industry and manufacturing were entering a new phase - new machines, new inventions and hundreds of new factories were mushrooming throughout the country. Along with the thousands of new workers had come new problems, one of which, in particular, was of major importance to all employers - "How can I keep an accurate record on the time spent by my employees in my factory." The answer was supplied by one of the pioneer organizations of IBM - "Make each employee his own time keeper." Thus, through an urgent need began the manufacturing of Time Recorders and card forms.

Methods used then were a great deal different than the procedures we now use to meet the demands of our customers. Time cards in those days were made something like this - copy was prepared and type laboriously set by hand and printed on a press whose production was limited to about 2000 per hour and depended on the strength of the operators good right leg. Today an operator on one of our improved card machines produces in the neighborhood of 18,000 cards per hour with little physical effort.

Devices have been used for centuries to try to arrive at the right time: the sun dial, the hour glass, and finally a mechanical clock. Here is a picture of a time recorder electrically controlled and incorporating all the engineering features that have made IBM the leader in the time systems field. This clock will keep and record on a time card every minute, of every hour, of every day. Program stops are placed in this clock at designated intervals so that regularly scheduled working hours are stamped on an employee's time card in blue ink and lateness or irregular time is stamped in red enabling time clerks to pick up irregular entries at a glance.

(Picture 2) Time card manufacturing begins with the salesman's order from our customer. A card is then designed to fill the needs of the office, factory or school (incidentally, the next time you park your car in a parking lot in any one of a number of cities the chances are that your claim ticket will be on a time card stub made in IBM and you will be timed by an IBM Clock System) relative to time worked and where it is to be recorded - social security deductions, with-holding tax, insurance and a host of other information is to be placed on this card. The card is sent to the Order Department of IBM. First, type is set and proofs are submitted to the customer for his O.K.

The stock used for time cards differs consierably from our card stock used to make operating units being made from ground wood and of varying thickness. We purchase our time card stock in 38" rolls weighing over 1/2 ton each. Last year, 1945, we used 1625 tons of ITR stock and this year, for ten months, we have used 1503 tons Our stock has the same color range as operating unit card stock, manila being the most popular. At first, time card stock was made in large flat sheets 24" x 28½" and slitting and cutting of cards to the correct size was done with two machines. The flat sheet was fed by hand into the first machine which slit the card into 28½" strips the width desired, then these strips were carried to the second machine where they were cut to the length needed for that particular order. These two machines required two operators and gave about 25% of todays production. (Picture 3) Today rolls are slit and cut to length on a Kidder

Slitter with a guillotine cutting feature. This machine slits the rolled stock to standard widths 2-11/16" to 4-13/64", or up to 38" if we should happen to ever want a card that wide, and the guillotine cutter (Picture 4) chops 11 cards to lengths of from 1 to 15" in a single stroke (an executioner in the French Revolution could have had a field day with a little larger guillotine like ours) at a rate of 70 cuts per minute, dropping each card into individual pockets that can be adjusted to take any widths that the machine is slitting.

Cards are removed from the slitters and placed in a 4-wheel carriage (capacity 80 M cards) and wheeled to the Time Card Imprinting Machines for processing. Through the suggestions of employees and fine engineering in IBM the machines we use have been very notably improved. Originally the press was designed to produce about 9 M cards per hour, but through the improvements made we have exactly doubled the production capacity. In addition safety features have been added to these presses to give the operator the maximum amount of protection.

(Picture 5) Plates used on our time card imprinting machines are made by taking a wax impression of the type set to the specifications and wording satisfactory to our customer - the wax impression is placed into a prepared bath and chemical action is introduced by an electric current which soon forms a copper shell on the wax. The shell is placed face down in a tray and molten lead poured over it to desired thickness, low spots brought up and finished, then curved to fit the cylinder on the imprinting machine.

(Picture 6) The plate is set-up on the press and the press is turned to position to receive the first card. Cards are taken from the carriage by the operator in 500 lots and placed in the hopper that is built to automatically select one card and start it through the press in a continuous motion. Cards pour through and from these presses like water over a dam at the average rate of 18 M per hour.

Cards are printed on one side or both sides, one or two colors, depending entirely on the wishes of our customers. One of our newer presses, that we are putting into operation, prints six 3-13/32" x 5½" cards on both sides in two colors in one operation.

(Picture 7) Banding and packing operations are placed conveniently near the press operators, necessitating as little walking and waste motion as possible. Our operators are a skilled group of men who can feed, remove, and inspect cards as rapidly as the imprinting machine can produce them. Like the links on a continuous chain, on an assembly line theory, cards come from the slitters, to the imprinting machines, to the banding and packing tables where skilled banders take tall stacks of cards and break them down into 500 card lots. A simple wooden block measuring device has been built so that it can be adjusted to the heighth of 500 cards, regardless of their thickness. The operator then takes the measured 500 cards, places them sidewise in a clamp arrangement (another time-saving development) that holds the cards, and has strips of paper sized to go around these cards. They are banded tightly and held by an adhesive paper. Banders and packers work side by side. (Picture 8) From the banders the banded cards are passed to the packers whose function consists of packing time cards into cardboard containers especially designed for these cards. From here they are trucked to our Shipping Department where a stencil is cut and customer's name and address and order number stencilled on the box and the order is completed and ready for shipment.

12/9/46