The How and Why of IBM Mark Sensing

A TRAINING PROGRAM FOR MARK SENSING

The purpose of this booklet is to provide in simple, illustrated form the basic information required to produce properly marked cards with a minimum of effort and a high degree of accuracy. The following outline is a suggested program for the training of personnel in the correct method of mark sensing.

1. An explanation of mark sensing as applied to the general system and the specific work involved. To become proficient, each person should have a full knowledge of what he is doing and why he is doing it.

2. Study of the instruction booklet until there is a complete knowledge of correct practices and results that should be expected. All questions should be answered before proceeding further.

3. A step by step explanation of the operation of the Mark Sensing Reproducer. Correct markings should be made and the electronic punching of those marks shown. Then, lighter marks should be made and demonstrated until the machine fails to punch a hole from the mark. This card should be examined for the error in marking. From actual practice in marking and punching cards, the student will be able to tell by looking at the mark whether it is satisfactory.

4. Frequent checks on each student's progress in handling actual work. An excessive number of errors should be brought to the student's attention immediately and steps taken to correct carelessness and faulty practices.

Mark sensing is a simple operation and is learned easily. However, the importance of proper training should not be overlooked because the operation is so simple.

A study of numerous mark sensing applications proves conclusively that failure to obtain maximum results is due entirely to lack of knowledge on the part of users and operators as to correct practices.

How does mark sensing work?

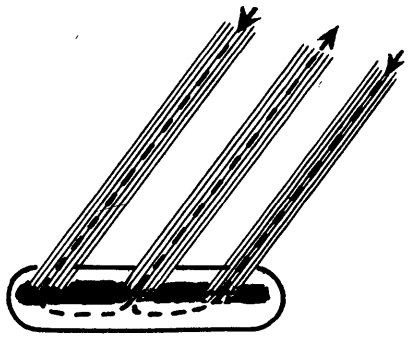
There are three steps

1

THE MARKING OF THE CARD

A horizontal or slightly slanted pencil mark is made on an IBM card to indicate certain given information. The position of the pencil mark with respect to the top of the card indicates the numerical value of the information which is recorded.

2



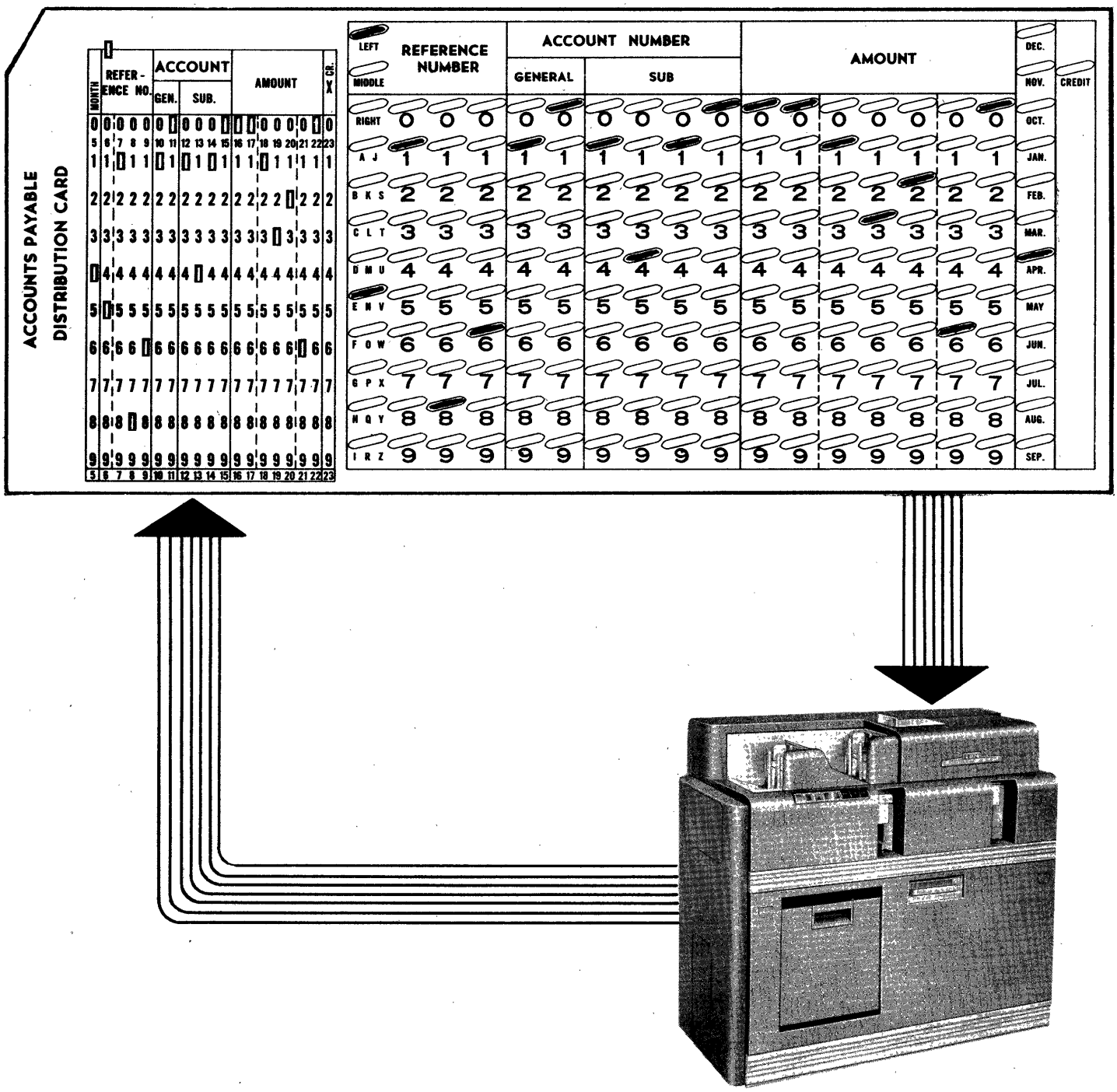
THE READING OF THE MARK

As the marked card passes through the Mark Sensing Reproducer, the pencil mark is spanned by three electrical contacts or "brushes." An electrical impulse is permitted to flow down to the mark through the two outer brushes, then through the mark toward the center, and out through the middle brush.

3

THE PUNCHING OF THE MARK

By means of a carefully timed series of electrical impulses, combined with a series of mechanical devices, the electricity permitted to flow through the mark is converted into the stroke of a punching mechanism, which punches out a hole in the card corresponding to the relative position of the pencil mark. The punched hole thus assumes the same numerical value as the mark which was originally made.


ACCOUNTS PAYABLE
DISTRIBUTION CARD
MONTH
REFERENCE NO.
ACCOUNT
GEN.
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CR. X
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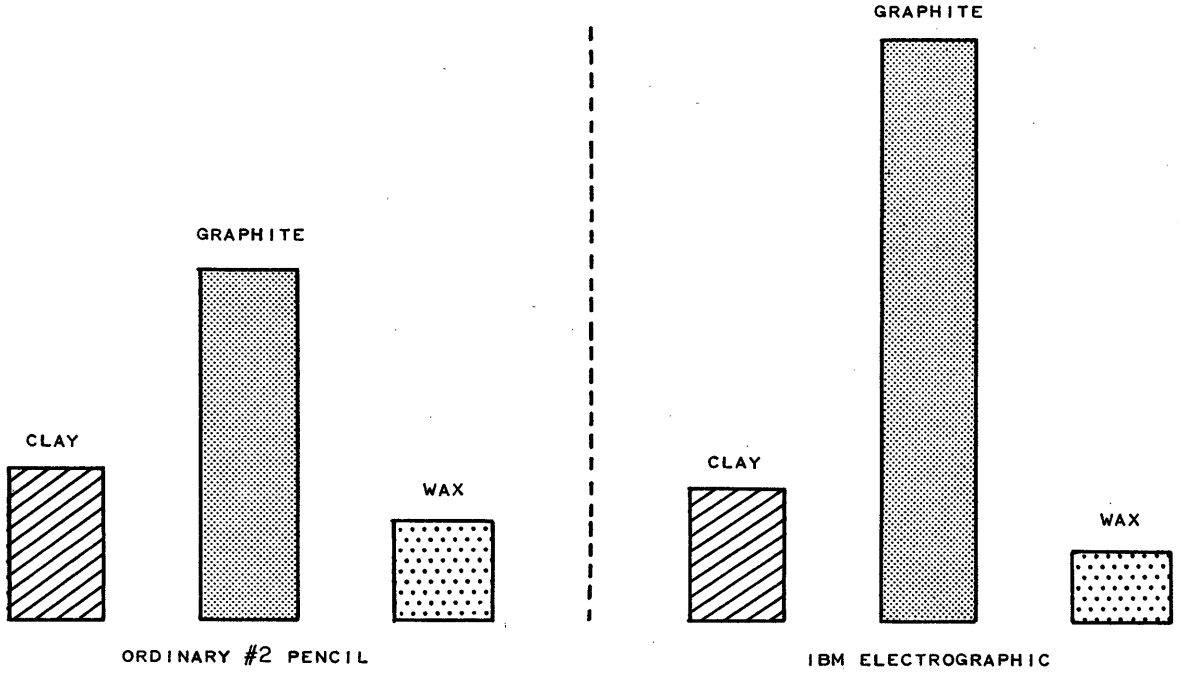
Why is the pencil mark important?

With the exception of the pencil mark, the links in the chain of electrical and mechanical sequence are carefully controlled parts of the machine. It is apparent that the mark is the one variable factor. Failure to provide a mark which will conduct the electricity results in the establishment of a weak link in the chain of electrical conductors.

Of what material is a pencil made?

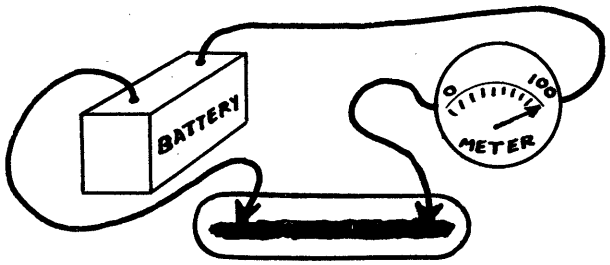
Ordinary lead pencils are made of a mixture of graphite and clay which is baked in an oven and later impregnated with a wax. The clay adds strength and hardness to the lead, while the wax adds smoothness to the writing qualities. The graphite adds blackness to the mark, and in mark sensing operations it is the one and only element of the pencil which conducts electricity. If the graphite content of a pencil is very high, the pencil is considered "soft," and it is possible to make a dense, jet-black mark which is extremely conductive to electricity. If the pencil is too soft, however, the point is easily broken, making it difficult to produce the type of mark necessary to conduct electricity satisfactorily. The electrographic lead used in IBM pencils recommended for mark sensing is the result of extensive experimentation and research devoted to establishing the best balance between the three elements of the lead to produce the desired results.



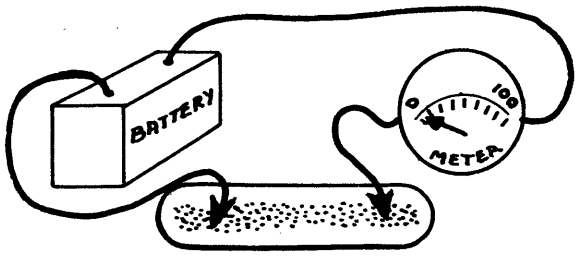
What makes a pencil mark conductive?

The graphite used in lead pencils is an electrically conductive material similar to copper, aluminum, and other metals. When it is deposited on paper in a continuous line, it is capable of transmitting electricity from one end of the mark to the other. If the particles of graphite scraped off the lead by the abrasive action of the paper do not touch each other, however, electricity cannot flow.

To make certain, therefore, that the pencil mark is capable of carrying electricity, it is necessary that the mark be JET-BLACK. A grey-black mark, no matter how wide, is not a reliable conductor of electricity because of the gaps which exist between the graphite particles.



A JET BLACK MARK WILL CARRY
A CURRENT OF ELECTRICITY

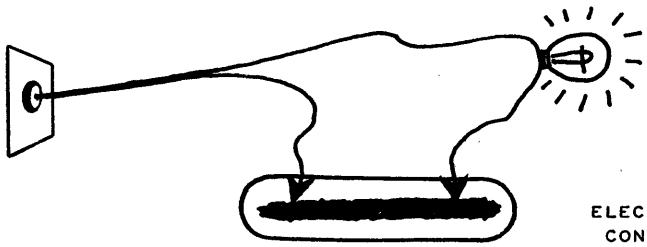


A GRAY BLACK MARK WILL NOT CARRY
A CURRENT OF ELECTRICITY

Are all pencil marks conductive?

No. All pencils contain some wax, which is an electric insulator. Pencils containing too much wax completely insulate the electrically conductive graphite particles, and prevent the flow of electricity. However, even marks which are made with pencils of a low wax content and high graphite content are conductive only if the graphite deposit is dense and continuous so that the electricity can flow along the mark from particle to particle.

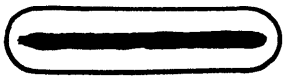
Hard pencils contain a large amount of clay. Because clay also is a non-conductor of electricity, pencil marks made with hard pencils are not conductive. Only pencils with the right proportion of graphite, wax, and clay are completely effective for making electrically conductive marks.



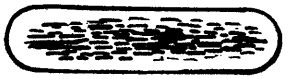
ELECTRICITY WILL FLOW THROUGH A
CONTINUOUS LAYER OF GRAPHITE.

Why is a narrow mark a better electric conductor than a broad mark?

A narrow pencil mark is a better conductor of electricity because it is more apt to be a continuous deposit of graphite particles. A continuous solid deposit of graphite is possible only under conditions of high marking pressure. When the pencil point is broad, the pressure exerted on the pencil is spread over a larger area than when the point is small. As a result, the large point has a lower pressure for each unit of surface area, and the graphite particles are deposited only in the high spots of the paper. With a narrow point the pressure for each unit of area is higher, and the graphite particles are thoroughly impressed into the surface of the paper.



THE GRAPHITE DEPOSIT IS DENSE IN A NARROW MARK DUE TO THE HIGH PRESSURE CONCENTRATION.



THE LOWER PRESSURE CONCENTRATION OF A BLUNT POINT RESULTS IN A POOR MARK.

What is the effect of pressure on making an electrically conductive mark?

The smaller the writing point, the greater the concentration of pressure, and the better the electrical conductivity of the mark.

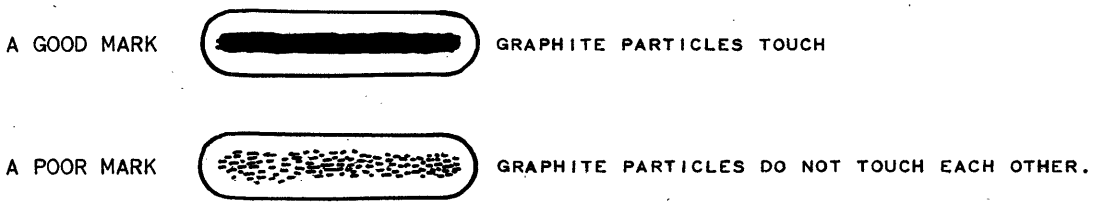
It is not the total amount of weight or pressure on the pencil point that determines whether or not the graphite particles are deposited in a continuous line. It is the CONCENTRATION of this pressure,in a small area that assures the proper deposit of graphite. For example; a point which is kept sharp by rotating the pencil slightly after each mark, requires only half as much pressure to produce a conductive mark as one which is turned after every five pencil strokes, and only about one-quarter as much pressure as that required from a pencil which is not rotated at all.

IBM Cards have sufficient surface roughness or "tooth" to scrub the graphite particles from the pencil lead, with the result that extreme pressures are not required to make the jet-black marks that are of the required conductivity.

Are all soft pencil marks conductive?

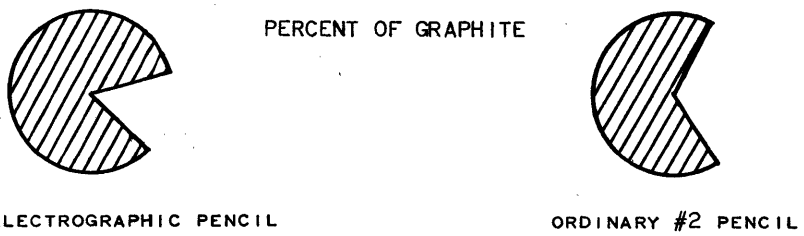
No. A pencil mark, even though made with a soft graphite pencil, is not a reliable conductor unless the mark is dense jet-black, because the particles of graphite do not touch each other throughout the full length of the mark. All soft pencils are capable of making an electrically conductive mark, but only if sufficient pressure is maintained on a small writing point to produce the jet-black color necessary.

Colored pencils, wax pencils, and crayons are not capable of making electrically conductive marks under any conditions.

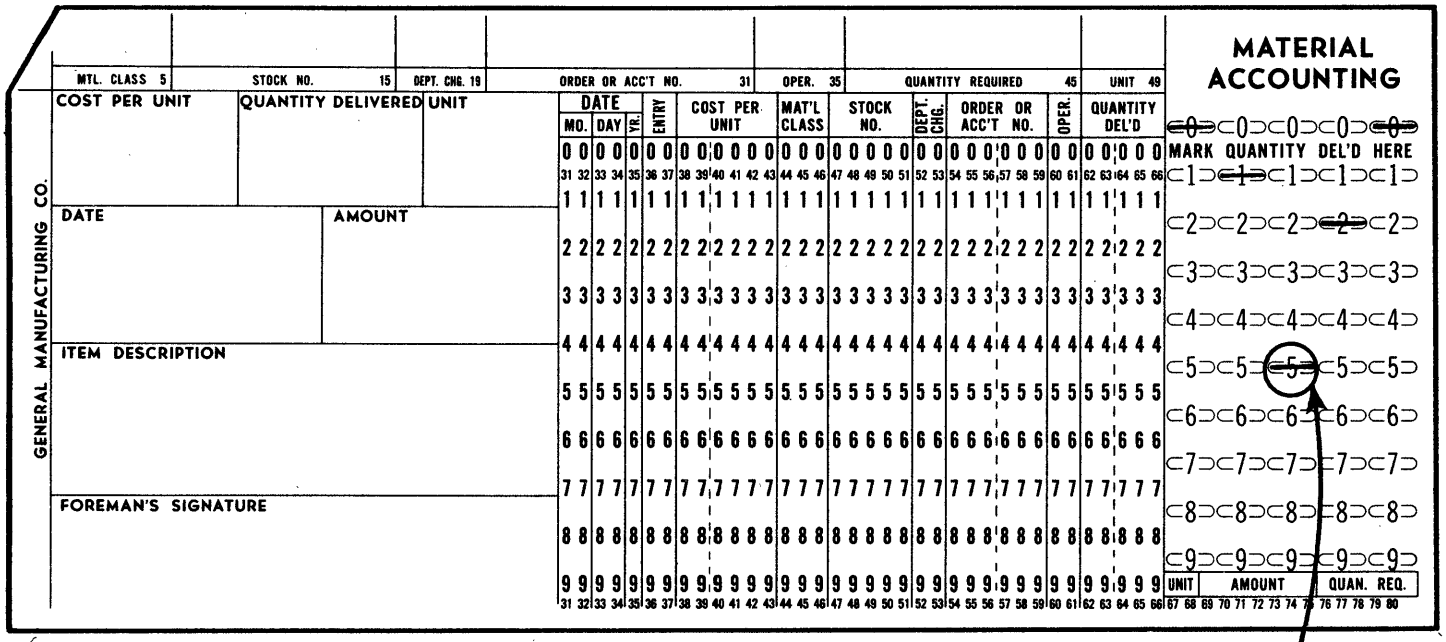


Are marks made with IBM electrographic lead more conductive than marks made with other pencils ?

Yes, when they are made under the same conditions. IBM electrographic lead is the product of extensive experimentation and research. It combines the highest ratio of graphite to clay and wax, which will provide a pencil with satisfactory strength characteristics as well as proper writing qualities. Therefore, it takes less effort to produce an electrically conductive mark with IBM electrographic lead than with leads which are harder, or even with leads which are softer.

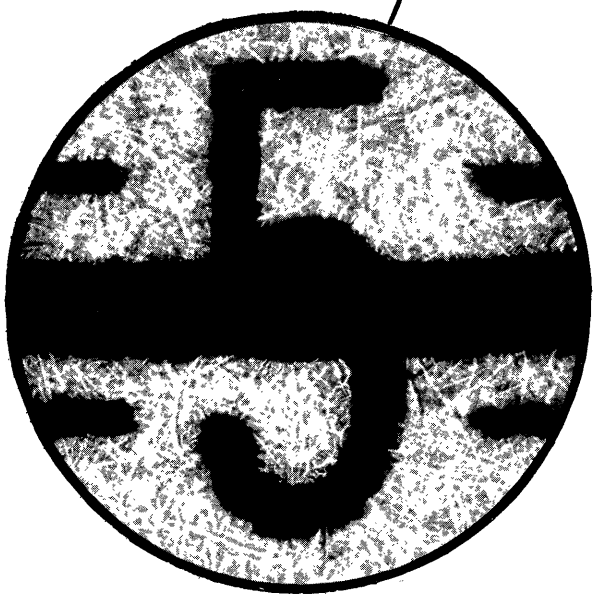


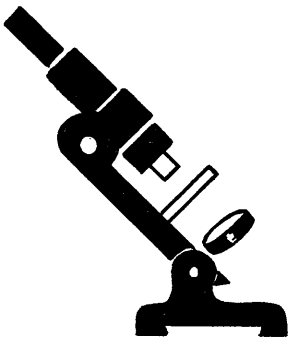
What does a pencil mark look like under a microscope?



A GOOD MARK AS SEEN THROUGH A MICROSCOPE

The marking of this card was done by sharp single strokes of the pencil which was held firmly in the hand. The point of the pencil was well sharpened. The graphite particles are deposited so closely together that the effect of a solid line of graphite is produced. This continuous deposit of graphite enables the electricity to travel through the mark in the same manner as it would do through an electrical conductor such as copper wire.





GENERAL MANUFACTURING CO.

MTL. CLASS 5 | STOCK NO. 15 | DEPT. CHG. 19 | ORDER OR ACC'T NO. 31 | OPER. 35 | QUANTITY REQUIRED 45 | UNIT 49

COST PER UNIT | QUANTITY DELIVERED | UNIT

DATE | AMOUNT

ITEM DESCRIPTION

FOREMAN'S SIGNATURE

DATE: MO. | DAY | YR. | ENTRY | COST PER UNIT | MAT'L CLASS | STOCK NO. | DEPT. CHG. | ORDER OR ACC'T NO. | OPER. | QUANTITY DEL'D | UNIT

MATERIAL ACCOUNTING

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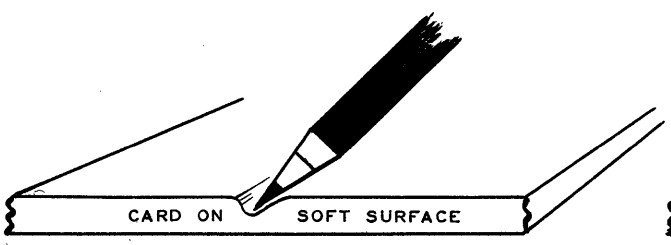
AN UNSATISFACTORY MARK AS SEEN THROUGH A MICROSCOPE

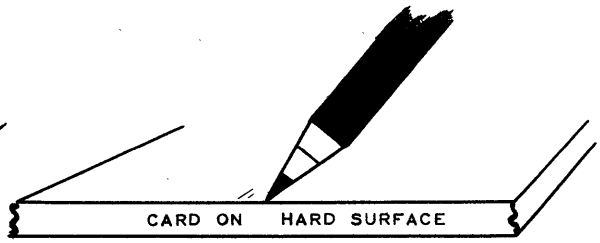
The marking of this card was done by several light strokes of the pencil. The pencil did not have a sharp point nor was it pressed firmly on the card. The graphite deposit is not sufficiently continuous to assure an uninterrupted current of electricity.

Does the surface on which marking is done affect the quality of marking?

Yes. Marking on a hard smooth surface always is preferable. If a soft surface such as a blotter, a pack of cards, or a pad of paper, is used as a marking surface, the pressure at the marking point is distributed over a larger area, thus requiring greater pressure on the pencil to obtain the necessary jet-black continuous mark. Marking on a soft surface also tends to leave indentations in the surface of the cards, thus making it more difficult for the machine to read the marks.

It is important that surface is smooth as indentations such as scratches in the varnish of a desk top may cause a break in the mark.





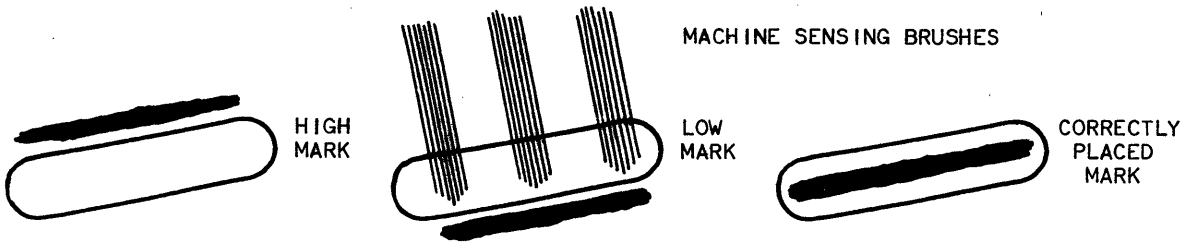
What is the effect of marking on a moist card?

The normal action of the surface of the card on the pencil lead is similar to the action of a very fine sandpaper. When cards are moist a large proportion of the abrasiveness of their surface is lost, and as a result they do not scrape off as much of the graphite as when they are dry and "toothy." If it is necessary to mark damp or moist cards, considerably more pressure must be exerted to insure the proper jet-black marks.

In addition to the loss of abrasiveness in a damp card, the material becomes softer so that the pencil lead sinks into the surface of the card, thus increasing the size of the marking area and requiring greater pressure. The effect is the same as that created when cards are marked on a soft surface.

What is the effect of marking above or below the outlined area?

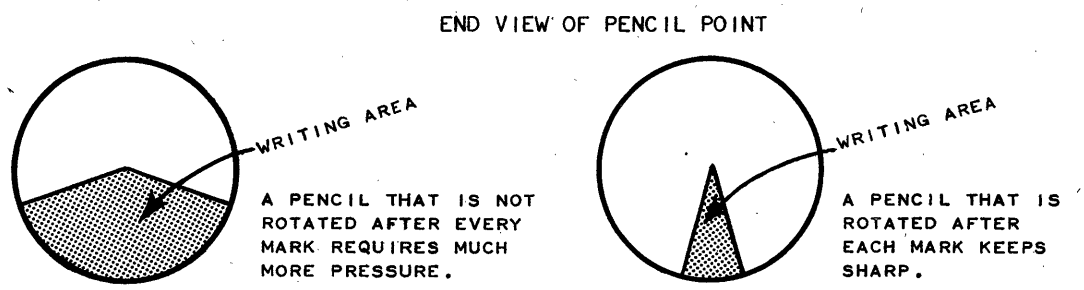
When the marked cards pass through the Mark Sensing Reproducer, the marks pass under three wire brushes which contact the mark at each end and in the middle. The electrical impulse, which must travel through the mark from the outside brushes toward the center, flows only at the instant the outlined marking area is in contact with the brushes. Therefore, pencil marks which are located above or below this area will not be in contact with the brushes at the proper time, the current will not be able to flow through them, and the machine will fail to recognize their presence.



Why is it important to turn the pencil between marks?

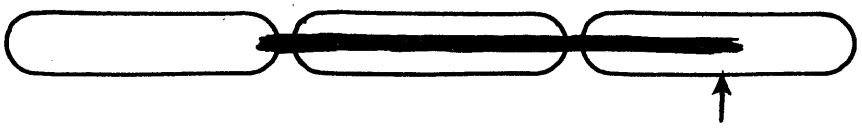
The ability of a pencil mark to conduct electricity depends upon the continuous deposit of graphite. The sharper the pencil point, the more certain it is that the deposit will be continuous. Rotating the pencil after every mark is the easiest and best way of insuring a small, sharp marking point which will produce the best mark with the least effort.

A sharp pencil will produce a good mark with only 16 ounces of pressure if the point is rotated after every mark. If the pencil is rotated after every fifth mark, it takes 32 ounces of pressure, while if it is not rotated at all, 56 ounces, or 3 1/2 pounds of pressure are required to produce a conductive mark.



What is the effect of marks which are too long?

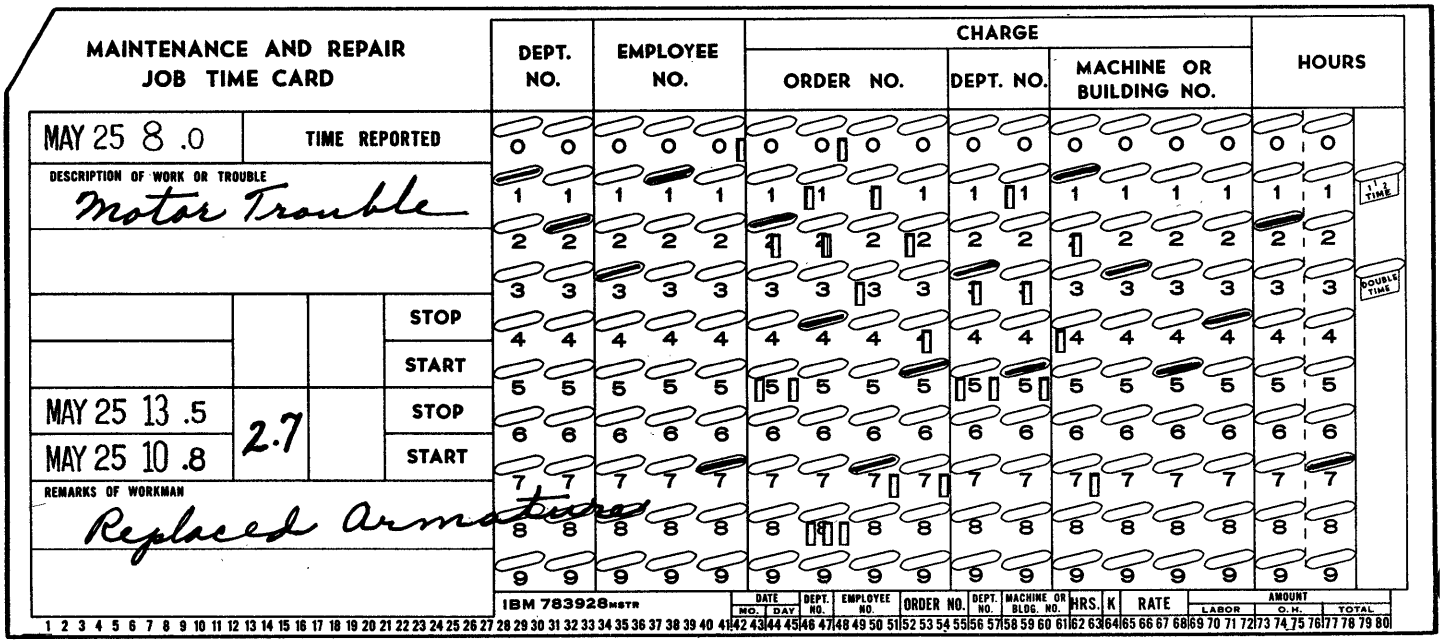
If pencil marks are extended in length so that they project into an adjoining marking space, these marks may be read or sensed by the machine and will result in improper punching of the IBM card.



A LONG MARK MAY CAUSE MACHINE OPERATION IN THIS SPACE ALSO.

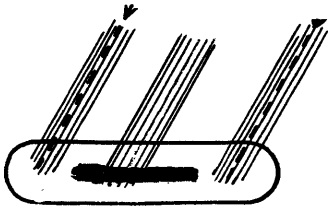
What is the result of writing on the surface of a card in an area designated for marking?

If words, figures, or other information are written in the mark sensing area of the card in pencil (or some inks) there is a strong possibility that the machine will not be able to detect the difference between the marks which are properly made and the written information. Therefore, it is good practice to make it a rule never to write in the marking area.



What is the effect of marks which are too short?

If marks are too short, their presence may not be detected by the machine. If the mark is not long enough to span the three electric brushes, the current is not able to flow from the outer ends through toward the middle. As a result, the machine will fail to sense the mark and the information will not be punched.



WHEN IN THE MACHINE A SHORT MARK DOES NOT CONNECT THE TWO OUTSIDE BRUSHES TO THE CENTER BRUSH.

Can two or more spaces be marked with one stroke?

Although, theoretically, two or more spaces may be marked with one stroke of the pencil, the point becomes progressively duller as the pencil progresses along the mark. This means that considerably greater pressure must be exerted on the pencil toward the end of the mark in order to produce the satisfactory jet-black graphite deposit. Marking each space individually and rotating the pencil after each mark is a far better way to assure accurate results, because then it is known that each mark is made with a sharp point, resulting in a continuous graphite deposit. Also it is made with a minimum of pressure.

A LONG PENCIL MARK TENDS TO GET GRAY TOWARD THE END OF THE STROKE.

What is the difference between a wooden pencil and a mechanical pencil?

The lead used in an IBM electrographic wood pencil is the same as that used in the IBM electrographic mechanical pencil.

It is much easier, however, to maintain a sharp writing point with a mechanical pencil than it is with a wooden pencil, especially after the wooden pencil has been used for marking a number of cards. The sharper the writing point, the less effort it takes to make a jet-black mark. As the wooden pencil becomes worn down and dull, therefore, increased pressure is necessary to produce the proper blackness in the mark. Resharpening of the wooden pencil, while it overcomes this difficulty, is less simple than turning out more lead in the mechanical pencil. In addition, the lead in the mechanical pencil is thinner, and by rotation the point is maintained at a highly desirable degree of sharpness. It should be noted that if the lead in the mechanical pencil is broken inside the pencil, it will be impossible to rotate it properly. The broken piece should be removed and the upper end used first. Then the broken piece may be reinserted as a new piece of lead.

What happens if two marks are placed in one column?

For most mark sensing purposes, it is essential that only one mark be made in each column. If two marks are made in the same column, two numbers are designated, sensed, and punched by the Mark Sensing Reproducer. The Electric Accounting Machine, which ultimately will read the holes punched into the card as a result of the marking, is unable to discriminate between two holes punched in the same column when one of them is incorrect. When multiple marks are made in one column, the Mark Sensing Reproducer recognizes these cards as erroneous, in ordinary cases, and indicates their presence to the machine operator, either by offsetting the cards from those which are correct or by flashing a red light and stopping. The machine also indicates the presence of unmarked (blank) columns and the presence of marks which are electrically unsatisfactory.

Can you see by looking at a pencil mark whether it is a dependable electrical conductor?

Yes. A pencil mark that is jet-black and has been made with an IBM electrographic lead will always be a conductor of electricity. If the deposit of graphite is so dense that you cannot see any of the card surface through the mark, then the particles of graphite are in contact and the mark will carry a current of electricity.

If the mark is grayish, or a gray-black, and the card may be seen through it, particles of graphite are scattered on the surface. As a result, there is no assurance that the graphite particles are in contact and will provide the necessary continuous path for the electrical current.

It is not the width of the mark that determines its conductivity. Rather, it is its color. A wide gray mark may have a greater quantity of graphite then a narrow jet-black mark, but the quantity is so widely scattered that the particles not being in contact, will fail to carry the electric current. The narrow jet-black mark with a small quantity of graphite will carry the current satisfactorily, because the particles are in continuous contact.

IF YOU CANNOT SEE THE PAPER THROUGH THE MARK, THE MARK IS GOOD.

What is the effect of going over a mark several times?

Going over a mark repeatedly or "scrubbing it in" insures a more continuous deposit of graphite, but because of the additional time and effort required and because of the fact that the machine is designed to recognize a properly made single stroke mark, multiple marking is not recommended.

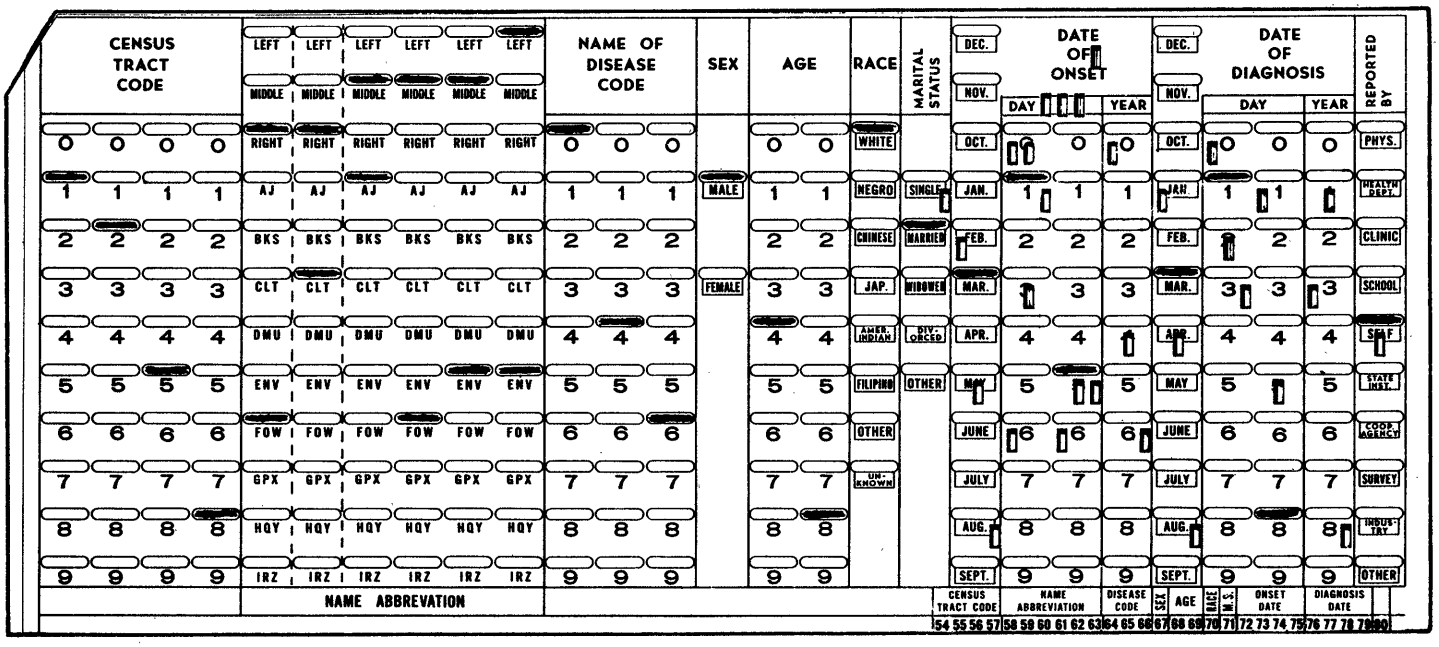
As the pencil point is moved in one direction over the paper, the graphite is scraped off by the protruding surface fibers. As the pencil is moved back over the same mark, additional graphite is scraped off by the opposite side of these same fibers, resulting in a more continuous graphite deposit. With sufficient pressure, however, and a properly sharpened marking point, one stroke of the pencil will deposit enough graphite to make a jet-black mark which is electrically conductive.

Can pencil marks be corrected?

Yes. It is permissable to erase, but the mark to be changed must be completely removed before the new mark is made. If any trace of the old mark is left, the machine may take both the old and the new marks as being intended for use.

May more than one mark be placed in a column?

In certain applications, such as those involving alphabetical characters, it is both necessary and desirable to make multiple marks in a single column. If the card is designed for this purpose the Mark Sensing Reproducer may be controlled to accept the multiple markings without signaling an error. However, you should make certain, before marking the card, that multiple marks in one column are actually permitted, since as a rule, one mark per column is the standard practice.



Use a pencil containing IBM electrographic lead.

Be sure that the pencil has a sharp point.

Mark on a hard, smooth surface.

Be sure that each mark is placed properly within the marking area, is of the right length and is a dense JET-BLACK color.

INTERNATIONAL BUSINESS MACHINES CORPORATION

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