IBM
ELECTRIC PUNCHED CARD
ACCOUNTING MACHINES

PRINCIPLES OF OPERATION

REPRODUCING PUNCHES
513 and 514
**MINOR REVISION**

This edition, Form 22-3180-3, is a minor revision of the preceding edition but does not obsolete Form 22-3180-2. The principal change in this edition is:

<table>
<thead>
<tr>
<th>PAGE</th>
<th>SUBJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Double Punch and Blank Column Detection Device</td>
</tr>
</tbody>
</table>
## CONTENTS

**Models; Features** .......................................................... 5

**Machine Operation** .................................................... 6
  Punching Unit .................................................................. 6
  Reading Unit ................................................................... 6
  Combined Operation ....................................................... 7
  Comparing Magnets ....................................................... 7

**Control Panel** .............................................................. 8

**Switches** ....................................................................... 11

**Gang Punching** ........................................................... 12
  One Master Card ........................................................... 12
  Interspersed Master Cards .............................................. 12
  Offset Gang Punching .................................................... 14

**Reproducing** ............................................................... 15
  Straight Reproducing .................................................... 15
  Field Selected Reproducing ........................................... 15
  Selective Reproducing .................................................. 16
  Combined Reproducing and Gang Punching ...................... 16
  X Elimination or Transfer .............................................. 17

**Summary Punching** ...................................................... 18
  Summary Punch with Net Balance Alphabetical Accounting Machine 18
  Summary Punch with Non-Net Balance Alphabetical Accounting Machine 19
  Combined Reproducing, Gang Punching and Summary Punching 20
  Summary Punching with Numerical Accounting Machine 20
  Card Comparing ............................................................ 21

**Mark Sensing** ............................................................... 22
  Straight Mark Sensing ................................................... 22
  Gang Punching ................................................................ 23
  Design of Mark Sensing Cards ........................................ 24
  Marking of Cards ........................................................ 24

**Special Devices** .......................................................... 26
  Gang Punch Emitter ....................................................... 26
  Double Punch and Blank Column Detection ...................... 26
  Offset Stacker ............................................................. 26
IN THE IBM Accounting method, an important function is the automatic preparation of the IBM cards which are the operating units of the method. The IBM Reproducing Punch is one of the machine units by means of which this automatic punching of cards is accomplished. It performs the following functions at the rate of 100 cards per minute:

Reproducing: the operation by which all or any part of the information punched in one set of cards can be punched into another set of cards. The accuracy of the punching operation can be simultaneously verified through the comparing feature of the machine.

Gang Punching: the copying of punched information from a master card to a group of detail cards.

Summary Punching: punching into a total or new balance card amounts which have been accumulated in the Accounting Machine.

Mark Sensing: the operation by which information recorded in the form of pencil marks on IBM cards is automatically transcribed as punched holes in those cards.

The Type 513 and Type 514 Reproducing Punches are similar in function and operation. The Type 513 is used with Types 405, 404 and 416 Accounting Machines, while the Type 514 is used with Types 402, 403, and 407 Accounting Machines. Either machine may be equipped with 45 or 80 columns of comparing, summary punching, and with mark sensing.

The location of the following features of the Reproducing Punch is shown in the accompanying illustration:

Control Panel
The mechanism which controls reading of information from the cards and punching of the information in the desired columns.

Card Feeds
The two hoppers, one each for the reading and punching units, in which cards are placed before they pass through the machine. If either hopper becomes empty, the machine will automatically stop.

Start and Stop Keys
The two keys used to start and stop feeding of cards.

Card Stackers
The location where the cards are stacked after they pass through the machine. Each stacker has a capacity of 1,000 cards; if either is filled to capacity, the machine will automatically stop.

Main Line Switch
This switch controls the power and must be on if the machine is to be operated. A red signal light indicates that the switch is turned on.

Comparing Indicator
When a red light signals an error in verifying, the machine automatically stops and the indicator points out the comparing position in which the error occurred.

Summary Punch Cable
This permits the combined operation of Reproducing Punch and an Accounting Machine for the automatic preparation of total or new balance cards simultaneously with the preparation of reports.
MACHINE OPERATION

There are two feed units in the Reproducing Punch, the reading unit and the punching unit. Cards may be fed in either or both of the units according to the operation being performed. For any operation, the cards are fed face down, top or 12’s edge first. Each feed hopper holds approximately 800 cards; feeding is continuous, and if either hopper becomes empty, or if a card fails to feed, the machine will automatically stop.

The relation of the two units to each other, and the sequence in which the cards pass the operating stations in the two units, are indicated in the schematic diagram (Figure 1).

Punching Unit

Cards fed in the punching unit first pass the six punch X brushes, which can be set to read six columns of the card. The purpose of the punch X brushes is to read X punches which identify master cards, in order to control the punching and feeding operations. If a mark sensing device is installed in the machine, the mark sensing brushes are the next station in the punching unit. The purpose of these brushes is to read marks on the card, in order to punch the corresponding positions into the card. The following station is the punching mechanism, consisting of 80 punches and dies corresponding to the 80 card columns.

Since there is a separate punch for each column of the card, and since each card passes the punch dies with its top edge first, the 12 position is the first punching to take place. All 12 positions are punched at one time, the 11 positions are punched next, etc., through the last or 9 positions. Thus, the card is punched completely in twelve steps of the card cycle. A card passes these three stations during one card cycle as it passes through the unit.

The 80 punch brushes represent the last station in the punching unit. A card passes the punch brushes on the next card cycle as it passes through the punching unit. Thus, when the 5 position of the first card in the punching unit is being read by the punch brushes, the 5 position of the card immediately following it is at the punch dies; and as the 9 position of the first card is passing over the punch brushes, the 9 position of the following card is at the punch dies.

Reading Unit

Cards fed in the reading unit first pass the five reading X brushes, which can be set to read five columns of the card. The purpose of these brushes is to read X punches in order to control the reading of other information from the card. At the following station are the 80 reproducing...
brushes, corresponding to the 80 card columns. A card passes these two stations on one card cycle as it passes through the reading unit.

If the comparing feature is installed on the machine, the next station is the set of 80 comparing brushes, one for each column of the card. The cards pass the comparing brushes on the next card cycle as they pass through the reading unit. Thus, when the 5 position of the first card in the reading unit is passing over the comparing brushes, the 5 position of the card immediately following it is being read by the reading brushes.

Combined Operation

When both units are being used for any operation, the cards feed simultaneously through the two units. At the time that the X position of a card in the reading unit is being read by the reading X brushes, the X position of the card in the punching unit is being read by the punch X brushes. At the time the 5 position of a card in the reading unit is being read by the reproducing brushes, the 5 position of a card in the punching unit is at the punch position. As the card in the reading unit passes on to the comparing brushes, the card in the punching unit passes on to the punch brushes, and at the time a 5 hole in a card in the reading unit is being read by the comparing brushes, the 5 position of a card in the punching unit is being read by the punch brushes.

Comparing Magnets

The comparing feature of the machine makes it possible to compare punching in two cards for purposes of verification and control. The comparison may be between one card in the reading unit and one in the punching unit, or between cards at the two stations in the reading unit. When the punching in the two cards is different, a signal light indicates the error, the machine stops, and the comparing indicator (Figure 2) points out the comparing position in which the error occurred. The comparing indicator is reset and the signal light is turned off by pressing the lever to the left of the indicator.
CONTROL PANEL

AUTOMATIC operation of the Reproducing Punch is controlled through wiring of the control panel and the setting of switches. The control panel fits into a rack on the front of the machine, as shown in Figure 3. The various groups of hubs, shown in Figure 4, are explained below.

Reproducing Brushes

The 80 reproducing brush hubs are outlets for the reproducing brushes. They are wired to the punch magnets for straight reproducing, to a class selector for selected reproducing, or to a column split for X elimination or transfer. For verification of gang punching, they are connected to the comparing magnets.

Punch Magnets

The 80 punch magnet hubs are inlets for the punch magnets, which actuate the punching mechanism. The punch magnets are wired from the reproducing brushes for reproducing, from the punch brushes for gang punching, from the counter exit hubs for summary punching, and from the mark sensing OUT hubs for punching from pencil marks.

Punch Brushes

There are 80 outlet hubs for the punch brushes. These hubs are connected to the punch magnets for gang punching, to a class selector for offset gang punching, and to a column split for X elimination or transfer. The punch brushes are connected to the comparing magnets in order to verify reproducing.

Comparing Magnets

There are two sets of hubs which are inlets to the comparing magnets, one set which is wired from the punch brushes, and a second set wired from the comparing brushes. The Reproducing Punch may have either 45 or 80 columns of comparing. The full complement of comparing magnets can be used except when the operations include summary punching or mark sensing. When the connector cable is attached to the Accounting Machine, the two sets of hubs for the last 40 comparing positions become exits from the counters, and only 40 comparing units can be used for verification of punching. This is one reason why the cable is attached to the Accounting Machine for summary punching but returned to the punch receptacle for other operations. When mark sensing is being done, the last 20 hubs in the comparing magnet sections become mark sensing IN and OUT hubs.

Comparing Brushes

The comparing brushes are effective only in a machine equipped with the comparing feature. The 80 outlet hubs for the brushes are connected to the comparing magnets for verification of reproducing or gang punching.

Punch X Brushes

The six punch X brushes in the machine may be placed on any six columns, provided that two columns intervene between any two consecutive X punched columns. On the control panel there

Figure 3. CONTROL PANEL AND SWITCHES, TYPE 514
are six outlets for the brushes, which may be con-
tected to the PX hub or directly to a PX pickup
hub of a selector.

Reading X Brushes
There are five outlets for the five reading X
brushes. Any of the five outlets may be wired to
the RX hub, the PX hub, or directly to the RX
pickup hub of a class selector.

PX and PD Hubs
The two PX hubs are common, and may be
wired from either a punch X or a reading X
brush. If the X punch is in the master cards (and
the detail or master switch is at master), the PX
is effective for an X master card. If the X punch
is in the detail cards (and the detail or master
switch is at detail), the PX is effective for a No
X master card. With the PX effective, machine
operation is affected in two ways:

1. The punch magnets are inoperative for one
card cycle. In an interspersed master gang punch
operation, therefore, the master card would not be
punched with information picked up from the last
detail card of the preceding group.

2. The feeding in the reading unit is stopped
for one card cycle (if the selective reproducing
and gang punch comparing switch is off). In an
operation combining master card gang punching
and reproducing, therefore, a source card in the
reading unit will not feed under the reproducing
brushes while a master gang punch card is passing
under the punch magnets.

In addition to these two results, the wiring of
the PX also affects the PD hub. Whenever an X
reaches the PX on one card cycle, this impulse is
available from the PD hub one card cycle later.
The PD can be used to control a class selector
when the X punched card is at the punch brushes.
The PD is not affected by the position of the
detail or master switch; that is, regardless of
whether the detail or master card contains the X,
it is the X punched card which causes the PD to be
in effect on the following card cycle, when the X
card is at the punch brushes.

RX and RD Hubs
The two RX hubs are common and may be
wired from a reading X brush. If the X punch is
in the master cards (and the detail or master
switch is at master), the RX is effective for an
X master card. If the X punch is in the detail
cards (and the detail or master switch is at
detail), the RX is effective for a No X master
card. With the RX effective, the comparing unit
is inoperative for the following card cycle (if the
reproducing switch is off). In verifying an in-
terspersed master gang punching operation, there-
fore, a master card would not be compared with
the last detail card of the preceding group.
When an X is wired to the RX, the other RX hub may be wired to the pickup of a selector to control the selector as the X card is passing the reproducing brushes.

When the RX is effective, the RD is effective on the next card cycle. The RD can be used to control a class selector from an X read by the reading brushes and wired to the RX, when the X card is being read by the comparing brushes.

Column Splits

The 8 column splits are used to transfer or eliminate X or 12 punches. A control punch can be transferred to a column other than that to which the numerical punch of the same original column is going.

0 and X Hubs

Four hubs connected together are a source of both X and 0 impulses. These hubs may be used to add control X punches or for increasing the size of a field by adding 0’s. To get either a single X or 0, a column split must be used.

Summary X Punch Control

A group of + and — summary X punch hubs are provided to summary punch a distinguishing X for either debit or credit totals. For use with a non-net balance Alphabetical Accounting Machine, the + and — hubs are paired and numbered 1, 2, 3, etc., to correspond with the number of the class selector on the Reproducing Punch used for balance selecting of totals. For use with the Numerical Accounting Machine, the hubs are paired and labelled 1, 2, 3, etc., to correspond with the number of the balance counter used on the Accounting Machine. The summary X punch control hubs are not needed in operations involving a net balance Alphabetical Accounting Machine.

These same hubs serve also as the outlets for mark sensing brushes 15-27.

Class Selectors

The 10-position class selectors may be installed as extra features. Each selector has three pickup hubs, the PX, RX, and total.

The PX pickup hub should be used if the selector must hold for a punching unit card cycle. This hub may be impulsed from the PX, RD, or directly from a punch X brush (the last to control a selector without affecting the regular PX circuit).

The RX pickup hub should be used if the selector must hold for a reading unit card cycle. This hub may be impulsed from the RX, RD, or directly from a reading X brush (the last to control a selector without affecting the regular RX circuit).

The total pickup hub is used only in balance selecting on the non-net balance Alphabetical Accounting Machine. It is impulsed from the left-hand position of one of the balance counters.

Mark Sensing Brushes

Outlets for the 27 mark sensing brushes are separated on the control panel; brushes 1-14 are to the right of the punch X brush outlets, and brushes 15-27 are the same hubs used for summary punch X control when summary punching.

Mark Sensing IN and OUT

These hubs are inlets and outlets for the amplifying unit. They are the same hubs used for comparing magnet positions 61-80, or for counter exits in summary punching. The mark sensing brush outlets are wired to the mark sensing IN hubs, and from the mark sensing OUT hubs to the punch magnets.

Double Punch and Blank Column Detection

These are inlet hubs to the unit which detects double punched or blank columns. They are wired from the punch brushes. On machines equipped with mark sensing, ten positions are standard, and 17 additional positions are available.

MX Hub

An X impulse is available at this hub when a 12 mark is read by a brush connected to the first mark sensing IN position. The impulse is used to control a selector for gang punching from marked master cards.
SWITCHES

Reproducing Switch

This switch, when on, synchronizes the feeds of the reading and punching unit, so that as a card is fed in the reading unit, one will be fed in the punching unit. If either hopper becomes empty, the machine will automatically stop. The reproducing switch must be on when the two feeds are used to perform a single operation. It is turned off when the two feeds operate independently to perform separate operations, or when only one feed is used.

Selective Reproducing and Gang Punch

Comparing Switch

This switch, when on, allows continuous feeding in the reading unit. If the switch is turned off, an impulse in the PX hub will cause the feeding in the reading unit to stop for the following card cycle, while a card is fed in the punching unit.

Detail or Master Switch

This switch controls the handling of two types of cards distinguished by X punching. It should be set to MASTER when the master cards have the control X punch in gang punching, or when the No X source cards are to be reproduced. It should be set to DETAIL when the detail cards have the control punch for gang punching, or when the X source cards are to be reproduced.

Mark Sensing Switch

The mark sensing switch must be on for any mark sensing operation. When the switch is on, the last 20 comparing positions on the control panel become mark sensing IN and OUT hubs, and the summary X punch control hubs become outlets for mark sensing brushes 15-27.

Master Card Punching Switch

This switch, when on, allows marked information to be punched into a card regardless of the operation of the PX hub. It is turned on only for a combination reproducing and gang punching operation with marked master cards. It should be off for all other operations.

Blank Column Detection Switches

For each position of blank column and double punch detection, there is a blank column detection switch. To verify for blank columns or double punches, the punch brushes are wired to the detection unit and the corresponding blank column detection switches must be on. With the punch brushes wired and the blank column switch off, only double punching causes the machine to stop.
GANG PUNCHING AND VERIFYING

THE PUNCHING unit is used in gang punching operations. The master setup cards must precede the detail cards to be punched. When the first master card has reached the punch brushes, the blank card following it is at the punch magnets. The master card is read by the punch brushes and the impulses are transmitted to the punch magnets. This results in the punching of the first detail card. The next card cycle then advances the punched detail card to the punch brushes where it, in turn, is read and serves as the setup card for the following detail card. Thus, every card passing through the machine serves in its turn as the setup card for the card directly behind it.

For machine verification of gang punching, the cards are taken from the punching unit stacker and placed in the reading unit feed. The verification is made by comparing the punched holes of the card at the comparing brush station with those of the card which is at the reproducing brush station. The relationship of cards for the verification is similar to that of gang punching; the master card is compared with the first detail card, and each subsequent detail card in that group is compared with the card which immediately precedes it. When a discrepancy occurs, the machine stops, and the signal light flashes on. The operator should remove the cards in the stacker and the feed hopper, reset the indicator, and depress the start key. The second card entering the stacker will be the error card. Both operations, gang punching and verification, can be done simultaneously.

One Master Card—Column for Column Gang Punching

If only one master card is to be used, this card is placed in front of the detail cards and all cards are placed in the feed hopper of the punching unit. In this case, X control of the master card is not needed. The only wiring required is from punch brushes to punch magnets, as shown in Figure 6.

The reproducing switch should be off, because only one feed unit is being used. The selective reproducing switch must be off, and the detail or master switch must be at MASTER.

The quickest method of verification for this type of gang punching is to compare manually the master card with the last card punched.

Interspersed Master Cards—Column for Column Gang Punching

The master cards are inserted in front of the detail cards which are to be gang punched. Either the master or the detail cards must have a distinguishing X punch. In addition to the wiring from punch brushes to punch magnets, there must be a wire from the punch X brush, placed on the column in which the control X is punched, to the PX hub, as shown in Figure 7. This allows the master cards to pass the punch magnets without being punched with information picked up from the preceding detail card.

The punching can be verified in the reading unit by wiring the reproducing and comparing brushes to the comparing magnets, and the proper read X brush to the RX hub, to prevent a comparison between the master card of one group and the last detail card of the preceding group. The verifying can begin as soon as a batch of cards has been punched, and while the remaining cards are being gang punched.
It is often desirable to have the distinguishing X punch in the detail cards rather than the master cards, for interspersed master gang punching operations. In this way, the master punching will be read from a No X card.

Because the two feed units are not to be synchronized, the reproducing switch should be off.

The selective reproducing and gang punch comparing switch should be on if verifying is being done in the reading unit; otherwise it should be off. The detail or master switch should be turned to MASTER if the control X is in the master cards, or to DETAIL if the X punch is in the detail cards.
Offset Gang Punching

In order to gang punch information into columns other than those punched on the master card, a class selector must be used, as shown in Figure 8. A punch X brush is placed in the proper column to pick up master X punches, and the corresponding outlet hub is wired to the PX hub, in order to prevent master cards from being punched and compared with the last detail card of the preceding group. With the X in master cards, the punch brushes corresponding to the columns punched on the master cards are wired to the controlled hubs of a class selector, the punch brushes corresponding to the columns to be punched on the detail cards are wired to the normal hubs of the selector, and the common hubs of the selector are wired to the punch magnets corresponding to the columns to be punched on the detail cards. The PD hub is wired to the pickup hub of the selector, in order to control the selector when the X punched master card is at the punch brushes.

The verification of offset gang punching requires another class selector, as shown by the dotted wiring in Figure 8. A read X brush is placed on the proper column to read the master X punch, and the brush outlet is wired to the RX hub. The comparing brushes corresponding to the columns punched in the master card are entered in the controlled hubs of the selector, the comparing brush outlets corresponding to the columns punched in the detail cards are connected to the normal hubs, and the common hubs of the selector are wired to the comparing magnets to compare with the field punched on the detail cards, as read by the reproducing brushes. The selector is controlled by an RD impulse, in order that it may be operative when the X punched card is at the comparing brushes.

If the detail cards, rather than the master cards, contain the X punch, the wiring to the selectors is reversed; that is, the columns of the master card are wired to the normal hubs of the selector, and the columns to be punched on the detail cards are wired to the controlled hubs of the selector.

Because the two feed units are not to be synchronized, the reproducing switch should be off. The selective reproducing and gang punch comparing switch should be on if verifying is being done; otherwise it should be off. The detail or master switch should be turned to master, if the X is in the master cards, or to detail if the X is in the detail cards.
IN REPRODUCING operations, the reading and punching units operate in synchronism. The original cards, called the source cards, are placed in the reading unit. The cards to be punched, called the reproduced cards, are placed in the punching unit. As each card feeds in the reading unit, a corresponding card feeds in the punching unit. As the card in the reading unit passes under the reproducing brushes, the punched information is picked up and transmitted to the punch magnets, and the corresponding card under the punch magnets at this time is punched.

Verification of the punching can be done one card cycle later, during the same operation. As the source card passes under the comparing brushes, the corresponding reproduced card passes under the punch brushes. If the punching sensed by the two sets of brushes is alike, the machine continues in operation. If there is any discrepancy, the machine will automatically stop and the red signal light will go on. The cards in error are those about to enter the stackers. The cards in the feed hoppers and the correct cards already in the stackers should be removed, the signal light should be reset, and the machine started. The error cards can then easily be removed.

Straight Reproducing

The source cards are placed in the reading unit and the blank cards to be reproduced are placed in the punching unit. The reproducing brush outlets are wired to punch magnets, as shown in Figure 9. To verify the reproduced data, the proper columns of the source and reproduced cards are wired from the comparing brushes and punch brushes, respectively, to the comparing magnets.

Because the feeds must operate together, the reproducing switch must be on. The selective reproducing and gang punch comparing switch should be off, and the detail or master switch should be at MASTER.

Field Selected Reproducing

In order to select information from one of two punched fields on the source cards and reproduce it into a single field on the reproduced cards, a class selector must be used, as shown in Figure 10. The field to be selected from the X punched cards is entered in the controlled or X row, the field from the No X cards is entered in the normal row, and the common or C row of hubs is connected to the desired punch magnets. A read X brush must be placed on the proper control column of the source cards, and the corresponding outlet must be connected to the RX hub. The class selector pickup is then wired from the second RX hub, so that the selector will be controlled when the X punched source card is at the reproducing brushes.
If this punching is to be verified, a second selector must be used, as indicated by the dotted lines in Figure 10. The field of the X punched card from the comparing brushes is entered in the Controlled hubs of the selector, the No X card field picked up by the comparing brushes is entered in the normal row of the selector, and the common row of the selector is taken to the comparing magnets. The selector is impelled from the RD hub in order that it may be controlled when the X punched card is at the comparing brushes.

Because the two units must operate together, the reproducing switch must be on. The selective reproducing and gang punching comparing switch should be off. The detail or master switch must be at MASTER.

Selective Reproducing

Selective reproducing is the operation by which only one type of card (X or No X) will be reproduced. For each source card not reproduced, there will be a blank card in the reproduced deck. As in normal reproducing, the proper reproducing brushes are connected to the punch magnets as shown in Figure 11. In addition, a read X brush must be placed in the X punched column, and the read X brush hub must be connected to the PX hub which prevents the punch magnets from operating for the following card cycle.

The verification of selective reproducing is the same as for straight reproducing, as shown by the dotted lines in Figure 11.

The two feed units should operate together; therefore, the reproducing switch must be on. The feeding in the reading unit should not be affected by the PX hub, and therefore the selective reproducing and gang punch comparing switch must be on. The detail or master switch should be turned to MASTER if the No X cards are to be reproduced, or to DETAIL if the X cards are to be reproduced.

Combined Reproducing and Gang Punching

For all combined operations, the separate reading and punching units operate together in the way already described. If, however, the gang punching is to be performed from a single master card, and the master card is not X punched and wired for control to the PX hub, a blank card must precede the detail cards in the reading unit. This is necessary because the master gang punch card must be one card cycle in advance of the first source card in the reading unit, to avoid reproducing the first source card data onto the master setup card. The reproduced data can be verified in this same operation. Control panel wiring is shown in Figure 12.

Figure 10. Field Selected Reproducing
X source cards are punched in columns 41-48; No X source cards are punched in columns 15-16; reproduced cards are to be punched in columns 22-25.
The reproducing switch must be on. The selective reproducing and gang punch comparing switch must be off, because it is necessary to stop the feeding in the reading unit for one card cycle while a gang punch master card is passing under the punch magnets. If the reading unit feed did not stop for one cycle, a source card would not be reproduced whenever a master card passed through the punch unit. The detail or master switch should be turned to MASTER if the master gang punching cards are X punched, or to DETAIL if the detail cards contain the X punch.

X Elimination or Transfer

When a brush outlet is wired to the common hub of a column split, the 0-9 punches of that column can be taken from the 0-9 hub to a punch magnet, and the X or 12 punch of that column can be eliminated entirely, or taken from the 11-12 hub to a different punch magnet, as shown in Figure 12. A column split must also be used to punch a single 0 or X from the 0 and X hubs.

**Figure 12. Reproducing with X-Elimination and Gang Punching**

1. X column 68 eliminated in reproducing columns 64-68.
2. X column 68 eliminated in verification of columns 64-68 punching.
3. Gang punching columns 60-65 into columns 60-63.
IN SUMMARY punching operations, the Reproducing Punch is connected to the Accounting Machine by the connector cable. The Accounting Machine operates as usual until a change occurs in the control for which the summary totals are to be punched; it then stops, and does not print or reset until the punching of the summary card has been completed. The punch magnets in the Reproducing Punch are actuated through an emitter, which reads the amounts standing in each counter and transmits the impulses to the punch magnets in the sequence determined by the wiring of the control panel. The reset circuit of the Accounting Machine is made operative when the punching of the summary card has been completed. At this time the machine prints the total, resets, and starts accumulating the next control group in the normal manner. Before any summary punching can start, a card must be fed under the punch magnets of the Reproducing Punch. One depression of the start key will automatically feed cards to this position.

Summary Punching with Net Balance Alphabetical Accounting Machine

The wiring for summary punching is shown in Figure 13. The proper counter total exit hubs are wired to the punch magnets. An X punch to identify a credit (or debit) total may be obtained by wiring on the accounting machine control panel the proper summary X punch control — or + hub to a column split hub. This column split hub is internally connected to the corresponding column split on the reproducing punch control panel. By wiring the C hub of the column split to a punch magnet, an X will be punched. If a numerical punch is to be in the same column as the X, the numerical impulse must be brought to the 0-9 hub of the column split, in which case the C hub carries both punches.

**Figure 13. Summary Punching with Alphabetical Net Balance Accounting Machine**

1. If counter A has gone through a conversion cycle indicating a credit balance, an X impulse is brought to column split.
2. Units position of amount field is brought to same column split.
3. Units position of amount field is punched and if field is a credit amount, an X is also punched.
The reproducing switch should be off, the selective reproducing and gang punch comparing switch should be off, and the detail or master switch should be turned to MASTER.

Summary Punching with Non-Net Balance

Alphabetical Accounting Machine

The wiring for summary punching is shown in Figure 14. The proper counter total exit hubs are wired to the punch magnets. If balance selection has been performed on the Accounting Machine, it must be repeated on the Reproducing Punch in order to punch a true figure. The counter total exit hubs representing the counter normally impelled to add and subtract are wired to the normal hubs of a class selector. The counter total exit hubs for the counter which was impelled in the reverse manner are wired to the controlled hubs of the selector. The common hubs of the selector are connected to the punch magnets. The selector is controlled by the extreme left position of the counter total exit hubs of the normal counter. Whenever a complement occurs in this position, the selector is controlled and a true credit figure will be punched, rather than a complement.

If an X is to identify a credit (or debit) total, the proper summary X punch control — or + hub to be wired to the punch magnet is determined according to the class selector used on the Reproducing Punch. If selector 1 was used for balance selecting, summary X punch control 1 must be used. If the X is to be punched into the same column as a numerical punch, a column split should be used.

The reproducing switch should be off, the selective reproducing and gang punch comparing switch should be off, and the detail or master card switch should be turned to MASTER.

Figure 14. Summary Punching with Alphabetical Non-Net Balance Accounting Machine

1. Selector is controlled by complement 9 of left-hand position of normal counter.
2. Units position of field is brought to 0-9 of column split.
3. Credit X impelled corresponding to selector used is wired to same column split.
4. Units position of amount field is punched and if field is a zero or a credit amount, an X is also punched.
5. Counter normally impelled is connected to normal hub of selector.
6. Counter impelled in reversed manner is connected to controlled hubs of selector.
Combined Reproducing, Gang Punching, and Summary Punching

All three operations of reproducing, gang punching (one master card only), and summary punching can be performed at one time. The wiring for each operation is done in the normal manner, as shown in Figure 15. In this kind of combined operation, one depression of the start key will feed cards in both reading and punching units so that the cards are in proper position for the combined operation. A control to make sure that the reproduced information has been punched in the right summary card can be obtained by wiring to the comparing magnets the punch brushes and comparing brushes corresponding to a control field in the summary and source cards.

The reproducing switch should be on, the selective reproducing and gang punch comparing switch should be off, and the detail or master card switch should be turned to MASTER.

Summary Punching with Numerical Accounting Machine

Summary Punching with the Numerical Accounting Machine is the same as with an Alphabetical Accounting Machine, Net Balance, except for the X punching. The wiring of the control panel is shown in Figure 16. If an X punch to distinguish a credit (or debit) total is needed, wire from the — (or +) hub of the summary X punch control unit corresponding to the number of the balance counter involved in the operation; that is, if the total of bank 5 is to be summary punched, the fifth — (or +) hub of summary X punch control would be used. To punch the X and a numerical punch in the same column, the X is taken to the 11-12 hub of a column split, the numerical punch to the 0-9 hub, and the C of the column split is connected to the punch magnets.
The reproducing switch should be off, the selective reproducing and gang punch comparing switch should be off and the detail or master switch should be turned to master.

Card Comparing

Two sets of punched cards can be checked with each other for agreement in the data punched and agreement in sequence. One set of cards is placed in the reading unit feed and the other set is placed in the punching unit feed. The fields to be compared are connected from the punch brushes and comparing brushes to the comparing magnets, as shown in Figure 17. When a discrepancy is detected between any two cards, the machine stops and the signal light flashes on. The cards in error are those about to enter the stackers. The cards in the feed hoppers and the correct cards already in the stackers should be removed, the signal light should be reset, and the machine restarted.

Figure 16. Summary Punching with Numerical Accounting Machine

1. Credit X is wired to column split.
2. Units position of amount field is wired to same column split.
3. Units position of amount field is punched, and if field is a credit amount, an X is also punched.

Figure 17. Card Comparing

Columns 64-68 of corresponding cards in each set are compared.
MARK SENSING

BY MEANS of the mark sensing feature, pen or pencil marks on cards are automatically converted to punched holes in any columns in the card. Each side of the card has a capacity of 27 columns of marked data (Figure 20) and there are 27 mark sensing brushes, one for each of these columns. Each of the 27 mark sensing brushes consists of three regular brushes; the two outer brushes of the group are common and the center brush is connected to the brush outlet on the control panel. Whenever an outer brush is connected with the center brush by means of a mark on the card, an impulse will be available at the brush outlet.

Straight Mark Sensing

Control panel wiring for straight mark sensing is shown in Figure 18. Because the marks are not sufficiently conductive to permit direct operation of the punch magnets, an amplifying unit...
is supplied. The mark sensing brushes corresponding to the positions marked are wired to the mark sensing IN hubs, representing the entrance to the amplifying unit, and the mark sensing OUT hubs are then wired to the punch magnets. Any number of marks can be sensed in any one column, except when using the first mark sensing IN position. A 12 mark entered in this position will punch as an X and cause MX to emit an X-control impulse.

To verify the mark sensing operation, the punch brushes are wired to the double punch and blank column detection unit, as shown by the dotted line in Figure 18. If a column is double punched, the machine will automatically stop and the double punch signal light will flash on. The signal light can be turned off by depressing the error reset button. If verification for blank columns is also desired, the blank column switches corresponding to the positions of the unit which are being used should be turned ON. Blank column detection must be accompanied by double punch detection.

The mark sensing switch must be ON. The master card switch should be OFF. The reproducing switch should be OFF, the selective reproducing and gang punch comparing switch OFF, and the detail or master switch at MASTER.

| Gang Punching with Marked Master Cards |

It is possible to use marked cards as master cards for gang punching. The master cards must have a control 12 mark or an X punch.

The control panel wiring is shown in Figure 19. The mark sensing brush reading the 12 control mark column is connected to the first mark sensing IN position, which allows an X impulse to be emitted from the MX hub. The mark sensing brushes are taken to the mark sensing IN hubs, and the mark sensing OUT hubs are wired to the controlled row of a selector. The punch brushes corresponding to the columns to be gang punched are taken to the normal row of the selector. The common hubs of the selector are then connected to the punch magnets. The MX is used to control the selector. To punch a control X in the master cards, the first mark sensing OUT position is connected to a punch magnet.

The mark sensing switch must be ON, and the master card switch must be ON. The reproducing switch and the selective reproducing and gang punch comparing switch should be OFF, and the detail or master switch at MASTER.

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**Figure 20. Column Arrangement and Eight Styles of Mark Sensing**
Design of Mark Sensing Cards

The field or fields to be used for marking are generally placed at the right of the card. This allows the operator to hold the card conveniently while marking it. Within the field, the marking columns are made three times as wide as the normal card column. The total marking capacity on one side of the card is limited to 27 columns as shown in Figure 20. This column arrangement must be adhered to in the design of card forms; that is, the center of a mark sensing column must be on columns 2, 5, 8, 11, 14, etc., to 80. In this arrangement, the normal right-hand card column of any mark sensing column is divisible by three.

The marking field can also be used as a punching field, and the information marked can be punched in any columns on the card. Each marking position is located above the corresponding punching position; that is, the 3 marking position is between the 3 and 2 punching positions. This eliminates any conflict between the marks and the punched holes.

Marking of Cards

The function of mark sensing is dependent upon the fact that a pen or pencil mark can be electrically conductive. It is necessary, therefore, that the correct method of marking be used.

To assure correct results, cards must be marked with the specified ink or lead which has a high graphite content. The marks should be made within each marking column and should not extend beyond the marking position. If marks for the same digits are to be made in adjoining columns, each mark should be made separately. Unnecessary marks in the marking field should be avoided.

A conductive mark is made by a single stroke of the pen or pencil. When a pen is used, a light touch produces an adequate mark; when a pencil is used, it must be pressed firmly and the point must be kept sharp. Figures 21 and 22 indicate the effect of a good and an unsatisfactory pencil mark on a card. The dark spots represent the graphite particles; and the closer these particles are together, the more conductive the mark will be. If an error is made, the mark in error should be completely erased and the correct mark made. When using ink, the special eraser on the pen should be used.

The same care should be used in the handling of ink-marked cards as is exercised in any ink writing. If smudging occurs, the mark may become nonconductive. As cards are marked, they should be stacked face up so that the wet marks can dry while the next card is marked. If the cards must be kept in sequence however, the wet card can be turned over and dropped face down on top of the marked pack. Although a slight transfer of ink to the back of the previous card may occur, the conductivity is not destroyed unless pressure is exerted on the wet mark. The cards should not be picked up and joggled until the last mark has dried; approximately 30 seconds drying time is necessary. Ink should not be used when cards are to be machine processed immediately after marking; a minimum of 20 minutes drying time should always be allowed.

Cards designed for ink mark sensing should never be printed with information within the marking areas since the printing may cause breaks in the continuity of ink marks, making them nonconductive.
**Figure 21. Microphotograph of a Good Mark**

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 through an electrical conductor such as a copper wire.

**Figure 22. A Microphotograph of a Poor Mark**

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 held firmly in the hand. The graphite deposit is not sufficiently continuous to assure an uninterrupted current of electricity.
Gang Punch Emitter

The gang punch emitter is an attachment for the Reproducing Punch which provides a means of gang punching common information without the use of prepunched master setup cards. The emitter supplies punching impulses which are identical to those obtained from punched cards passing the reproducing or punch brushes. Such impulses, when wired to the punch magnets, cause the punching of predetermined data in every card. The emitter does not in any way affect the normal punching operation of the machine.

The control panel arrangement for the emitter consists of one hub for each of the twelve punching positions of a card (Figure 23). The wiring is from the emitter hubs to the punch magnets. The emitted impulses can be class or field selected, or wired for multiple punching. Split wires can be used from the emitter, and therefore its capacity for gang punching is not limited.

Before a gang punch emitter can start to operate, a card must be at the punch brushes. When the emitter is being used, therefore, a blank card should be fed ahead of the detail cards to be punched.

Double Punch and Blank Column Detection Device

This device is standard on a machine equipped for mark sensing, but it can be installed as a special device on other machines. It can be used to verify summary punching or gang punching operations, to determine that all columns have been punched, and that there are no double punches. Its operation and control panel wiring are the same as shown in connection with the straight mark sensing operation.

On all Type 514 Reproducing Punches that are equipped with the double punch and blank column detection device, two special sets of hubs are provided on the control panel for X or NX control of double punch and blank column detection. The hubs are labeled D.P.D. (X and PU) and are located on the control panel as shown below:

![Diagram of D.P.D. hubs]

The D.P.D. PU hubs may be impelled from an X read by either an RX brush or a PX brush. When the two hubs labelled X are connected, only X punched cards will be checked for double
punches and blank columns. When the two hubs labelled X are not connected, only NX cards will be checked for double punches and blank columns. If the D.P.D. PU hubs are not wired from an RX or PX brush, all cards will be checked for double punch and blank column detection.

Offset Stacker Device

The offset stacker device is designed for use with the double punch and blank column detection device. It can be installed on the punch unit stacker. Without any special wiring of the control panel, an error card having either a blank or double-punched column will be offset 3/8" forward in the stacker. This device may be specified as standard for any machine equipped with the mark sensing feature.

If continuous machine operation is desired, the offset stacker switch should be turned to OFFSET. If the operator wants the machine to stop whenever an error card is detected, the switch should be turned to OFFSET STOP. In either case, the error card will be offset in the stacker.