BASIC DATA PROCESSING

Prepared by the Bureau of Naval Personnel

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PREFACE

This book is intended as an aid for men who are seeking to acquire the theoretical knowledge and the operational skills required of candidates for advancement to the rate of Data Processing Technician Third Class or Data Processing Technician Second Class. As one of the Navy Training Manuals, this book was prepared by the Training Publications Division, Naval Personnel Program Support Activity, Washington, D. C., for the Bureau of Naval Personnel. Review and technical assistance were provided by the U. S. Naval Examining Center, Great Lakes, Ill.; U. S. Naval Command Systems Support Activity, Washington, D. C.; the Service Schools Command, Naval Training Center, San Diego, Calif.; and by the Bureau of Naval Personnel.

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CREDITS

Preparation of this manual was aided by the cooperation and courtesy of International Business Machines Corporation; UNIVAC, Division of Sperry Rand Company; Honeywell, Incorporated; Radio Corporation of America; and General Kinetics Incorporated. These companies have supplied technical information, machine reference manuals, photographs of machines, and machine features which aided considerably in the preparation of this text. Permission to use these materials is gratefully acknowledged.

Illustrations not listed below are from Navy sources.

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CHAPTER 1

ADVANCEMENT

This training manual is designed to help you meet the occupational qualifications for advancement to Data Processing Technician Third Class and Data Processing Technician Second Class.

The Data Processing Technician qualifications used as a guide in the preparation of this training manual are those contained in the Manual of Qualifications for Advancement, Nav-Pers 18068-B.

Chapters 2 through 14 of this training manual deal with the technical subject matter of the Data Processing Technician rating.

The remainder of this chapter gives information on the enlisted rating structure, the Data Processing Technician rating, requirements and procedures for advancement in rating, and references that will help you both in working for advancement and in performing your duties as a DP. This chapter includes information on how to make the best use of rate training manuals. Therefore, it is strongly recommended that you study this chapter carefully before beginning intensive study of the remainder of this manual.

THE ENLISTED RATING STRUCTURE

The two main types of ratings in the present enlisted rating structure are general ratings and service ratings.

GENERAL RATINGS identify broad occupational fields of related duties and functions. Some general ratings include service ratings; others do not. Both Regular Navy and Naval Reserve personnel may hold general ratings.

SERVICE RATINGS identify subdivisions or specialties within a general rating. Although service ratings can exist at any petty officer level, they are most common at the PO3 and PO2 levels. Both Regular Navy and Naval Reserve personnel may hold service ratings.

THE DATA PROCESSING TECHNICIAN RATING

Personnel of the Data Processing Technician (DP) rating operate many types of automatic data processing equipment to provide accounting and statistical services for the Navy. They wire control panels for electric accounting machines (EAM) and write programs for electronic data processing machines (EDPM). They process incoming information and make routine and special reports as required. They are thoroughly familiar with data processing applications and in the higher paygrades are thoroughly familiar with administrative and management functions peculiar to data processing offices and installations.

The DP rating is a general rating, and does not include service ratings. Areas of specialization within the rating are identified by Navy Enlisted Classification Codes. These codes identify such specialists as an Electronic Data Processing Systems Operator, who operates large-scale electronic data processing machines and a Tabulating Machine Serviceman, who adjusts and repairs electric tabulating equipment.

The use of naval personnel to operate electric accounting machines goes back to the early days of World War II. The enormous expansion of the naval forces to meet the threat of enemy aggression resulted in a greatly increased workload for clerical personnel. Concerned with this problem, the Chief of Naval Personnel explored possibilities of handling the mountains of paperwork more efficiently. As a result of this research, Bureau of Naval Personnel installed and began using punched card data processing equipment, resulting in the establishment of the Specialist (I) rating. This rating remained a specialist rating until 1948. At that time it was designated Machine

Accountant (MA) and incorporated into the Regular Navy rating structure. On July 1, 1967, it was redesignated Data Processing Technician, a more descriptive and appropriate title for the rating. Also in 1967, new Warrant Officer (783X) and Limited Duty Officer (623X) categories were established for Data Processing Technicians. This afforded DPs the first opportunity to apply for commissioned status and remain in their field, rather than branch into Supply or General Administration.

DP Assignments

Data Processing Technicians may be ordered to many different types of activities which perform data processing by both electrical and electronic methods. These include ship and shore installations of the Operating Force, Shore Support activities, Bureaus, Systems Commands, and Offices of the Navy Department. Generally speaking, the mission of a data processing installation is prescribed by the Bureau, Office, or Systems Command exercising command. The data processing systems employed may be broadly grouped as personnel, supply, maintenance and material management (3-M), fiscal, research, security, communications, and operations control. An installation may perform data processing services under one or more of these systems, and various other miscellaneous services, depending upon the type of installation and its assigned mission.

A few Data Processing Technicians who are qualified instructors may be assigned instructor duty in the DP "A" or "C" schools. Other duty assignments include the U.S. Naval Examining Center, Great Lakes, where the service-wide advancement in rating examinations are prepared and scored; the U. S. Navy Training Publications Division, Naval Personnel Program Support Activity, Washington, D. C., and various other highly specialized billets. (This training manual that you are now studying was revised by a Chief Data Processing Technician while he was assigned to an instructor billet at Training Publications Division.) Regardless of location, all Data Processing Technicians are assigned by the Bureau of Naval Personnel, Washington, D.C.

The DP As A Leader

Data processing installations often accomplish their work on an assembly-line basis.

They are divided into sections, with each section responsible for accomplishing certain phases of data processing applications. For example, one section receives, codes, and files source documents. Another converts the source documents into punched card data. Other sections apply the incoming data to existing files and produce reports and services as required. Each section must complete its work accurately and on time so that the work can be kept flowing in an orderly fashion. The efforts of all sections working together are required to accomplish the mission of the installation.

Obviously, someone in each section has to be responsible for seeing that the work is accomplished. This is the job of the section leader, who could be YOU. The term LEADER usually implies responsibilities in supervising and directing a group of people. As a leader, you must be able to make job assignments, supervise the work, and see that all jobs are performed correctly and on time. If you are thoroughly familiar with the work for which you are responsible, are willing to accept responsibility (both assigned and assumed), and practice the habit of setting a good example, then you are on the right road to effective leadership.

Leadership is not restricted to those in positions of supervision or authority. It concerns each and every one of us, from the Seaman on up. You exercise leadership in the way you perform your job; whether it is keypunching, operating a console, or any other task. The manner in which you follow instructions, the care you exercise when handling data, your observance of safety precautions, and your adeptness at operating machines, are only a few of the ways that leadership characteristics are displayed. You must remember that there are always others around who learn their habits (sometimes unconsciously) from what they see YOU do. Remember also that your supervisor evaluates you from personal observance of your performance. His evaluation counts in the final decision to recommend or not recommend you for advancement in rating.

The rewards for practicing good leadership traits are many. For example, you get a certain feeling of pride when your supervisor compliments you on a job well done or when he tells someone he doesn't see how he can get along without you. There is satisfaction also in knowing that you are setting a good example

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for less experienced personnel to follow. Most important of all, you have an inner satisfaction in knowing that you have performed your work to the best of your ability. No one could ask more of you.

While we are on the subject of leadership, it may be well for you to stop and read that portion of Military Requirements for Petty Officers 3 & 2 that deals with leadership. You will find points on how to exercise good leadership that can be easily applied to the Data Processing Technician rating. In addition, you will find quotations from Navy Department General Order 21, which all of us should be familiar with.

ADVANCEMENT IN RATE

Some of the rewards of advancement are easy to see. You get more pay. Your job assignments become more interesting and more challenging. You are regarded with greater respect by officers and enlisted personnel. You enjoy the satisfaction of getting ahead in your chosen Navy career.

But the advantages of advancement are not yours alone. The Navy also profits. Highly trained personnel are essential to the functioning of the Navy. By each advancement, you increase your value to the Navy in two ways. First, you become more valuable as a specialist in your own rating. And second, you become more valuable as a person who can train others and thus make far-reaching contributions to the entire Navy.

HOW TO QUALIFY FOR ADVANCEMENT

What must you do to qualify for advancement? The requirements may change from time to time, but usually you must:

1. Have a certain amount of time in your present grade.
2. Complete the required military and occupational training manuals.
3. Demonstrate your ability to perform all the PRACTICAL requirements for advancement by completing the Record of Practical Factors, NavPers 1414/1. In some cases the Record of Practical Factors may contain the old form number, NavPers 760.
4. Be recommended by your commanding officer, after the petty officers and officers supervising your work have indicated that they

consider you capable of performing the duties of the next higher rate.
5. Demonstrate your KNOWLEDGE by passing written examinations on the occupational and military qualification standards for advancement.

Some of these general requirements may be modified in certain ways. Figure 1-1 gives a more detailed view of the requirements for advancement of active duty personnel; figure 1-2 gives this information for inactive duty personnel.

Remember that the qualifications for advancement can change. Check with your division officer or training officer to be sure that you know the most recent qualifications.

Advancement is not automatic. Even though you have met all the requirements, including passing the written examinations, you may not be able to "sew on the crow" or "add a stripe." The number of men in each rate and rating is controlled on a Navywide basis. Therefore, the number of men that may be advanced is limited by the number of vacancies that exist. When the number of men passing the examination exceeds the number of vacancies, some system must be used to determine which men may be advanced and which may not. The system used is the "final multiple" and is a combination of three types of advancement systems.

Merit rating system
Personnel testing system
Longevity, or seniority system

The Navy's system provides credit for performance, knowledge, and seniority, and, while it cannot guarantee that any one person will be advanced, it does guarantee that all men within a particular rating will have equal advancement opportunity.

The following factors are considered in computing the final multiple:

Factor	Maximum Credit
Examination score	80
Performance factor (Performance evaluation)	50
Length of service (years x 1)	20
Service in pay grade (years x 2)	20
Medals and awards	15
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ACTIVE DUTY ADVANCEMENT REQUIREMENTS

REQUIREMENTS *	E1 to E2	E2 to E3	#†E3 to E4	#E4 to E5	†E5 to E6	†E6 to E7	†E7 to E8	†E8 to E9
SERVICE	4 mos. service— or completion of recruit training.	6 mos. as E-2.	6 mos. as E-3.	12 mos. as E-4.	24 mos. as E-5.	36 mos. as E-6. 8 years total enlisted service.	36 mos. as E-7. 8 of 11 years total service must be enlisted.	24 mos. as E-8. 10 of 13 years total service must be enlisted.
SCHOOL	Recruit Training.		Class A for PR3, DT3, PT3. AME 3, HM 3			Class B for AGC MUC, MNC.		
PRACTICAL FACTORS	Locally prepared check-offs.	Records of Practical Factors, NavPers 1414/1, must be completed for E-3 and all PO advancements.						
PERFORMANCE TEST			Specified ratings must complete applicable performance tests before taking examinations.					
ENLISTED PERFORMANCE EVALUATION	As used by CO when approving advancement.		Counts toward performance factor credit in advancement multiple.					
EXAMINATIONS **	Locally prepared tests.	See below.	Navy-wide examinations required for all PO advancements.				Navy-wide, selection board.	
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIREMENTS)			Required for E-3 and all PO advancements unless waived because of school completion, but need not be repeated if identical course has already been completed. See NavPers 10052 (current edition).				Correspondence courses and recommended reading. See NavPers 10052 (current edition).	
AUTHORIZATION	Commanding Officer		U.S. Naval Examining Center			Bureau of Naval Personnel		

* All advancements require commanding officer's recommendation .
† 1 year obligated service required for E-5 and E-6; 2 years for E-6, E-7, E-8 and E-9.
# Military leadership exam required for E-4 and E-5.
** For E-2 to E-3, NAVEXAMCEN exams or locally prepared tests may be used.

Figure 1-1.—Active duty advancement requirements.

INACTIVE DUTY ADVANCEMENT REQUIREMENTS

REQUIREMENTS *	E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7	E8	E9
TOTAL TIME IN GRADE	4 mos.	6 mos.	15 mos.	18 mos.	24 mos.	36 mos.	36 mos.	24 mos.
TOTAL TRAINING DUTY IN GRADE †	14 days	14 days	14 days	14 days	28 days	42 days	42 days	28 days
PERFORMANCE TESTS			Specified ratings must complete applicable performance tests before taking examination.					
DRILL PARTICIPATION	Satisfactory participation as a member of a drill unit.							
PRACTICAL FACTORS (INCLUDING MILITARY REQUIREMENTS)	Record of Practical Factors, NavPers 1414/1, must be completed for all advancements.							
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIRE- MENTS)	Completion of applicable course or courses must be entered in service record.							
EXAMINATION	Standard Exam	Standard Exam or Rating Training.	Standard Exam required for all PO Advancements.		Standard Exam, Selection Board. Also pass Mil. Leadership Exam for E-4 and E-5.			
AUTHORIZATION	Commanding Officer		U.S. Naval Examining Center		Bureau of Naval Personnel			

* Recommendation by commanding officer required for all advancements.
† Active duty periods may be substituted for training duty.

Figure 1-2.—Inactive duty advancement requirements.

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All of the above information (except the examination score) is submitted to the Naval Examining Center with your examination answer sheet. After grading, the examination scores, for those passing, are added to the other factors to arrive at the final multiple. A precedence list, which is based on final multiples, is then prepared for each pay grade within each rating. Advancement authorizations are then issued, beginning at the top of the list, for the number of men needed to fill the existing vacancies.

HOW TO PREPARE FOR ADVANCEMENT

What must you do to prepare for advancement? You must study the qualifications for advancement, work on the practical factors, study the required rate training manuals, and study other material that is required for advancement in your rating. To prepare for advancement, you will need to be familiar with (1) the Quals Manual, (2) the Record of Practical Factors, (3) a NavPers publication called Training Publications for Advancement, NavPers 10052, and (4) applicable rate training manuals. The following sections describe them and give you some practical suggestions on how to use them in preparing for advancement.

Quals Manual

The Manual of Qualifications for Advancement, NavPers 18068-B (with changes), gives the minimum occupational and military qualification standards for advancement to each pay grade within each rating. This manual is usually called the "Quals Manual," and the qualifications themselves are often called "quals." The qualifications standards are of two general types: (1) military qualification standards and (2) occupational qualification standards.

MILITARY STANDARDS are requirements that apply to all ratings rather than to any one particular rating. Military requirements for advancement to third class and second class petty officer rates deal with military conduct, naval organization, military justice, security, watch standing, and other subjects which are required of petty officers in all ratings.

OCCUPATIONAL STANDARDS are requirements that are directly related to the work of each rating.

Both the military requirements and the occupational qualification standards are divided

into subject matter groups; then, within each subject matter group, they are divided into PRACTICAL FACTORS and KNOWLEDGE FACTORS. Practical factors are things you must be able to DO. Knowledge factors are things you must KNOW in order to perform the duties of your rating.

In most subject matter areas, you will find both practical factor and knowledge factor qualifications. In some subject matter areas, you may find only one or the other. It is important to remember that there are some knowledge aspects to all practical factors, and some practical aspects to most knowledge factors. Therefore, even if the Quals Manual indicates that there are no knowledge factors for a given subject matter area, you may still expect to find examination questions dealing with the knowledge aspects of the practical factors listed in that subject matter area.

You are required to pass a Navywide military/leadership examination for E-4 or E-5, as appropriate, before you take the occupational examinations. The military/leadership examinations are administered on a schedule determined by your commanding officer. Candidates are required to pass the applicable military/leadership examination only once. Each of these examinations consists of 100 questions based on information contained in Military Requirements for Petty Officers 3 & 2, NavPers 10056 (current edition) and in other publications listed in Training Publications for Advancement, NavPers 10052 (current edition).

The Navywide occupational examinations for pay grades E-4 and E-5 will contain 150 questions related to occupational areas of your rating.

If you are working for advancement to second class, remember that you may be examined on third class qualifications as well as on second class qualifications.

The Quals Manual is kept current by means of changes. The occupational qualifications for your rating which are covered in this training course were current at the time the course was printed. By the time you are studying this course, the quals for your rating may have been changed. Never trust any set of quals until you have checked it against an UP-TO-DATE copy in the Quals Manual.

Record of Practical Factors

Before you can take the servicewide examination for advancement, there must be an entry

in your service record to show that you have qualified in the practical factors of both the military qualifications and the occupational qualifications. The RECORD OF PRACTICAL FACTORS, mentioned earlier, is used to keep a record of your practical factor qualifications. This form is available for each rating. The forms lists all practical factors, both military and occupational. As you demonstrate your ability to perform each practical factor, appropriate entries are made in the DATE and INITIALS columns.

Changes are made periodically to the Manual of Qualifications for Advancement, and revised forms of NavPers 1414/1 are provided when necessary. Extra space is allowed on the Record of Practical Factors for entering additional factors as they are published in changes to the Quals Manual. The Record of Practical Factors provides space for recording demonstrated proficiency in skills which are within the general scope of the rating but which are not identified as minimum qualifications for advancement.

Until completed, the NavPers 1414/1 is usually held by your division officer for insertion in your service record. If you are transferred before qualifying in all practical factors, the incomplete form should be forwarded with your service record to your next duty station. You can save yourself a lot of trouble by making sure that this form is actually inserted in your service record before you are transferred. If the form is not in your service record, you may be required to start all over again and requalify in the practical factors which have already been checked off.

NavPers 10052

Training Publications for Advancement, NavPers 10052 (revised), is a very important publication for any enlisted person preparing for advancement. This bibliography lists required and recommended rate training manuals and other reference material to be used by personnel working for advancement.

NavPers 10052 is revised and issued once each year by the Bureau of Naval Personnel. Each revised edition is identified by a letter following the NavPers number. When using this publication, be SURE that you have the most recent edition.

If extensive changes in qualifications occur in any rating between the annual revisions of NavPers 10052, a supplementary list of study material may be issued in the form of a BuPers Notice. When you are preparing for advancement, check to see whether changes have been made in the qualifications for your rating. If changes have been made, see if a BuPers Notice has been issued to supplement NavPers 10052 for your rating.

The required and recommended references are listed by pay grade in NavPers 10052. If you are working for advancement to third class, study the material that is listed for third class. If you are working for advancement to second class, study the material that is listed for second class; but remember that you are also responsible for the references listed at the third class level.

In using NavPers 10052, you will notice that some rate training manuals are marked with an asterisk (*). Any manual marked in this way is mandatory—that is, it must be completed at the indicated rate level before you can be eligible to take the servicewide examination for advancement. Each mandatory manual may be completed by (1) passing the appropriate enlisted correspondence course that is based on the mandatory training manual; (2) passing locally prepared tests based on the information given in the training manual; or (3) in some cases, successfully completing an appropriate Class A school.

Do not overlook the section of NavPers 10052 which lists the required and recommended references relating to the military qualification standards for advancement. Personnel of ALL ratings must complete the mandatory military requirements training manual for the appropriate rate level before they can be eligible to advance.

The reference in NavPers 10052 which are recommended but not mandatory should also be studied carefully. ALL references listed in NavPers 10052 may be used as a source material for the written examinations, at the appropriate rate levels.

Rate Training Manuals

There are two general types of rate training manuals. RATING manuals (such as this one) are prepared for most enlisted ratings. A rating manual gives information that is directly related to the occupational qualifications of ONE rating. SUBJECT MATTER

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manuals or BASIC manuals give information that applies to more than one rating.

Rate training manuals are revised from time to time to keep them up to date technically. The revision of a rate training manual is identified by a letter following the NavPers number. You can tell whether any particular copy of a training manual is the latest edition by checking the NavPers number and the letter following this number in the most recent edition of List of Training Manuals and Correspondence Courses, NavPers 10061. (NavPers 10061 is actually a catalog that list all current training manuals and correspondence courses; you will find this catalog useful in planning your study program.)

Rate training manuals are designed to help you prepare for advancement. The following suggestions may help you to make the best use of this course and other Navy training publications when you are preparing for advancement.

1. Study the military qualifications and the occupational qualifications for your rating before you study the training manual, and refer to the quals frequently as you study. Remember, you are studying the manual primarily in order to meet these quals.

2. Set up a regular study plan. It will probably be easier for you to stick to a schedule if you can plan to study at the same time each day. If possible, schedule your studying for the time of day when you will not have too many interruptions or distractions.

3. Before you begin to study any part of the manual intensively, become familiar with the entire book. Read the preface and the table of contents. Check through the index. Look at the appendixes. Thumb through the book without any particular plan, looking at the illustrations and reading bits here and there as you see the things that interest you.

4. Look at the training manual in more detail to see how it is organized. Look at the table of contents again. Then, chapter by chapter, read the introduction, the headings, and the subheadings. This will give you a pretty clear picture of the scope and content of the book. As you look through the book in this way, ask yourself some questions:

● What do I need to learn about this?
● What do I already know about this?
● How is this information related to information given in other chapters?

● How is this information related to the qualifications for advancement?

5. When you have a general idea of what is in the training manual and how it is organized, fill in the details by intensive study. In each study period, try to cover a complete unit—it may be a chapter, a section of a chapter, or a subsection. The amount of material that you can cover at one time will vary. If you know the subject well, or if the material is easy, you can cover quite a lot at one time. Difficult or unfamiliar material will require more study time.

6. In studying any one unit—chapter, section, or subsection—write down the questions that occur to you. Many people find it helpful to make a written outline of the unit as they study, or at least to write down the most important ideas.

7. As you study, relate the information in the training manual to the knowledge you already have. When you read about a process, a skill, or a situation, try to see how this information ties in with your own past experience.

8. When you have finished studying the unit, take time out to see what you have learned. Look back over your notes and questions. Maybe some of your questions have been answered, but perhaps you still have some that are not answered. Without looking at the training manual, write down the main ideas that you have gotten from studying this unit. Don't just quote the book. If you can't give these ideas in your own words, chances are that you have not really mastered the information.

9. Use enlisted correspondence courses whenever you can. The correspondence courses are based on rate training manuals or on other appropriate texts. As mentioned before, completion of a mandatory rate training manual can be accomplished by passing an enlisted correspondence course based on the rate training manual. You will probably find it helpful to take other correspondence courses, as well as those based on mandatory manuals. Taking a correspondence course helps you to master the information given in the training manual and also helps you to see how much you have learned.

10. Think of your future as you study rate training manuals. You are working for advancement to third class or second class right now, but someday you will working toward

higher rates. Anything extra that you can learn now will help you both now and later.

SOURCES OF INFORMATION

One of the most useful things you can learn about a subject is how to find out more about it. No single publication can give you all the information you need to perform the duties of your rating. You should learn where to look for accurate, authoritative, up-to-date information on all subjects related to the military requirements for advancement and the professional qualifications of your rating.

Some of the publications described here are subject to change or revision from time to time—some at regular intervals, others as the need arises. When using any publication that is subject to change or revision, be sure that you have the latest edition. When using any publication that is kept current by means of changes, be sure you have a copy in which all official changes have been made. Studying canceled or obsolete information will not help you to do your work or to advance in rating; it is likely to be a waste of time, and may even be seriously misleading.

This training manual covers only the basic principles of machine operation and control panel wiring for EAM data processing machines, and basic languages, components, and functions for programming and operation of an electronic data processing system (EDPS). While the information contained herein will give you a working knowledge of the equipment and procedures discussed, it does not cover every aspect and feature of any particular type of component or system.

PUBLICATIONS YOU SHOULD
KNOW ABOUT

Each different type of data processing installation where Data Processing Technicians are assigned has a different set of manuals and instructions for operating procedures and guidelines. It is important that you obtain and study the appropriate publications pertaining to the type of work your installation performs.

Technical Manuals

Manufacturers' technical manuals are usually furnished to the activity upon request. These manuals contain detailed information concerning machine operation, including information on optional and special devices with which machines may be equipped.

It is recommended that, in order to broaden your knowledge of the particular device or devices that you are working, you obtain and study the appropriate manufacturers' technical manuals, as these manuals cover in detail the areas covered broadly in the rate training manuals.

TRAINING FILMS

Training films available to naval personnel are a valuable source of supplementary information on many technical subjects. Films that may be of interest are listed in the United States Navy Film Catalog, NavWeps 10-1777, published in 1966. This catalog is now listed in the NavSup Forms and Publications Catalog, NavSup 2002, as NavAir 10-1-777. Supplements to the film catalog carry the latter number.

When selecting a film, note its date of issue listed in the Film Catalog. As you know, procedures sometimes change rapidly. Thus, some films become obsolete rapidly. If a film is obsolete only in part, it may still have sections that are useful, but it is important to note procedures that have changed. If there is any doubt, verify current procedures by looking them up in the appropriate source.

CHAPTER 2

AUTOMATIC DATA PROCESSING

For one person to know all there is to know about existing automatic data processing equipment and systems is virtually impossible and certainly beyond the scope of this course. Automatic data processing encompasses all operations from the collection of raw data to the final preparation of a meaningful report. Data processing systems, regardless of size, type, or basic use, share certain common fundamental concepts and principles. To present a logical association of these concepts and principles, the subject matter in this chapter has been generalized.

Automatic data processing, as we think of it today, normally conveys an image of flashing lights on a computer control panel and the spinning of reels of tape as they convert mountains of facts and figures into understandable terms and language. Facts needed to make decisions, solve formulas and equations make analyses and diagnoses are all part of the expected by-product and end result of data processing.

Development of the modern electronic computer cannot be clearly traced to one, or even a few individuals. Its origins stem from the efforts of literally hundreds of men, including engineers, economists, and mathematicians. From human appendages to knotted strings; from symbols and numbers to the birth of mathematics and record keeping; from the ancient abacus to the slide rule and thence to mechanical calculators and comptometers; from punched cards and electrically powered business machines to the electronic computer; all these developments have phenomenally accelerated men's computational ability. Today, hundreds of business firms, governmental agencies, and the military services are automatically processing data more effectively and more economically than ever before possible.

THE REVOLUTION IN RECORD KEEPING

No one can be certain when counting began, for even ancient man used his fingers and toes to indicate numbers. Down through the centuries, as the science of mathematics was developed, symbols and numbers dispensed with the job of counting things over and over each time, one by one. At the same time, the development of record keeping relieved man's burden of keeping everything in his head.

Pencil and Paper Accounting

As long as businesses were small and communications slow, the bookkeeper (fig. 2-1) took every accounting entry and laboriously updated it, manually entering figures and reaching true balances of business standings. After about 1900, as businesses grew, the books became more complex and the lone bookkeeper could not cope with accounting problems on a manual basis. Since manual data processing was slow and vulnerable to human error, the trend from the earliest stages has been toward the replacement of human efforts even when supplemented by mechanized tools (fig. 2-2).

Key-driven Accounting

The ancestor of today's calculator was a set of numbered rods invented by John Napier in the 17th century. They were called "Napier's Bones," (fig. 2-3) and simplified multiplication. In 1642, Blaise Pascal's "toothed-wheel" adding device, the first calculating machine, had the additional ability to subtract. Refinements to this have resulted in the open market stylus calculators of today. Gottfried Wilhelm and Baron von Leibnitz next invented the first mechanical calculator (fig. 2-3) which could accurately

R49.178X

Figure 2-1.—Pencil and paper accounting.

R49.179X

Figure 2-2.—Key driven accounting.

perform the four arithmetic operations by simply turning its handle in a clockwise or reverse direction. In due time, these rudimentary devices were improved upon and with the advent of the Burroughs simple adding and listing machine in 1890, the age of key-driven accounting rapidly advanced. However, all key-driven devices are operated manually, not automatically. As a result, both their speed and accuracy are limited by the operator's manual proficiency at manipulating the key board.

Punched Card Accounting

To meet the need for more efficient equipment, the makers of business machines revised an old tool for handling paperwork—the punched card. Joseph Jacquard, a French engineer, used it over 200 years ago to operate a loom for weaving cloth in a textile mill. A chain of stiff punched cards, held together by strings, was rotated past needles of the loom. As the cards advanced, the needles which matched the holes in the cards were able to pierce the cards to form a pattern in the woven cloth. This came to be known as the Jacquard Loom.

The punched card idea disappeared until the later 1800s when Dr. Herman Hollerith adapted the theory to a smaller, more convenient card in which information could be punched (fig. 2-4). This was probably the most profound advance in data processing, for it introduced a system which employed for the first time the concept of mechanically stored information. By 1900, Hollerith had developed an automatic electric sorting machine (fig. 2-5), a semiautomatic tabulator, and a keypunch machine. These were forerunners of our present electric punched card data processing equipment which can automatically code, sort, store input, perform calculations, and print output. The only required manual control is classifying data preparatory to punching, starting and stopping machines, and moving cards from one machine in a system to another.

Electronic Data Processing

Electronic data processing (EDP) (fig. 2-6) is accomplished through principles of electronics rather than those of a mechanical or electromechanical nature. The first attempt to build a computer largely independent of operator action was in England in 1830 by Charles Babbage. Though the machine was a failure as a practical accounting device, due to the limited technology of that era, the underlying ideas are similar to those employed in today's computers. In 1944, an electromechanical digital computer, the Mark I, was completed at Harvard University for the U. S. Navy and was controlled by electromagnetic relays. Between 1942 and 1946, the first truly electronic computer, ENIAC, (electronic numerical integrator and calculator shown in fig. 2-7) was constructed at the University of Pennsylvania and substituted electronic vacuum tubes for the electromagnetic relays. During the past decade, the memory sections and processing circuitry of computers have been replaced with magnetic cores and transistors. With all the data processing functions of today virtually self-contained within the computer, little, if any, human intervention is required once the machine is given instructions.

PUNCHED CARD ACCOUNTING

In the census of 1880, data for each person were handwritten on large cards. The cards were then hand-sorted by classifications and manually tallied over and over to produce facts. This cumbersome task was costly and provided no means for checking accuracy. Seven and one-half years were required for the final compilation of census figures.

During the latter part of the 1880 census, Dr. Herman Hollerith was engaged by the United States Government to devise a faster method for

11

1642: PASCAL'S CALCULATING MACHINE. OPERATED BY TURNING WHEELS. THE RESULT APPEARS AT SIGHT HOLES ABOVE, AS IN TODAY'S MACHINES.
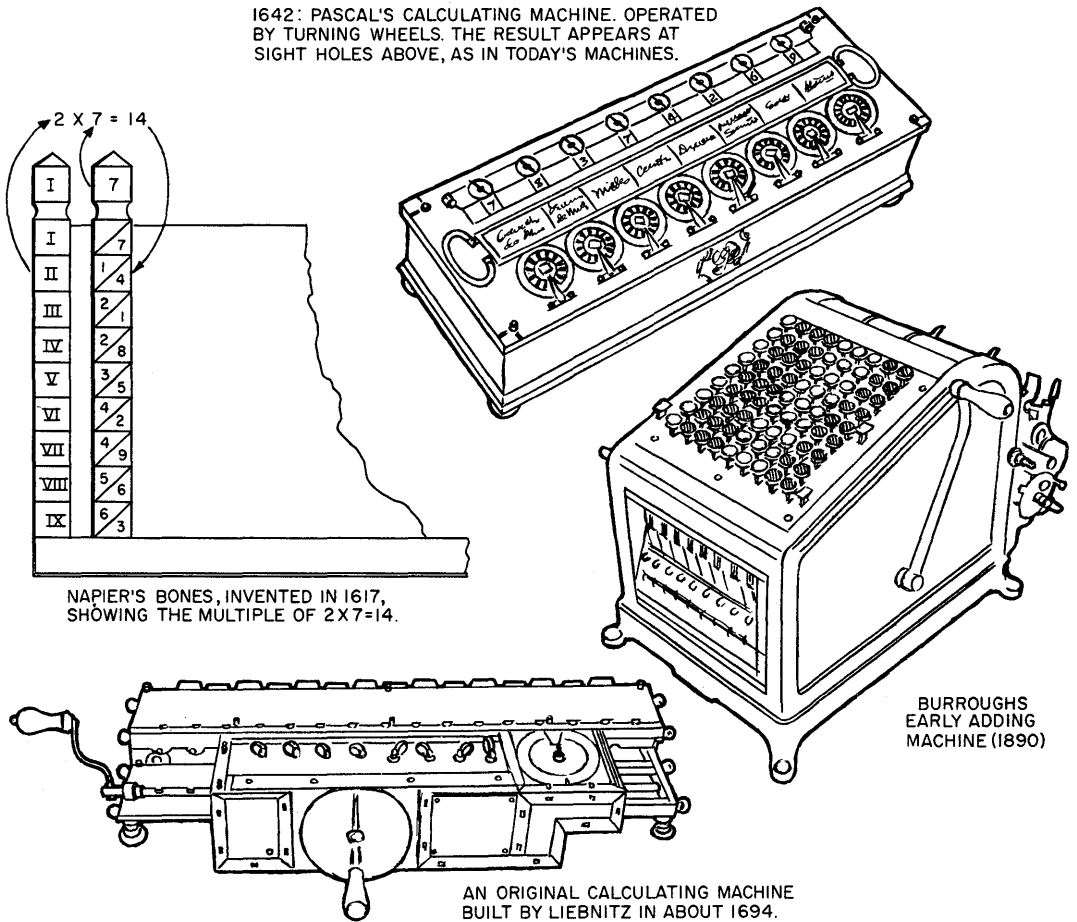
NAPIER'S BONES, INVENTED IN 1617, SHOWING THE MULTIPLE OF 2 X 7 = 14.

BURROUGHS EARLY ADDING MACHINE (1890)

AN ORIGINAL CALCULATING MACHINE BUILT BY LIEBNITZ IN ABOUT 1694.

R49.180X

Figure 2-3.—Advancement of calculating devices.

processing the 1890 census. He worked out a mechanical system of recording, compiling, and tabulating census facts. The operating basis of this system was long strips of paper into which were punched census data in a planned pattern, so that each hole in a specific location meant a specific thing. This new system increased the accuracy of results and reduced the cost and time in preparing the census. Data were available in 2 1/2 years.

For the ease of handling and durability, these paper strips eventually were replaced by cards of a standard size and shape. Following the purchase of Hollerith's Tabulating Machine Company in the early 1900s by the International Business Machine Corporation, further modifications to the card resulted in the one we now recognize as the 80-column card.

Data Processing by EAM

Despite the vast recent increase in the use of electronics, certain areas remain in which the employment of electronic data processing
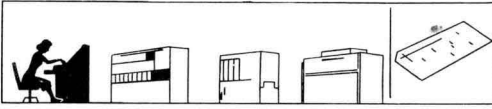
R49.181X
Figure 2-4.—Punched card accounting.

systems is not practicable. In these areas, electric accounting machine (EAM) systems function effectively and provide the answer to mechanized data handling processes. Systems which process data entirely from punched cards are normally referred to as PUNCHED CARD or EAM DATA PROCESSING SYSTEMS. Electrically powered machines so designed that each performs certain processing functions as directed by externally wired control panels (except key-driven and most sorting machines) are classified as ELECTRIC ACCOUNTING MACHINES (EAM). The optimum use of this equipment under precise rules of procedure can minimize clerical operations, standardize methods, and speed up output of records and reports.

The Unit Record

Transferring information from a source document, such as a Personnel Diary or supply requisition into cards, produces individual records of hundreds and thousands of transactions. Once holes have been correctly punched into a
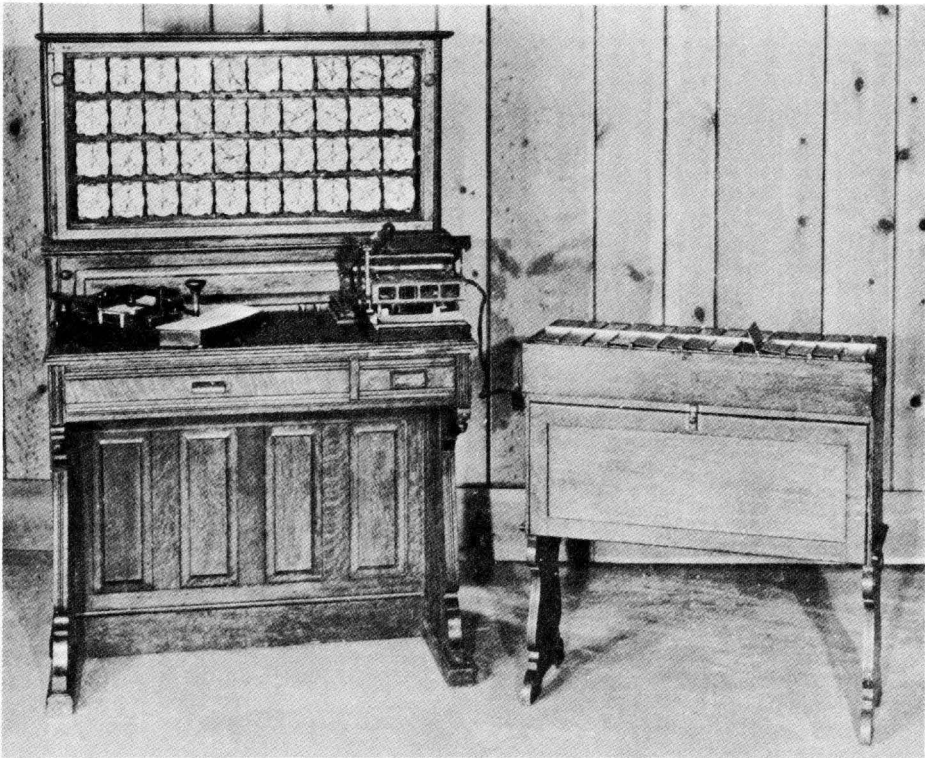
R49.182X
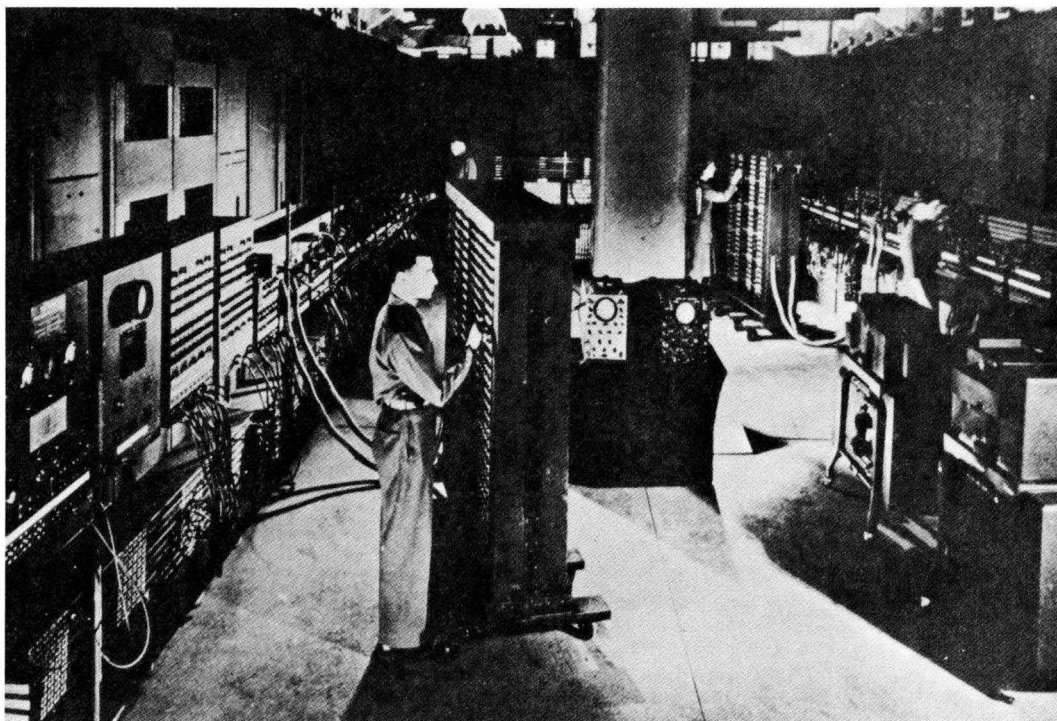Figure 2-5.—Hollerith's early model tabulating machine and sorting box.

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R49.183X

Figure 2-6.—Electronic data processing.

card, that card becomes a permanent UNIT RECORD which may be processed by different data processing machines without losing any of its original information. The punched card is the basic unit of punched card accounting and the basis from which all mechanical data processing applications evolve.

THE PUNCHED CARD

The standard punched card is 7 3/8 inches in length, 3 1/4 inches in width, and .007 inches thick. Cards (fig. 2-8) often contain a corner cut, usually at the top left or right corner of the card. These corner cuts are normally used to identify a type of card visually, or to ensure that all cards in a group are facing the same direction and are right side up.

The card is divided into 80 vertical columns, called card columns. These are numbered 1 to 80 from left to right. Each column is then divided into 12 punching positions which form 12 horizontal ROWS across the card. The punching positions are designated from the top to the bottom of the card by 12, 11 (often referred to as X), 0, 1. 2, 3, 4, 5, 6, 7, 8, and 9. (See col. 8 of fig. 2-8). The 0 through 9 punching positions correspond to the

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Figure 2-7.—ENIAC, the first all-electronic digital computer.

14
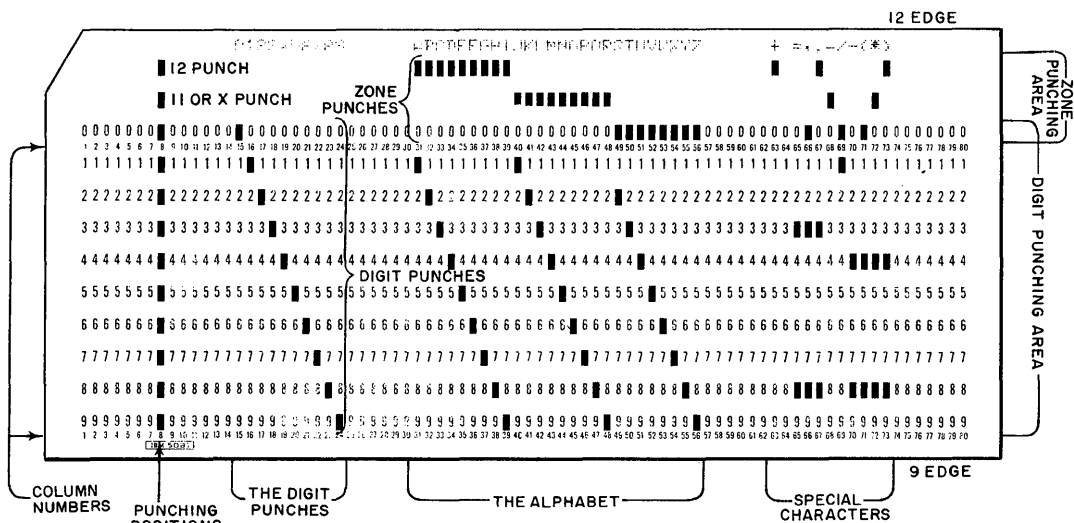
Figure 2-8.—Card punching codes.

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numbers printed on the standard stock card. The 12 and 11 punching positions normally are not printed on the card, as this area is generally reserved for printed headings or for interpreting punched information.

Since one or more punches in a column represent a character, the number of columns used depends on the amount of data to be punched. If a record requires more than 80 columns to hold its data, two or more cards may be used. However, continuity between cards of one record must be established by punching identifying information in a particular column of each card.

The top edge of the card is known as the "12" EDGE, and the bottom edge as the "9" EDGE. The manner in which cards are placed in machines is governed by their respective feeding requirements. Therefore, cards are fed either 12 edge first or 9 edge first, and either FACE UP (which means the printed side of the card is facing up) or FACE DOWN, meaning the opposite. Cards are read and punched by machines either row by row (digit by digit), or column by column. Figure 2-9 illustrates how cards pass the punching mechanism of card punches column by column. First, column 1 is punched, followed by column 2, and so forth. Since only one column at a time is covered by

the punching mechanism, which is capable of punching any of the 12 positions or combinations thereof, it is referred to as SERIAL punching. Figure 2-9B shows how cards fed either 1 or 9 edge first, are actually fed on a row by row basis, resulting in all like digits being punched at the same time. This is due to the fact that this type of punching mechanism (e.g. IBM 514 reproducing punch) is equipped with 80 punch dies or magnets, one for each card column. Thus, if fed 12 edge first, all 12's, then 11's, and so on are punched as the card moves forward, or all 9's, 8's, and so on through 12's are punched if fed 9 edge first. This is PARALLEL punching.

Card Language

The standard card language, commonly referred to as the Hollerith code, uses the 12 punching positions of a vertical column to represent numeric, alphabetic, or special character punching. These 12 positions are divided into two areas known as numeric and zone. The first nine punching positions from the bottom edge of the card are the NUMERIC or DIGIT positions of 9 through 1. The remaining 0, 11, and 12 are the ZONE positions. (The 0 is used interchangeably to represent a zone punch or numeric punch.)
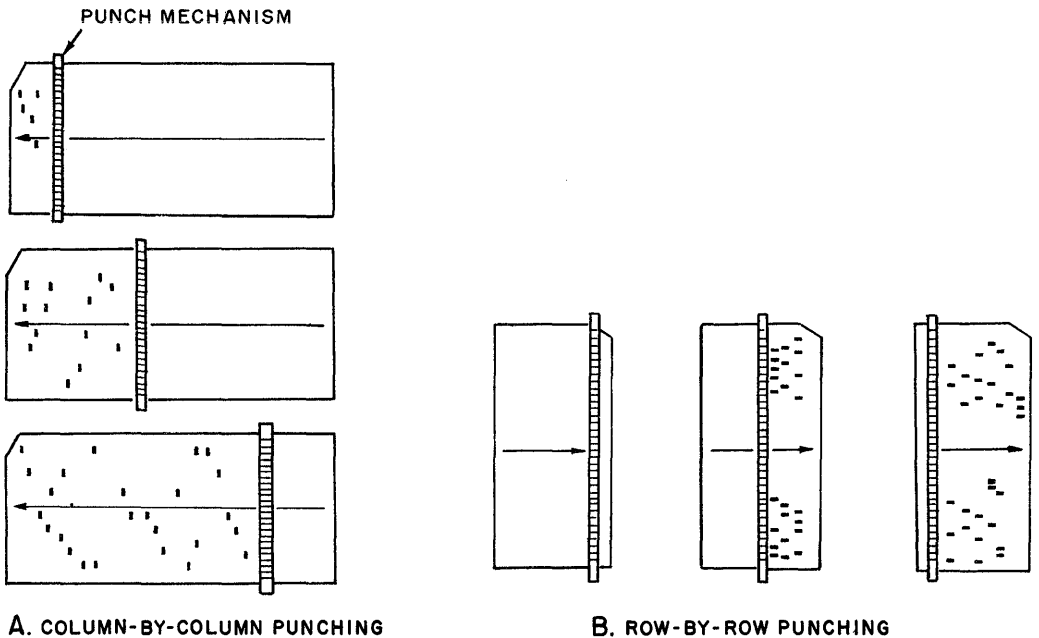
15

PUNCH MECHANISM

A. COLUMN-BY-COLUMN PUNCHING   B. ROW-BY-ROW PUNCHING

49.221X

Figure 2-9.—Punching the card.

Numeric.—Rows 0 through 9 are used to store the 10 decimal digits and are represented by a single punch in a particular column. For example, a single punch in the 0 zone position would represent an assigned numeric value of zero.

Alphabetic.—To accommodate any of the 26 letters in one column, a combination of a zone and digit punch (under-punch) is used. The alphabet is divided into three groups and each group is identified with one of the three uppermost rows, or zones. The first nine letters of the alphabet, A through I, use a 12 zone punch and a numeric punch of 1 through 9, respectively. The 12 punch indicates that the character in that column lies in the first group of nine letters of the alphabet. A punch in any of the 1 through 9 rows of the same column specifies which letter of the nine is represented. (Thus 12 and 1 represent A, 12 and 2 represent B, etc.) The second group of nine letters, J through R, use the 11 zone punch and a numeric punch 1 through 9, respectively. (Thus 11 and 1 represent J, 11 and 2 represent K, etc.) Since only eight letters are left for the 0 zone, letters S through Z are represented by the 0 zone punch and a numeric punch 2 through 9, respectively. Examining figure 2-8, you will see that the 0-1 combination represents a special character. It should be noted that when the 0 punch is combined with a digit under-punch to represent an alphabetic character, it is then considered a zone punch.

Special Characters.—These characters provide printed symbols, cause certain machine operations to occur, and identify various cards. Standard special characters consist of one, two, or three punches in a card column but differ from the configurations used to represent numeric or alphabetic characters.

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What the Punched Hole Will Do

Information recorded as punched holes in specific locations on standard size cards is converted into the electrical (or electronic) language of the processing equipment through which it is fed. The arrowhead of figure 2-10 lists the various capabilities of the punched hole. However, to do any of these, data must be punched according to standard arrangements.

Card Fields.—Specific columns on the card, called FIELDS, are grouped and reserved for facts relative to each transaction. For example, a card would have one field assigned for punching name, another for punching

WHAT THE
PUNCHED HOLE WILL DO

1 It will add itself to something else.
2 It will subtract itself from something else.
3 It will multiply itself by something else.
4 It will divide itself into something else.
5 It will list itself.
6 It will reproduce itself.
7 It will classify itself.
8 It will select itself.
9 It will print itself on the IBM card.
10 It will produce an automatic balance forward.
11 It will file itself.
12 It will post itself.
13 It will reproduce and print itself on the end of a card.
14 It will be punched from a pencil mark on the card.
15 It will cause a total to be printed.
16 It will compare itself to something else.
17 It will cause a form to feed to a predetermined position, or to be ejected automatically, or to space from one position to another.

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Figure 2-10.—Capabilities of the punched hole.

service number, another for punching service abbreviation, and so on. The number of adjacent columns reserved for a field is dependent upon the MAXIMUM number of characters, or numbers, of each item appearing on the source document that is to be punched. Thus, a field could

consist of from 1 to 80 card columns. Without this grouping of information into fields, classifying, comparing, and other machine processing functions would be severely hampered and in most cases, impossible. (See fig. 2-11.)
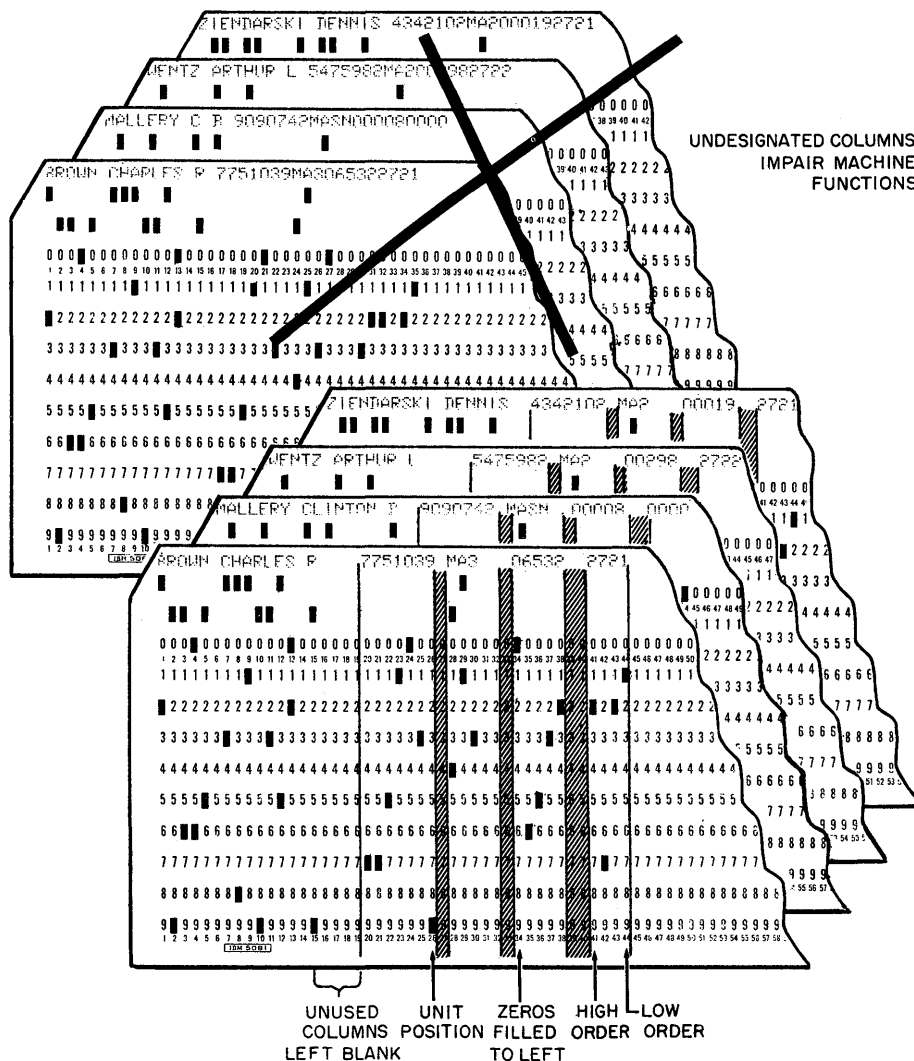

Figure 2-11.—Card fields facilitate machine processing.

49.223

Field Positions.—From right to left, the positions in each field are known as the units position, tens position, hundreds position, and so on. The extreme right position of a field is also called the LOW ORDER position, and the extreme left position is the HIGH ORDER position. When punching numerical fields, the punching is from left to right, with the units position of the number punched in the low order position of the field. If the number to be punched is shorter than the columns allowed in the field, zeros may be added to the left of the number to complete the field. Punching of alphabetic fields starts in the high order position and continues until the last letter is punched. Unused columns of the field are left blank.

Types of Cards

Generally speaking, cards are categorized by their manner of preparation. They are as follows:

1. TRANSCRIPT cards are punched from data previously recorded on another document. As a general rule, they consist of detail and master cards keypunched from a source document, such as a Personnel Diary.

2. DUAL cards are punched from data recorded on the card itself. Thus, they serve the dual purpose of both source document and processing medium.

3. MARK-SENSE cards are punched automatically from graphite markings recorded manually on the card itself. This type of card is especially suited to the recording of quantities and values. Machines known as reproducers, equipped with amplifying units to strengthen the electrical impulses created when the machine senses the marks, punch the recorded data into the card. Markings must be accurate, however, and cards unbent to ease machine processing.

4. OUTPUT cards are machine created as a result of processing and could include summary cards, new detail cards, or updated files. These cards undergo additional processing or replace outdated cards in a file.

5. SPECIAL cards are those that enable on-the-spot punching of data, such as the IBM port-a-punch card, which is a card punched from a portable device at a place remote from the data processing installation.

Patterns of Card Design

Variously designed cards reflect the wide variety of applications of punched card accounting. Seldom do different installations use identical card forms. Designing cards will normally be of little concern to you at your present rating level. However, being familiar with some of the patterns of card design will further your understanding of punched card applications. Figure 2-12 depicts a standard multiple card layout form used in designing one or more cards. This is especially helpful in aligning information common to more than one card.

Determination of Data.—Following are some of the factors considered when deciding what data should be recorded in the card, and where it should be placed to meet contemplated procedures:

1. Requirements for the final preparation of finished reports are of utmost importance. All information to be listed must be included in the card, unless it is to be calculated, emitted, or summarized.

2. The sources of original information are examined for desired data. Sometimes, other data must be substituted, a different type of card used, or certain available data (though not presently needed) included in the card for future planning.

3. Once data requirements have been decided, the principle of alignment is considered. Machine processing requires a consistent arrangement of data in cards. Common types of information, therefore, are placed in corresponding columns of all cards. For instance, if service number is punched in columns 20-26 of all current personnel cards, then service number is placed in the same columns of any new card. This facilitates control panel wiring and eases sorting and controlling operations when various cards are used together.

4. Information is punched in the card in the sequence that it appears on the source document. Keypunching is speeded when card fields are aligned to permit punching in unison with the left to right or top to bottom reading of a document.

5. Each field of a card is assigned a method of punching (keypunched, duplicated, summary punched, gangpunched, or calculated) so that all like punching operations can be grouped together. This simplifies wiring, enables operators to take advantage of various machine characteristics, and eases other processing techniques.

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MULTIPLE LAYOUT FORM
FOR ELECTRIC ACCOUNTING MACHINE CARDS
INTERPRETER SPACING

BRANCH OFFICE NO. *EAM ROOM*

FORM 374-4823-3-END.

DATE *15 JUNE, 66*

1. ELECTRO NUMBER

PROJECT CODE   PROJECT NAME   MACH   PROD   CODE NO.   LOST   TOTAL

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2. ELECTRO NUMBER

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3. ELECTRO NUMBER

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5. ELECTRO NUMBER

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6. ELECTRO NUMBER

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

CUSTOMER'S NAME & NO. _____

ADDRESS _____

49.148

Figure 2-12.—Multiple card layout form.

Types of Information.—All items of information placed in the card can be classified by any of the following three types:

1. REFERENCE identifies the original source document from which it was created, such as name, date, batch number, or activity processing code. The size of a reference field is determined by the largest single number item to be recorded. For example, names, can usually be recorded in 20 columns or less.

2. CLASSIFICATION cross indexes, classifies, or identifies a particular item on the source document, such as service number, part, or stock number, and social security number. Field size is readily established, as a set number of columns are always required.

3. QUANTITATIVE information consists of totals punched in the card that are to be added, subtracted, multiplied, or divided, such as quantity on hand or unit price. A realistic assignment of columns for totals can be made only if the maximum size of expected totals is known. Total fields are set up to take care of all but the unusual cases, and these are handled by punching extra cards for the overflow total. Assigning too many columns to a total field results in a waste of card columns, while a field that is too small requires punching of too many extra cards for overflow totals.

Information Arrangement

When determining the position of information on cards by the type of information, consideration is usually given to the following arrangements: reference information is placed to the left of the card; classification information in the center; quantitative information to the right of the card.

To take further advantage of punched card accounting methods and equipment, other factors affecting information arrangement are borne in mind, such as:

1. Grouping fields to be duplicated together.

2. Keeping manually punched fields from being interspersed among duplicated, gang-punched, reproduced, or summary punched fields.

3. Aligning fields to be skipped (not punched) in a uniform pattern on all card forms.

4. Placing numerical fields together to speed keypunching and lessen operator fatigue.

5. Locating fields to be visually checked near the right or left margin.

6. Restricting the size of fields to the number of columns absolutely essential for efficient handling of transactions.

7. Placing control fields adjacent to one another to simplify wiring and sorting operations.

Priority Arrangement

Though we have discussed various patterns of card design in a somewhat logical order of importance, conflicts sometimes arise due to varying installation requirements. When this happens, good judgment must be exercised to resolve matters on a priority basis. The four major considerations used to decide card data sequence, in the order of their priority, are recommended as follows.

1. The location of information identical or common to all cards.

2. The sequence of data on source documents from which it will be punched.

3. The methods of punching and machines to be used during processing.

4. Types of information and manual card operations.

TOOLS OF PUNCHED CARD ACCOUNTING

How do we explain the word "tool" with regard to data processing? Machines differ from tools, as a tool is heavily dependent on the energy and skill of its user, and generally speaking, machines perform tasks with a minimum of human participation or intervention. Since some types, however, require the efforts of skilled operators, they are thought of as machine tools. Therefore, because the effective use of EAM machines is restricted by the level of human efficiency in operating them, they can be referred to as the tools of punched card accounting.

Raw Data to Input Data

Coding systems have been devised using letters, numbers, or both, (although numeric codes predominate) to identify information appearing in raw form on source documents. The proper application of these codes to the source document eases the subsequent punching and handling of card data during machine processing.

Machine Conversion of Data

Since the card introduces information to the machines, it may also be considered a conveyor of data. The holes are READ by the machines in a fashion similar to the weaving pattern of the Jacquard Loom; that is, electrical contact can only be made exactly where punched holes are located, just as the needles of the Jacquard Loom pierced the holes of its card only at given spots.

The passage of the cards between brushes and electric contact rollers at specific times in the cycle of a machine, convert the punched holes into timed electrical impulses which are machine processable.

Machine Processing of Data

The reading and conversion of data into electrical impulses by a machine, together with a properly wired external control panel, enables the punched card data to be processed. The machine receives its instructions from the control panel which affords processing flexibility and diversity in jobs. The type of machine used

and the desired end results determine the type of processing the data undergoes. For instance, the control panel of an electric accounting machine could tell the machine what data was to be accumulated and when to print totals. (See fig. 2-13.)

Machine Output of Data

The results of processing are also in the form of electrical impulses and these too are converted into output form. Once again, dependent upon the type of machine used, the output form may be a machine function, holes punched into the same or other cards, printed lines of information, or any combination of these. It

READING BRUSH
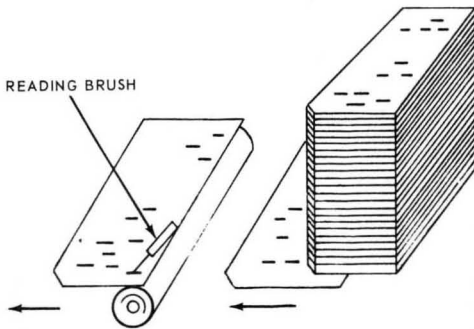
1. CARDS BEING READ AS THEY PASS BETWEEN A BRUSH AND AN ELECTRIC CONTACT ROLLER.
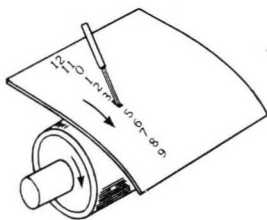
2. ELECTRICAL CONTACT IS MADE ONLY WHERE PUNCHED HOLES ARE LOCATED.

3. THE WIRED EXTERNAL CONTROL PANEL AFFORDS THE FLEXIBLE PROCESSING OF PUNCHED CARD DATA.
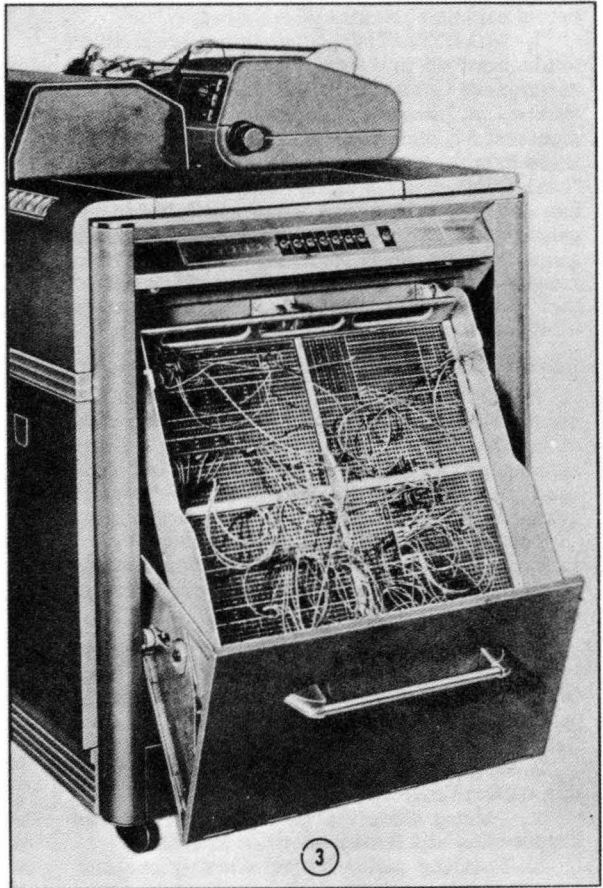
R49.3X

Figure 2-13.—Machine conversion and processing of data.

must be remembered, however, that output capabilities are limited, for most EAM equipment will accept but one file of cards as input and will produce only one result. There are a few exceptions, of course, such as a collator, which will accept two files of cards at the same time and manipulate these cards into one or several groups. Another is the alphabetic accounting machine, which, when connected by a cable from an automatic punch, creates both a printed report and punched summary cards during the same operation.

Basic Unit Record Equipment

Of all the types of data processing tasks performed by punched card accounting systems, three are basic: recording data, classifying or arranging data, and summarizing data. Commensurate with these tasks are several types of basic unit record equipment. They are categorized as such because they are a MUST in all EAM systems to carry out the aforementioned basic tasks. Figures 2-14 through 2-22, depicting punched card equipment, illustrate Remington Rand UNIVAC and IBM models that are comparable to one another in design, purpose, and function.

Card Punches.—The basic method of RECORDING data or converting source data into punched cards (fig. 2-14) is through keypunching, a method whereby the operator reads a coded source document and presses the keys of a keyboard to punch the data into cards. This operation is similar to typing and is done on a keypunch, often called a card punch. Since various other machines will act on information supplied by these punched cards, the transcription of data into the cards must be accurate.

The CARD VERIFIER (fig. 2-15) is used to check the accuracy of the original keypunching, but since there are manual ways of verifying punched card data, this machine is not normally considered one of the basic unit record machines. While reading from the source document from which the data was initially punched, a second operator verifies the punched data by depressing the keys of a verifier. Each key pressed is automatically compared with the hole already punched in the card and any difference causes the machine to stop.

Sorters.—The end result of punched card accounting is usually a printed report. Information in these reports is invariably grouped according to some definite sequence or arrangement of unit records. Since cards produced by card punch operators are seldom in any particular order, this CLASSIFYING or arranging of cards is performed on a card sorter (fig. 2-16). Although sorting cards to a particular sequence is the major function of a card sorter, certain types of selection of individual cards that require special attention can also be automatically accomplished.

Accounting Machines.—The basic function of the accounting machine (fig. 2-17) is the conversion of punched card data into printed statements and reports. The ability to print and total or SUMMARIZE information by classifications of punched card data, is made possible by its comparing and selecting techniques and by its mathematical capability of adding and subtracting. Through the function of DETAIL PRINTING or LISTING, complete details of individual transactions can be shown. Of equal importance is the function of GROUP PRINTING, which permits the summarization, identification, and printing of totals for groups of cards. As the accounting machine prints a report, accumulated totals can also be punched into a card or cards in a reproducing machine. This operation of punching one card to represent the total of a particular group cf cards is known as SUMMARY PUNCHING and requires additional control panel wiring plus the connecting of a cable from the reproducer to the accounting machine. (fig. 2-18.)

Because all equipment in an EAM card system prepares cards for end-of-the-line processing in the accounting machine, the latter is considered the heart of a punched card data processing system. The name tabulator, which is sometimes shortened to tab, is synonymous with accounting machine.

Auxiliary Unit Record Equipment

In addition to the three basic types of machines used in an EAM system, machines in other categories have been developed to perform data processing needs of an auxiliary nature. These machines speed processing functions and lessen human effort but are NOT always essential for a system's output.

Interpreters.—The interpreter (fig. 2-19) translates the punched holes into printed information on the face of the card thereby increasing the use of the card as a documentary
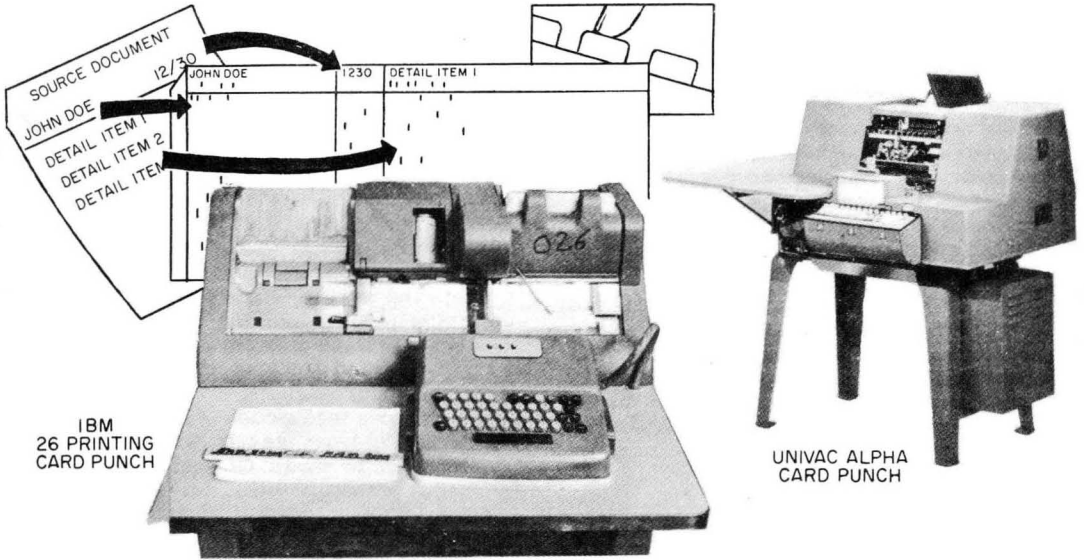
R49.193X

Figure 2-14.—Converting source data to punched cards.

R49.5X
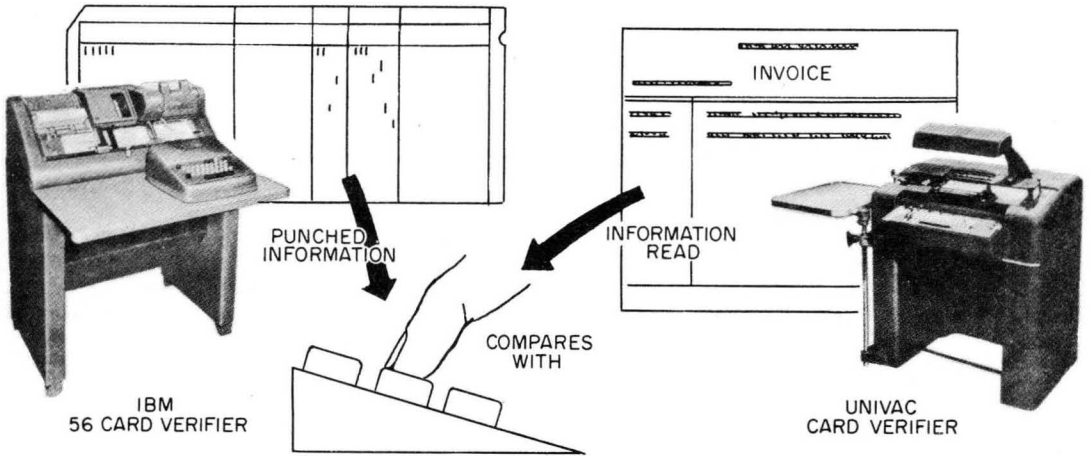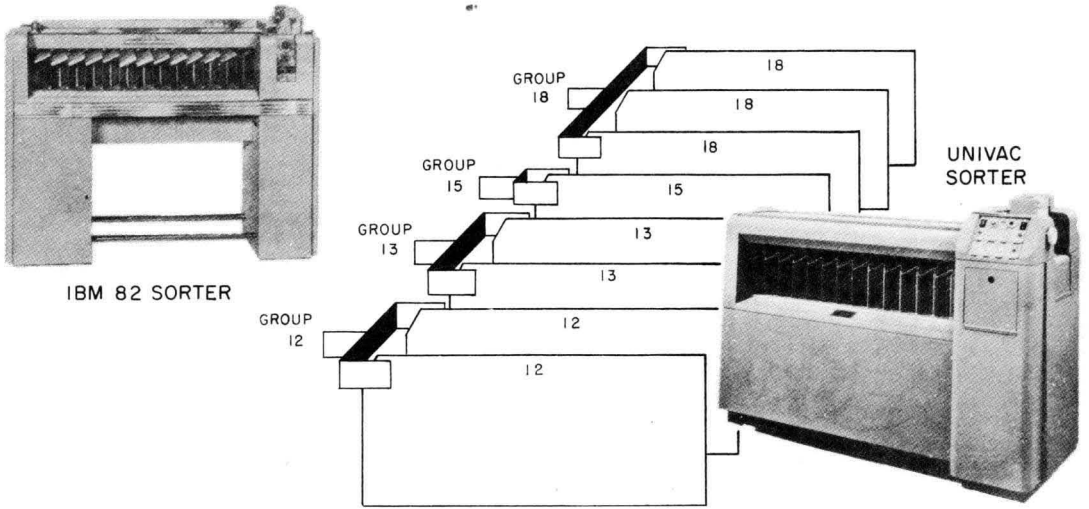
Figure 2-15.—Checking the accuracy of the original keypunching.
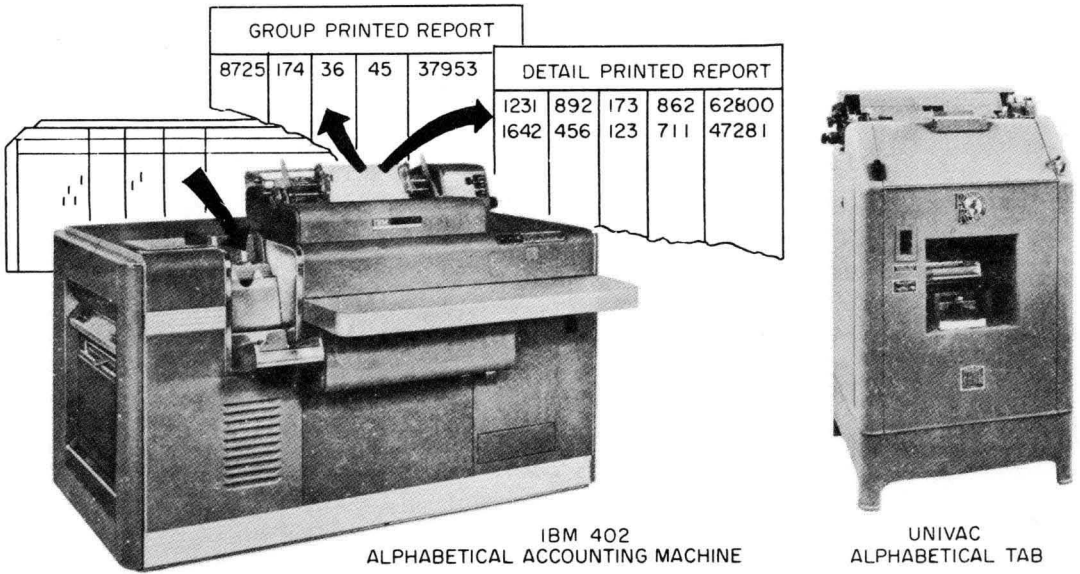
Figure 2-16.—Grouped cards in a definite sequence.
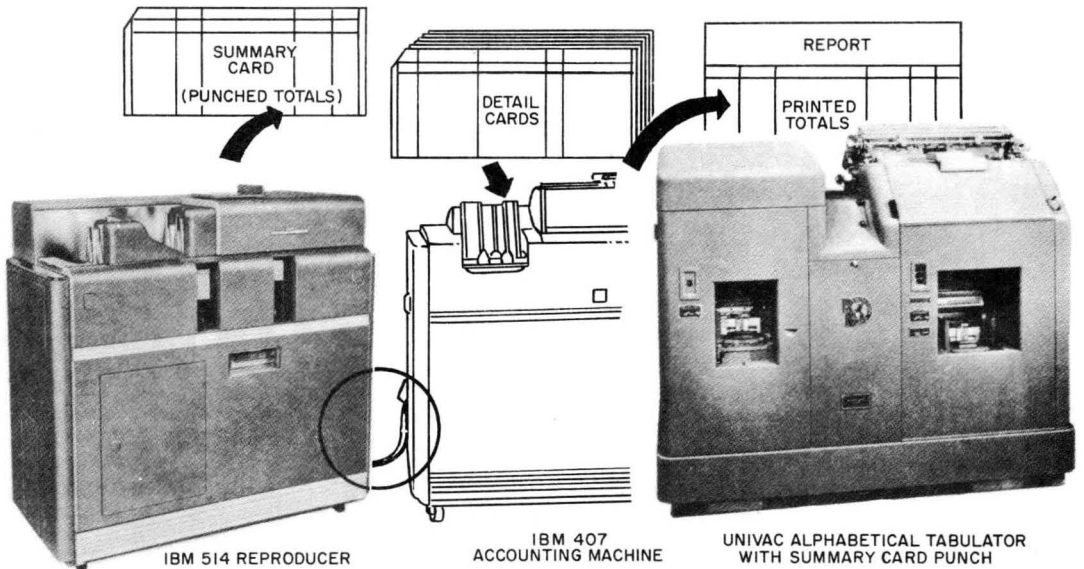

Figure 2-17.—End of the line processing.

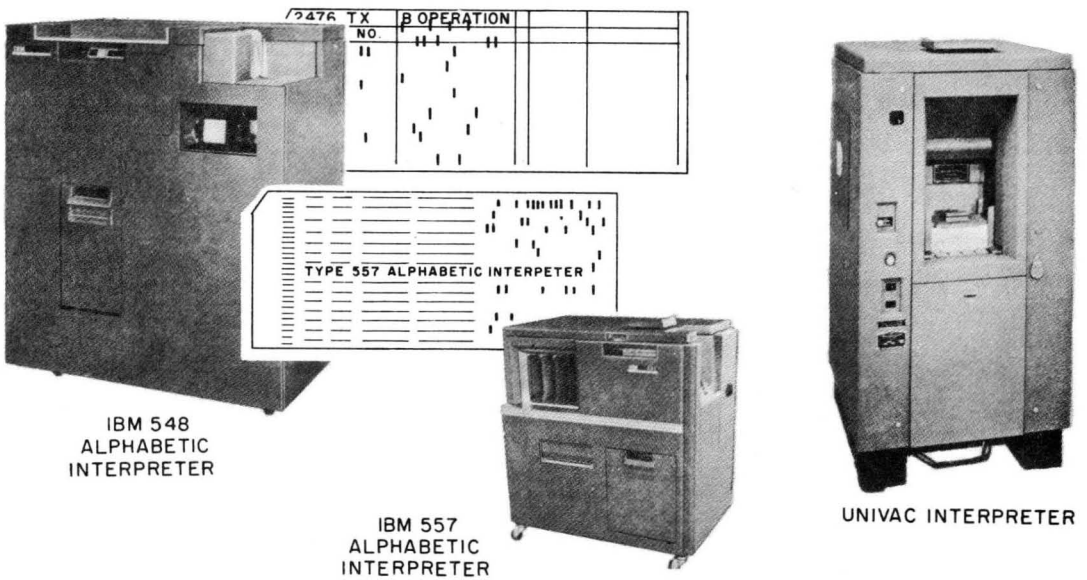Figure 2-18.—Summary punching grouped information.

R49.194X

Figure 2-19.—Translating punched holes into printed information.

R49.20:.29X

recording medium. Normally, interpretation appears at the top of the card, but some interpreters can print information on any of 25 designated lines. Although skilled operators can translate punched information into correct digits and characters, interpretation is required when visual reference must be made to punched card data files.

Reproducers.—When information is recorded in the form of holes in a card, all or part of the information is sometimes desired in another set of like cards (fig. 2-20). In preference to manually rekeying information into new cards on the keypunch, maximum efficiency can be achieved in the copying of one unit record to another card through the use of the reproducer or document originating machine. This process of punching any or all of the information from one set of cards into another is known as REPRODUCING. Other primary functions of automatic reproducers are: GANG PUNCHING (fig. 2-20), the oper-

ation of punching information from a single master card into detail cards; SUMMARY PUNCHING, the punching of total cards with amounts accumulated in the accounting machine and MARK SENSING, the automatic transmission of pencil marks into punched holes.

Collators.—Development of the basic unit record equipment for EAM systems (fig. 2-21) was brought about by the pressing need for speed and accuracy. However, jobs performed by these machines are sometimes overlapped by those that others can do, adding the advantages of versatility and convenience of interspersed operations to auxiliary equipment. Sometimes data required for printing operations on the accounting machine must be obtained from two or more card files. This MERGING, or combining two sets of punched cards into one of a given sequence to satisfy the needs of the tabulator, could be performed on the sorter but for quicker

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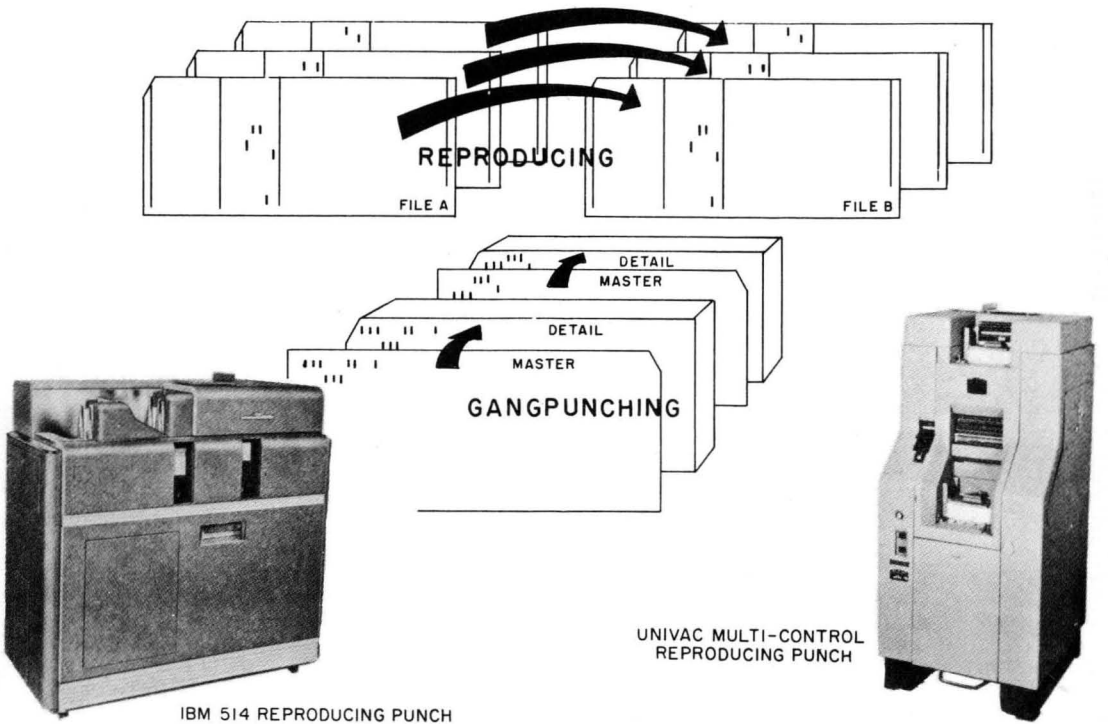
Figure 2-20.—Automatic reproducing and gang punching.

27

MATCHING

UNIVAC COLLATOR

IBM 085 COLLATOR

SELECTING

MERGING
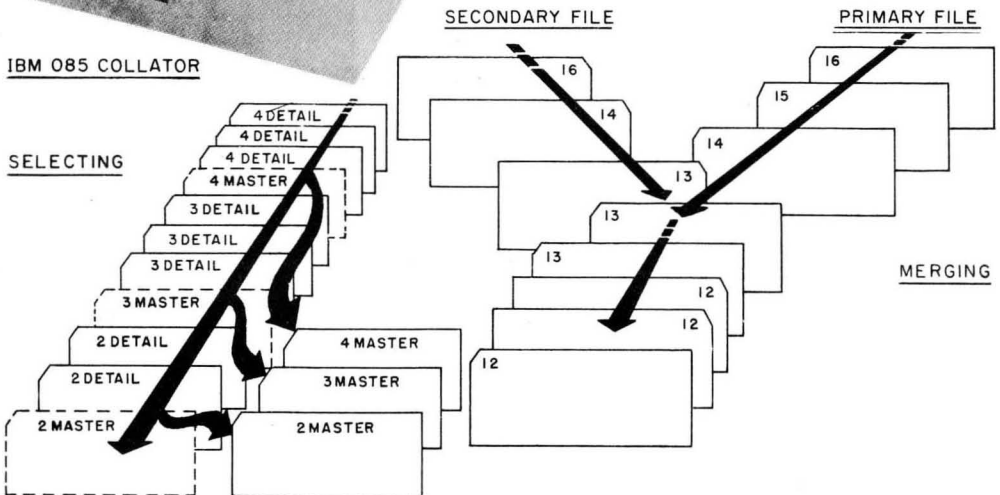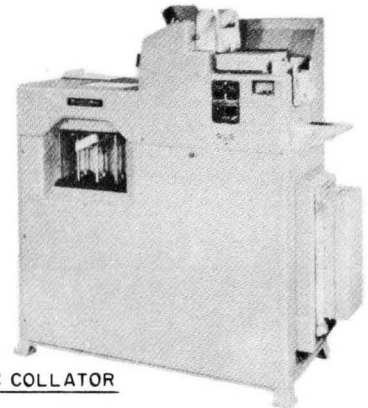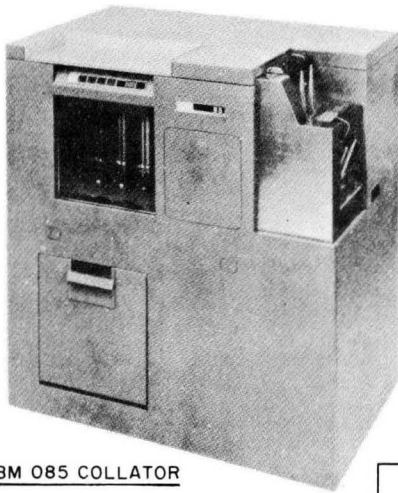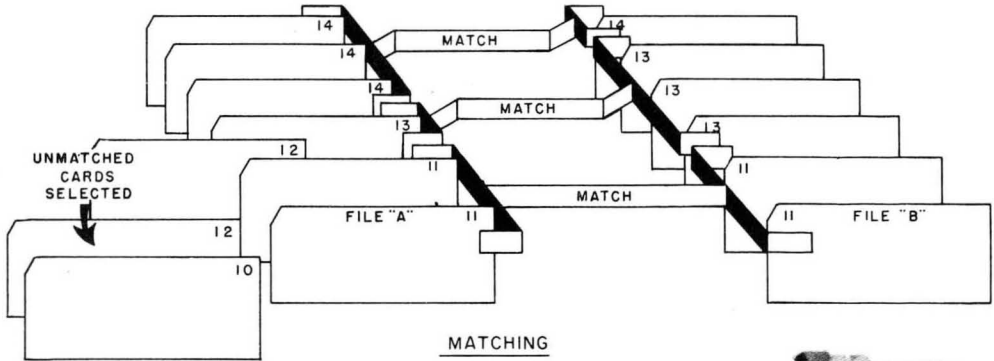
R49.53X

Figure 2-21.—Filing machines that arrange cards for subsequent operations.

and more accurate results, the collator is generally used. Peak workloads and periods of machine breakdown will also affect this overlapping of jobs between basic and auxiliary machines. Additional collator functions include MATCHING, which is checking the agreement between two sets of cards; SEQUENCE CHECKING cards of an ascending or descending sequence and various types of CARD SELECTION.

Electronic Unit Record Equipment

There are certain properties common to electronic computing equipment such as magnetic core storage, resistors, and solid-state circuitry that are not associated with electro-mechanical equipment. Also, the internal storage of programmed computer instructions is in direct contrast to the wired external control panels of EAM equipment. This capacity to store instructions internally is the most distinguishing feature of electronic data processing equipment.

UNIVAC 1004 Card Processor.—One example of electronic computing equipment which has characteristics of both EAM and EDP, and is now being utilized within punched card EAM systems, is the Univac 1004 card processor (fig. 2-22). This equipment eliminates intermediate processing operations by consolidating into a single unit, three data processing functions: card reading, arithmetic processing, and printing—at speeds never before associated with tabulating installations. Punched card output is available through the inclusion of a cable connected card punch to the card processor.

The 1004 is a solid-state electronic machine, which means that it conveys and controls electrons within solid materials such as transistors. Magnetic core storage is provided for input and output data and the results of mathematical computations, but NOT for the storage of programmed instructions. Though more complex than EAM equipment, it is under the control of a series of instructions wired on a control panel and, therefore, is considered punched card equipment. You will, however, find the 1004 used with magnetic tape input and output and as card and printer peripherals of large computer processing systems.

FUNDAMENTALS OF EAM ACCOUNTING

Applying what you have learned about card language and design to actual accounting prac-

tices through the use of EAM equipment will provide you with a more complete picture of punched card accounting.

Basic Principle

The basic principle of punched card accounting is that information, once recorded in punched cards, may be used time and time again. Data is punched and verified and may then be classified (sorted) and summarized to produce desired results through machine processing. (See Fig. 2-23.)

Basic Elements

Recording.—Transactions of an installation involve essential information vital to management. In processing data, single transactions must appear in numerous records. Under the manual methods of accounting, each time information is used, it must be copied and checked. Machine accounting affords mechanical and automatic means of recording transactions which enable them to be read and transcribed by other machines. Recording is done by keypunching each transaction into a single card, offering the advantage of producing permanent records for automatic processing. This recording corresponds to a single entry made manually under other methods of accounting.

To ensure consistency of common data, such information is often DUPLICATED. This card punch function allows the operator to punch a field of common information once in the first card of a group; henceforth, the card punch will automatically punch it into the remaining cards of the group.

Classifying.—One transaction sometimes affects more than one account, or many transactions will affect but one account. Grouping these like items of information, or transactions, as a preliminary step toward report preparation, is a slow and tedious task when done manually.

Under the punched card accounting system, the machine solution to this problem of classifying or arranging transactions is the high-speed sorting machine. This machine groups cards in numeric or alphabetic sequence according to any classification punched in them. Thus, a fast automatic method is provided to classify and reclassify transactions for file or account processing and to facilitate their use in various reports—reports that use the same cards, but each requiring a different sequence of grouping of transactions.
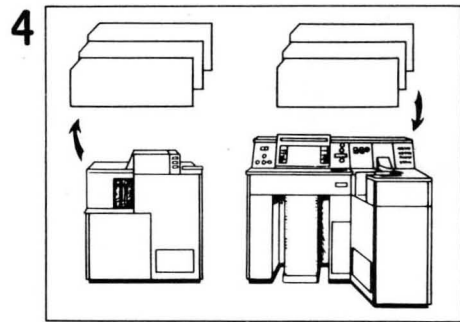
29

1

TWO-FILE READ ONLY

3

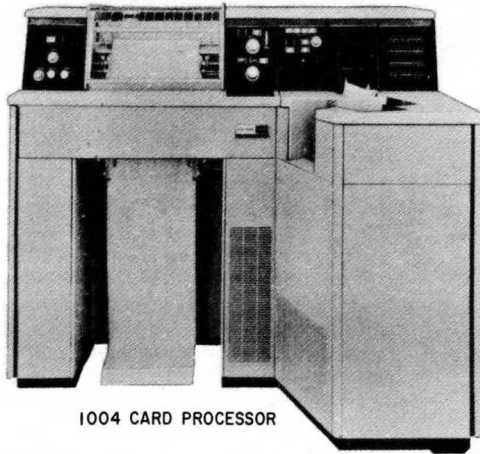READ-PUNCH ONE FILE
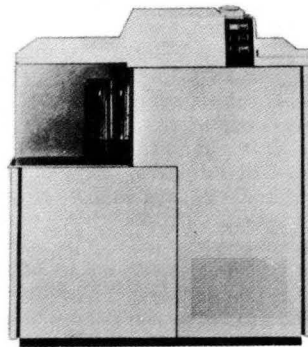
2
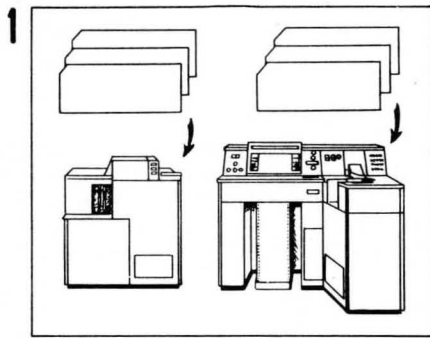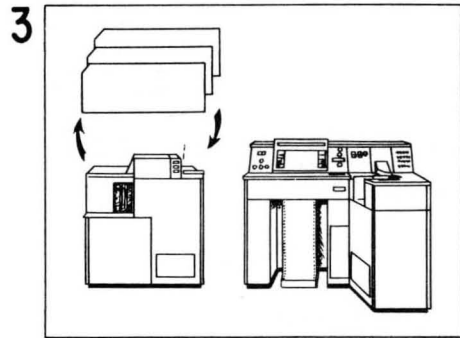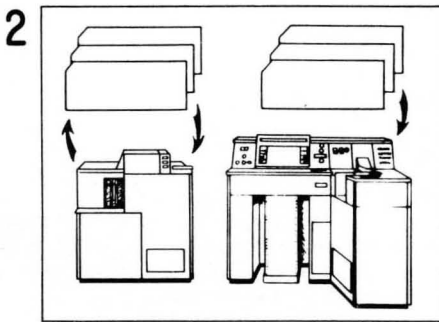
TWO-FILE READ—PUNCH ONE FILE

4

PUNCH ONLY

VARIABLE APPLICATIONS OF THE OPTIONAL CARD READ PUNCH

1004 CARD PROCESSOR

CARD READ PUNCH

READER, PRINTER AND PROCESSOR WITH 961 CHARACTERS OF CORE STORAGE ARE HOUSED IN ONE UNIT.

49.196X

Figure 2-22.—The UNIVAC solid-state electronic 1004 card processor.
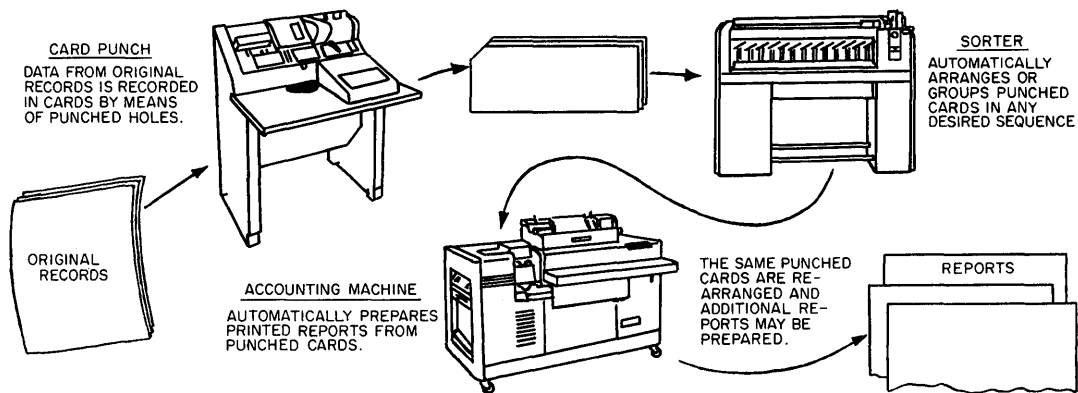
CARD PUNCH
DATA FROM ORIGINAL RECORDS IS RECORDED IN CARDS BY MEANS OF PUNCHED HOLES.

SORTER
AUTOMATICALLY ARRANGES OR GROUPS PUNCHED CARDS IN ANY DESIRED SEQUENCE

ORIGINAL RECORDS

ACCOUNTING MACHINE
AUTOMATICALLY PREPARES PRINTED REPORTS FROM PUNCHED CARDS.

THE SAME PUNCHED CARDS ARE RE-ARRANGED AND ADDITIONAL RE-PORTS MAY BE PREPARED.

REPORTS

49.225

Figure 2-23.—Principle of punched card accounting.

Summarizing.—The final step in any accounting procedure is the summarization of information to produce final reports and required records. Summarization includes not only accumulating totals of grouped transactions, but also the printing of these totals with identification data such as names and codes necessary for their proper interpretation. As transactions occur and are posted to accounts during a given period, totals are eventually taken and manually recorded on printed forms and documents.

Automatic detail listing and group printing accounting machines replace the above manual methods. These machines electrically sense group changes within series of cards and, as a result, subtotals within a report and numerical or alphabetical descriptions of the totals can be printed automatically. Also, many combinations of totals can be printed, involving adding, subtracting, and crossfooting operations, with totals of a given group subdivided and distributed horizontally across the report form. Vertical columnar totals are also possible. Cards may be re-sorted to various group arrangements and resummarized by machine until all necessary totals have been taken. Because machine functions are flexible, many types of accounting and analytical reports can be produced. Figures 2-24 through 2-26 illustrate the above three basic elements of punched card accounting.

Principles of Machine Processing

Most punched card equipment can accomplish more than a single function. But this equipment must know what function to perform and how to handle information it receives. The machines are capable only of following your instructions. They can make decisions only after you have decided the decisions to be made for each given set of conditions. Many of the instructions and most of the information depend upon the holes punched in the card and the wired control panel.

Reading the Card.—Cards are read at a point in a machine that contains a brush or brushes (referred to as a BRUSH STATION or READING STATION) which read the cards to cause the machines to perform some function. The process of converting punched holes into electrical impulses is known as READING and is done by the completion of an electrical circuit through the hole punched in a card column. Here is what happens when a particular column in a card is read by a particular brush.

As the card passes through the machine, it passes between an electric contact roller and a reading brush. As long as there is no hole punched in the column the brush is reading, the card acts as an insulator to prevent the brush from making contact with the roller. When a punched hole reaches the brush, contact is made between the roller and the brush through the
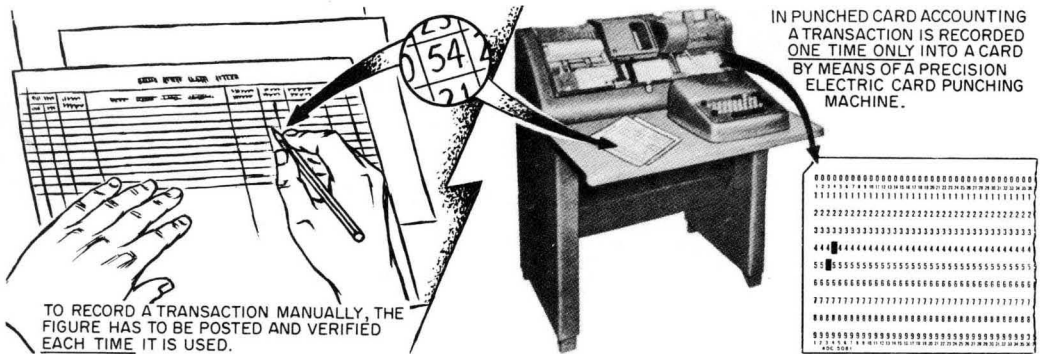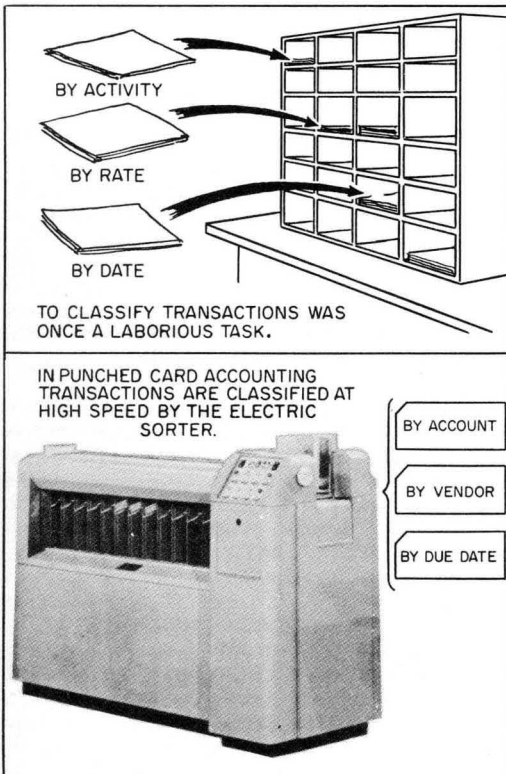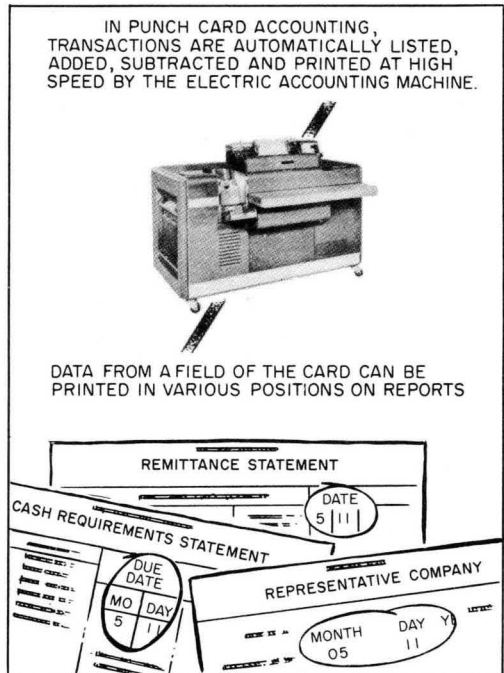
31

IN PUNCHED CARD ACCOUNTING A TRANSACTION IS RECORDED ONE TIME ONLY INTO A CARD BY MEANS OF A PRECISION ELECTRIC CARD PUNCHING MACHINE.

TO RECORD A TRANSACTION MANUALLY, THE FIGURE HAS TO BE POSTED AND VERIFIED EACH TIME IT IS USED.

49.226

Figure 2-24.—The element of recording.

BY ACTIVITY

BY RATE

BY DATE

TO CLASSIFY TRANSACTIONS WAS ONCE A LABORIOUS TASK.

IN PUNCHED CARD ACCOUNTING TRANSACTIONS ARE CLASSIFIED AT HIGH SPEED BY THE ELECTRIC SORTER.

BY ACCOUNT

BY VENDOR

BY DUE DATE

49.227

Figure 2-25.—The element of classifying.

IN PUNCH CARD ACCOUNTING, TRANSACTIONS ARE AUTOMATICALLY LISTED, ADDED, SUBTRACTED AND PRINTED AT HIGH SPEED BY THE ELECTRIC ACCOUNTING MACHINE.

DATA FROM A FIELD OF THE CARD CAN BE PRINTED IN VARIOUS POSITIONS ON REPORTS

REMITTANCE STATEMENT

CASH REQUIREMENTS STATEMENT

DATE 5 | 11

DUE DATE MO DAY 5 | 11

REPRESENTATIVE COMPANY

MONTH 05 DAY 11 Y

49.228

Figure 2-26.—The element of summarizing.

punched hole. An electrical impulse then flows from the roller through the brush, and can be directed to perform a specific function by control panel wiring or by internal machine circuits. Figure 2-27 illustrates how a brush reads a "2" punched in the card.

individual punching position—not between cards.)

Timing as a Character Recognition.—Machines determine which hole is punched in the card by the time at which contact is made between the contact roller and the brush. If cards

CARD PASSING BETWEEN ROLLER AND BRUSH ACTS
AS AN INSULATOR SO THAT NO IMPULSE IS AVAILABLE
AT THE BRUSH

PUNCHED HOLE

9 8 7 6 5 4 3 2 1 0 11 12

CARD MOVEMENT

CARD

CONTACT ROLLER

SOURCE OF CURRENT
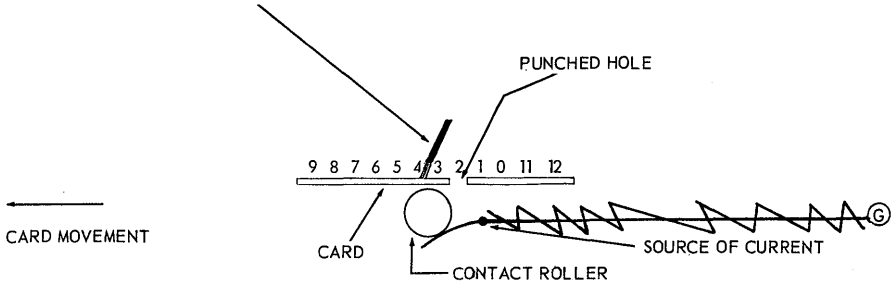
WHEN BRUSH MAKES CONTACT WITH ROLLER, A CIRCUIT
IS COMPLETED AND AN ELECTRICAL IMPULSE IS
AVAILABLE TO INSTRUCT THE MACHINE TO DO A SPECIFIC
JOB

TIMED ELECTRICAL IMPULSE

9 8 7 6 5 4 3 2 1 0 11 12

SOURCE OF CURRENT

49.2
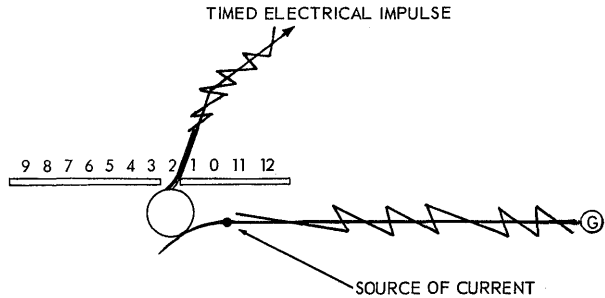
Figure 2-27.—Brush reading the numeral "2."

The impulse is, however, of a short duration, lasting only as long as contact is maintained through the hole by the roller and the brush. In the absence of a hole in a column, no circuit is completed nor is an impulse available when brush and roller make contact between cards. (This is due to the fact that a rotating commutator allows impulses to be available at the contact roller only during the reading of each

are to be fed 9 edge first, and an impulse is available just after the 9 edge has passed between the roller and the brush, this punch is recognized as a 9. If the impulse is available a little later, it is recognized as an 8. This is true of all positions that can be punched in the card. The machine recognizes which punch is being read by the amount of time that passes from the moment the leading edge of the card

33

passes under the brush to the instant when the brush drops into a punched hole and an impulse is available. In other words, the 2 position of the column being read in figure 2-27 would create an impulse at a time distinct from all other positions 9 through 12. Thus, the punched hole is actually converted into a TIMED electrical impulse. Also, if a column contains two or more holes, an equal number of impulses would be created, each of which would be distinct to the machine and be indicative of a specific punch.

If cards are to be fed 12 edge first, the first punch that can be read is recognized as a 12, the second punch as an 11, the third as a zero, and so on through 9.

Multiple Column Reading.—So far we have only one brush reading one column. However, most data processing machines contain 80 reading brushes, one brush for each column of the card, so that the entire card may be read as it passes through the machine. A single brush and an 80-column brush assembly are illustrated in figure 2-28.

Theory of Timing.—When we speak of impulses being available and machine action occurring at 9 time, 8 time, and so forth, we simply mean that impulses are available and things are happening at those particular times when cards are in position for a 9, 8, and so forth to be read. For example, when a 9 hole is read, it could cause the printing or punching of a 9. We therefore would use the term 9 TIME to mean action is taking place at 9 time of a cycle.

The Cycle Concept.—A cycle is a period of time necessary for the completion of a series of operations that occur in sequence on a recurring basis. In simple terms, a cycle can be thought of as the time required for a pointer to make one complete revolution of a circle, similar to the second hand of a clock (fig. 2-29A).

All machines perform functions within given periods of time, called MACHINE CYCLES, which are regulated to a certain number per minute. During any given machine cycle, the machine moves completely through one operation. The feeding of cards during any operation is known as a CARD-FEED cycle; the movement of the machine in performing a printing or punching operation is a PRINT or PUNCH cycle (fig. 2-29B).

Specific points in a cycle during which time holes are read or punched, or typebars positioned
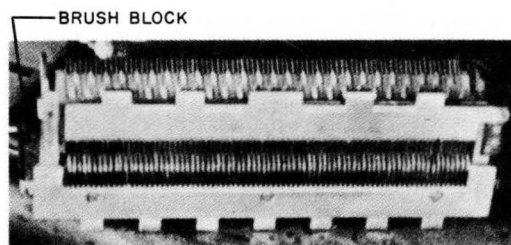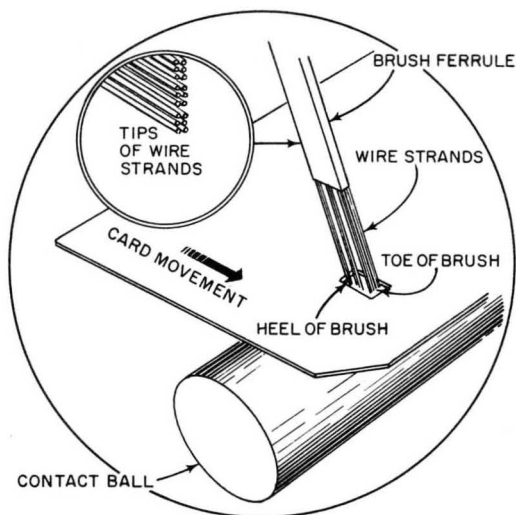
49.229
Figure 2-28.—An 80 column brush assembly (block).

for the printing of specific digits, are called CYCLE POINTS. Circular disks, or gears, are used as an index for indicating these cycle points, (or timing of a cycle) and make one revolution per cycle (fig. 2-29C). The time when a 9 punch is read is normally referred to as 9-time, but since these disks sometimes are further divided into degrees (fig. 2-29D), the reading of the 9 punch could also be expressed in DEGREES of a cycle.

Timing Charts.—Most machine manufacturers include timing charts in their reference manuals. A thorough knowledge of timing is one of the most important keys to the application
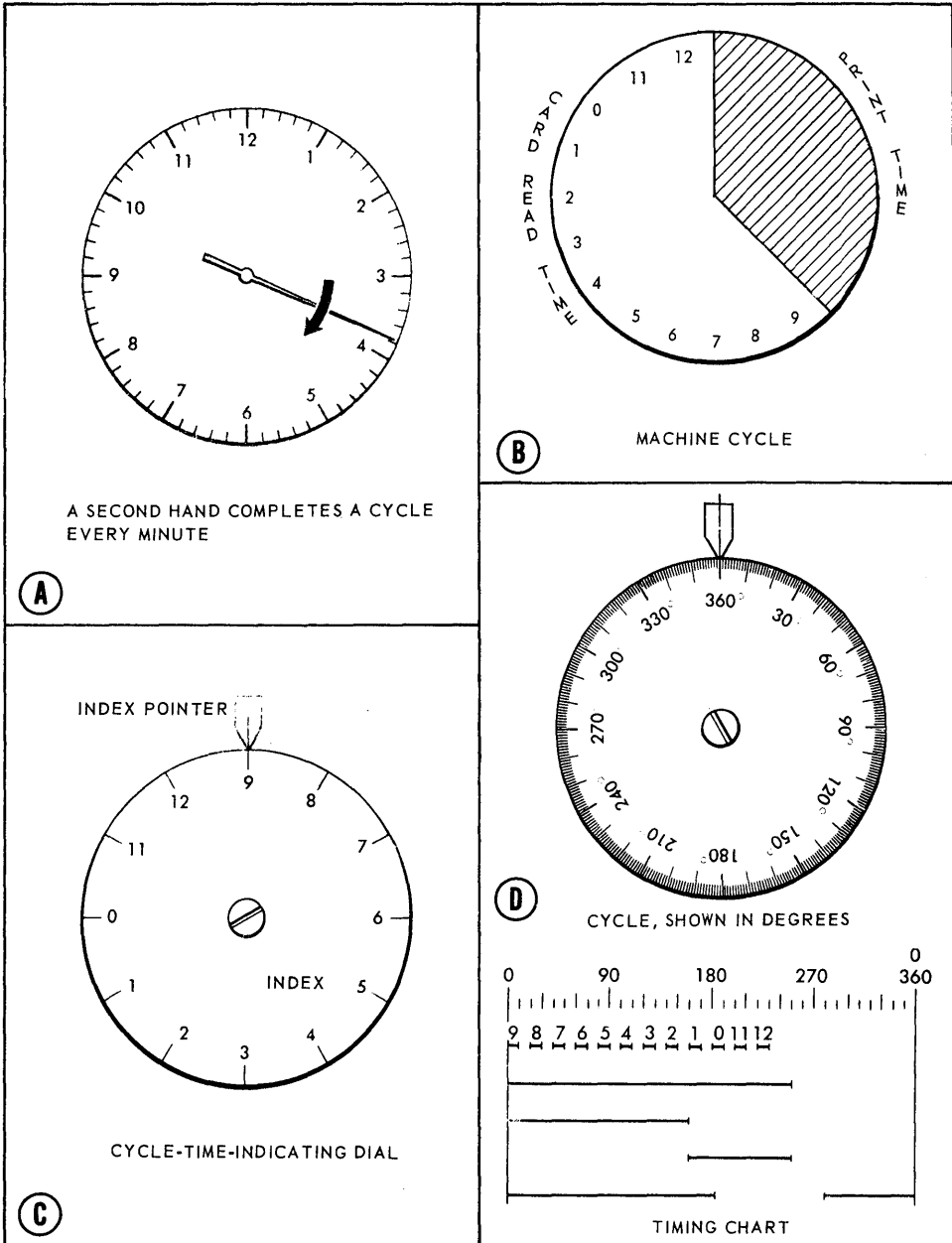
49.230

Figure 2-29.—The concepts of cycles.

of wiring principles. These charts help you determine the proper wiring to control machine functions and also lessen the risk of damaging the machine internally. The time, indicated by degrees, at which various control-panel hubs accept or emit impulses within the cycle, and notes to indicate the types of cycles during which they occur, are clearly indicated for you. After acquiring a working knowledge of a particular machine and its capabilities, you can use timing charts and control panel summaries, also included in machine reference manuals in learning to solve wiring problems, both basic and complex. Ask your supervisor to explain these charts to you.

THE CONTROL PANEL - "THE HEART OF EAM"

A control panel is a panel or board which, in most cases, can be removed from, or inserted into, the machine when desired. The panel has many small holes, called HUBS, into which you can insert wires with special tips to control the functions of the machine. Each of these hubs has a specific purpose or function.

Generally, the size of the panel and the number of hubs depend upon the type of machine. Larger machines have more varied functions; hence larger control panels. New sets of instructions for processing data are given to a machine by simply changing its control panel.

Purpose of the Control Panel

Basically, a control panel is similar in principle to a telephone switchboard. An incoming call on a switchboard produces a signal light that tells the operator which line the incoming call is on. After she answers the call, she plugs the cord into a hub on the board that is internally connected to the desired line. Thus, the operator has completed an electrical circuit to establish a telephone connection.

A control panel does exactly the same thing; it completes electrical circuits through wires you insert in the panel. The internal machine circuits that may be controlled by external control panel wiring are connected to rows of metal prongs, called CONTACTS, that are the ends to these internal circuits. When the control panel is inserted in the machine, a JACK or a self contacting wire on the control panel touches each one of the metal prongs in the machine. In this way the external wiring completes the electrical circuit desired. (See fig. 2-30.)

Figure 2-31 illustrates the internal and external wiring of an accounting machine. Some hubs of the accounting machine are connected to typebars which do the printing, some accept data for adding and subtracting while others cause machine functions such as spacing, ejecting forms, and so forth.

As cards are fed into the machine (point A on fig. 2-31), all 80 columns are read by a set of 80 reading brushes, each brush being connected to a hub on the control panel. In this manner, timed impulses, as a result of card reading, are internally transmitted to the control panel. To print the data, these impulses are directed to typebars by inserting external wires into the reading brush hubs and also into the hubs connected to the typebars. Completion of these circuits causes the punched characters of each card column to be printed. This, is an example of what is meant by CONTROL PANEL, PLUGBOARD, or BOARD WIRING.

Types of Control Panels

There are two general types of control panels. Wires with special tips are used for wiring each type.

One type of panel has metal jacks that press against the metal prongs in the machine. (See fig. 2-30A). The external wires are plugged into these jacks to complete the internal machine circuits. This type of control panel can be either FIXED or MANUAL. Fixed control panels are usually wired with PERMANENT wires, that is, wires that are not easily removed from the panel. These panels are used for jobs of a recurring nature that do not require changing the wiring. Manual control panels are usually wired with TEMPORARY wires; that is, wires that are easily removed from the panel. These panels are used for jobs of short duration, or one-time operation.

The second type of control panel consists only of hubs into which the external wires are inserted. The wires themselves have longer and larger tips than those used with jack-type panels, and are pushed directly through the hubs in the control panel to make contact with the prongs in the machine. (See fig. 2-30B.) The wires used for this type of control panel are called SELF-CONTACTING wires, and may be either permanent or temporary in design. (See fig. 2-32.)
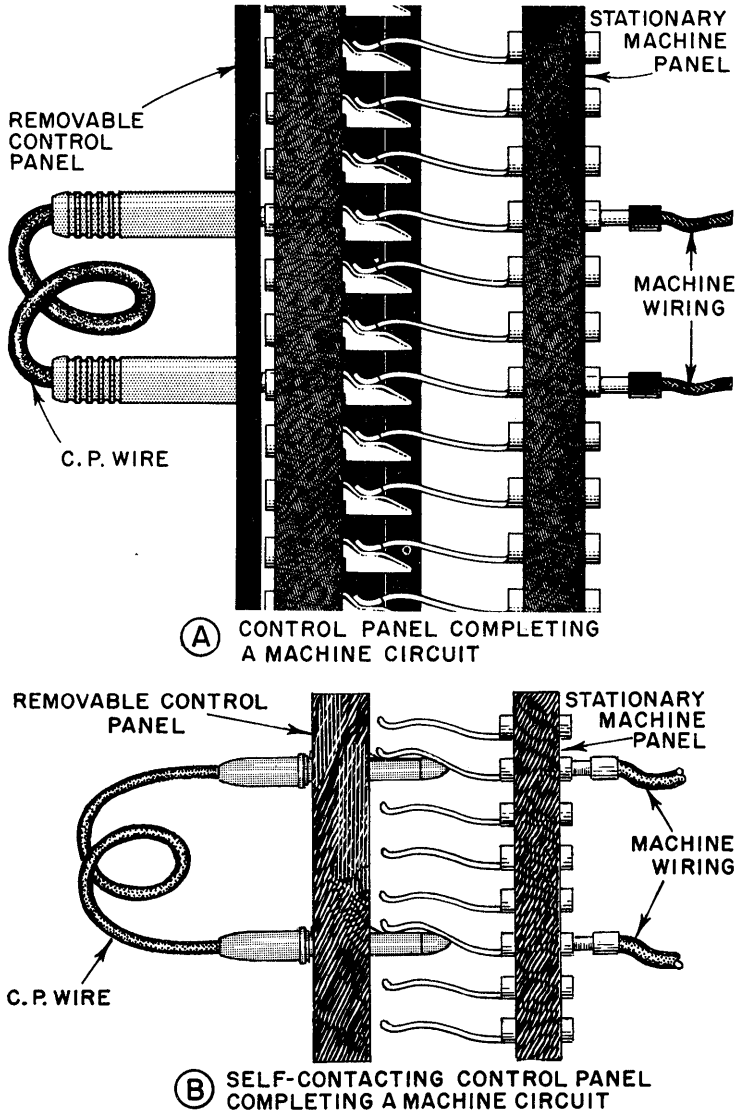
36

(A) CONTROL PANEL COMPLETING A MACHINE CIRCUIT

(B) SELF-CONTACTING CONTROL PANEL COMPLETING A MACHINE CIRCUIT

R49 4X

Figure 2-30.—Circuits completed by external wiring.

Types of Control Panel Hubs

There are two basic types of hubs on the control panel; EXIT hubs and ENTRY hubs. Exit hubs EMIT electrical impulses which may be used to control certain machine functions. Some exit impulses originate from holes read in the card, while others are machine generated under certain conditions or at a particular time. Entry hubs ACCEPT electrical impulses to control certain machine functions. Some entry hubs are used primarily to accept card generated impulses, or machine generated impulses occurring while a card is being read, and others accept impulses occurring at other than card reading time. An exit or entry hub may be single, or may consist of two or more hubs connected internally to each other. If internally connected, they are called COMMON hubs, and are identified on the control panel by lines connecting them. If they are exit hubs, the exit impulse is available out of each of the hubs common to each other. If they are entry hubs, an impulse wired to one is directed into the machine and is also available out of all other hubs common to it.

Under certain conditions some hubs may be used either as an exit or as an entry. This is particularly true in a selector, where one impulse can be directed to either one of two places, or either one of two impulses can be directed to the same place.

Sometimes there are hubs on the control panel which are neither exits nor entries. These hubs are called BUS hubs. They are internally connected to each other, but not to any internal machine circuit. Any impulse entered into one hub is available out of all the other hubs common to it. For this reason, they are used primarily to avoid the necessity of using split wires; that is, wires with three or more plug-ends. By using bus hubs, one exit impulse can be directed to several entry hubs, or several exit impulses can be directed to one entry hub.

Occasionally, when it is necessary to connect one exit hub to more than one entry hub and bus hubs are not available, COMMON CONNECTORS are used. An impulse brought into the
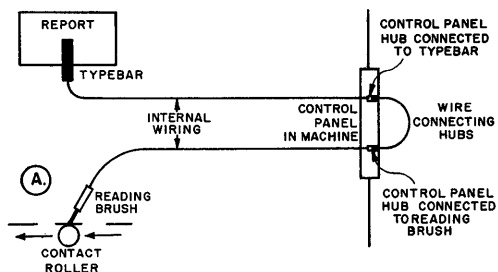
49.234

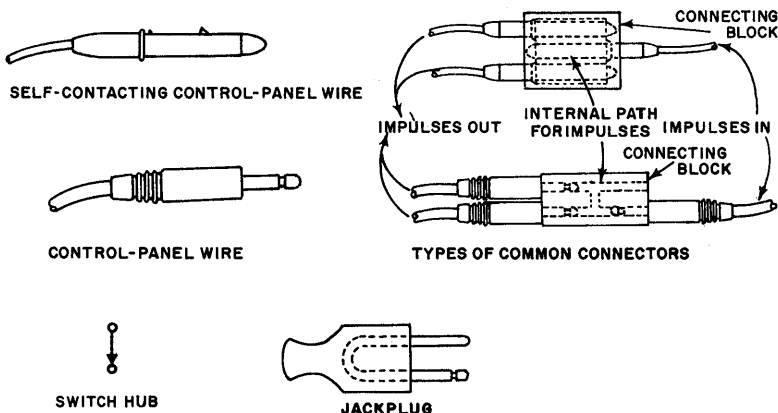Figure 2-31.—Internal and external wiring to cause printing.

49.235

Figure 2-32.—Control panel wires and wiring aids.

connecting block is available from all other terminals in the block. (See fig. 2-32.)

An arrow between two hubs identifies them as a SWITCH, which is turned on by connecting the two with an external wire. For convenience and to eliminate bulkiness, JACKPLUGS are used in preference to wires when connecting two adjacent hubs, also illustrated in figure 2-32.

ELECTRONIC DATA PROCESSING

The trend in recent years has been toward the use of electronic data processing equipment, especially in those areas where huge volumes of data must be processed as rapidly as possible. This equipment enables an organization to expedite its data handling processes in the most economical manner, and yet provide for speed, accuracy, and flexibility in the production of results.

When we speak of electronic data processing, we are thinking in terms of the computer and its many components as related to INPUT, PROCESSING, and OUTPUT functions. There are many different types of computers and computer devices with various data handling capabilities. They are classified generally as computers, electronic data processing machines (EDPM), electronic data processing systems (EDPS), and data processing systems (DPS). Regardless of what they are called, bear in mind that they have these characteristics: they process data automatically and at electronic speeds, (fig. 2-33).
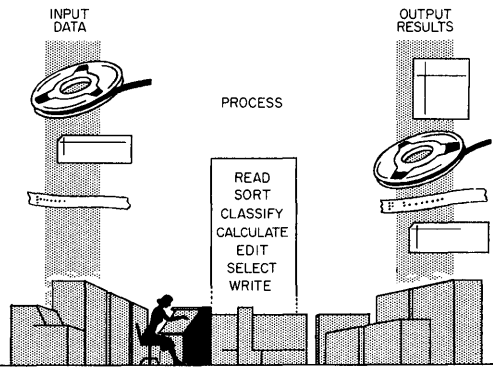
R49.197X

Figure 2-33.—Data processing by computer.

Data Processing by EDP

In certain respects, electronic data processing is similar to the unit record system in that punched cards may be used as input, and printed reports or punched cards may be produced as output. The unique difference lies in the manner of processing the data and the electronic equipment used in its processing applications. Whereas the unit record system requires the physical movement of cards from one machine to another, the electronic system permits many processing functions to be performed in one operation. (See fig. 2-34.) This is made possible through the use of several interconnected devices which, working together, can receive, process, and produce data in one operation without human intervention. These devices constitute an electronic data processing system.

The operations of preparing source documents, punching cards from source documents, and (for a punched card EDPS) sorting punched cards, are accomplished by the same methods used in the unit record system. However, systems using magnetic tape for input generally have punched card data transcribed onto the tape, and it in turn is sorted into a sequence acceptable for processing by the computer. Once information has been entered into the system, all classification, identification and arithmetic operations are performed automatically in one or several processing routines. This is accomplished by a set of written instructions called a PROGRAM which, when recorded onto punched cards or magnetic tape and fed into the system, control operations automatically from start to finish.

Information used as input to an electronic data processing system may be recorded on punched cards, paper tape, magnetic tape, or magnetic ink or optically read documents, depending upon the system requirements. Similarly, output may be in the same forms with the addition of printed reports, again depending upon the system (fig. 2-35).

The Electronic Brain

The computer has earned for itself the reputation of an electronic brain, but this is a gross misrepresentation and exaggeration. Computers can accept data at the rate of thousands of digits per second (millisecond), perform arithmetic computations in millionths of a second (microsecond), and print results by so many characters
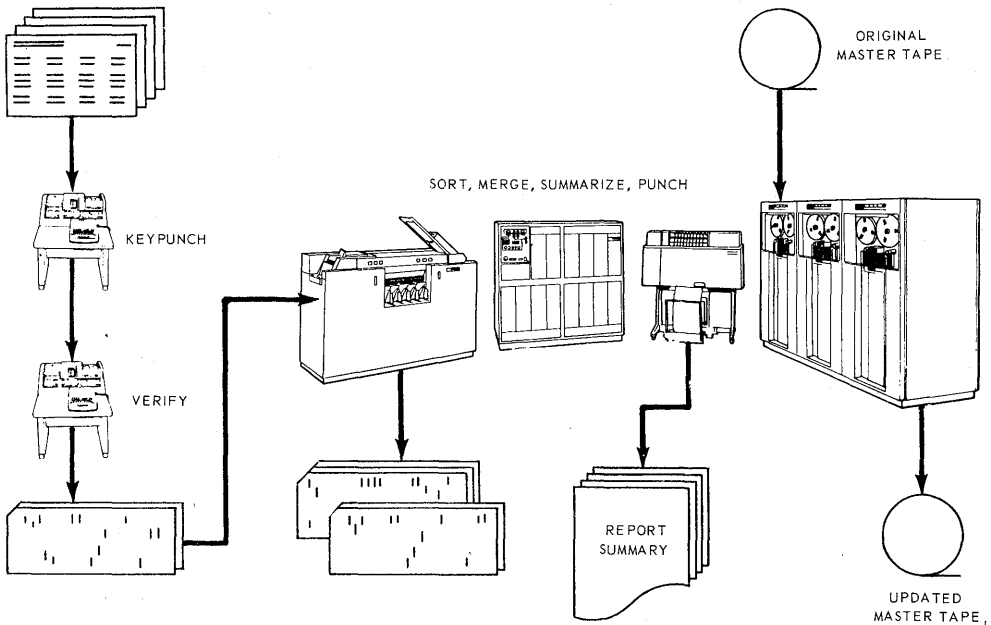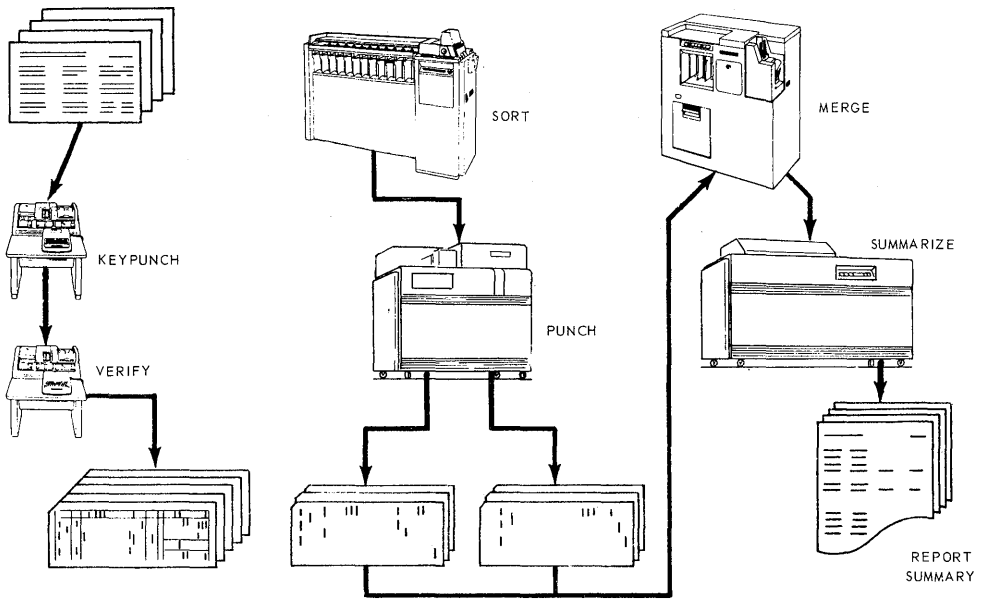
39

SORT

MERGE

KEYPUNCH

SUMMARIZE

VERIFY

PUNCH

REPORT
SUMMARY

ORIGINAL
MASTER TAPE

SORT, MERGE, SUMMARIZE, PUNCH

KEYPUNCH

VERIFY

REPORT
SUMMARY

UPDATED
MASTER TAPE

49.200

Figure 2-34.—A simple analogy of EAM vs EDP processing applications.

PUNCH CARD

MAGNETIC TAPE

PAPER TAPE

OPTICALLY READABLE CHARACTERS

MAGNETIC INK CHARACTERS

R49.201X

Figure 2-35.—Examples of EDP input media.

per second. But in spite of its remarkable achievements, the computer can only do what it is told by human beings. We might say that the computer is comparable to the human

brain to the extent that it has the ability to accept, remember, and send out information given it. Unlike the human brain, it is incapable of creative thought. It is a complicated mechanism made up of basic elements that imitate certain functions of the human brain. It surpasses the human brain in the speed and reliability, and it is notable among machines for both speed and flexibility.

What Is a Computer?

Simple in its makeup, the computer consists of an input section which introduces data into the system. Once interpreted, the information is sent to a control section where it is further directed according to programmed instructions. As specified, the data is sent to storage or memory, a high-speed device able to read in and read out data in a few millionths of a second. Data in storage can be used over and over, or can be used only once and replaced. If the computer is so instructed, the data can be directed to the processor or arithmetic section. It is here that the computer really computes; adding, subtracting, and comparing numbers. The organized results are transferable to an output section for the creation of records and reports, or to produce new media for further processing needs.

What Makes It Work?

The calculating mechanism of the computer has electronic circuit devices (fig. 2-36), whose speed of response is less than a billionth of a second (nanosecond). When data is written in a code acceptable to the computer and fed into it, electric impulses flow through the solid-state electronic circuitry in a pattern which causes the transistors to switch the signals, count certain impulses flowing through, or direct their flow according to programmed commands. Other factors which add to and form the basis for fast data manipulation are: (1) Memory units made up of magnetic cores, which are tiny rings consisting predominantly of ferrite, a magnetic material that is easily magnetized and remains so indefinitely after the magnetizing force has been removed; (2) Magnetic storage devices such as tapes, disks, and drums, upon which data is encoded by means of magnetic spots and (3), the binary mode of representing data, a two-value system which can represent alphabetic or numeric information by combining ones and zeros in various ways.
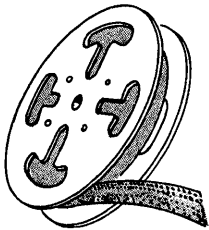
41

IBM 1301/1302 DISK STORAGE
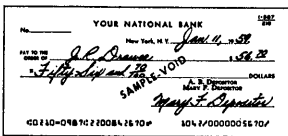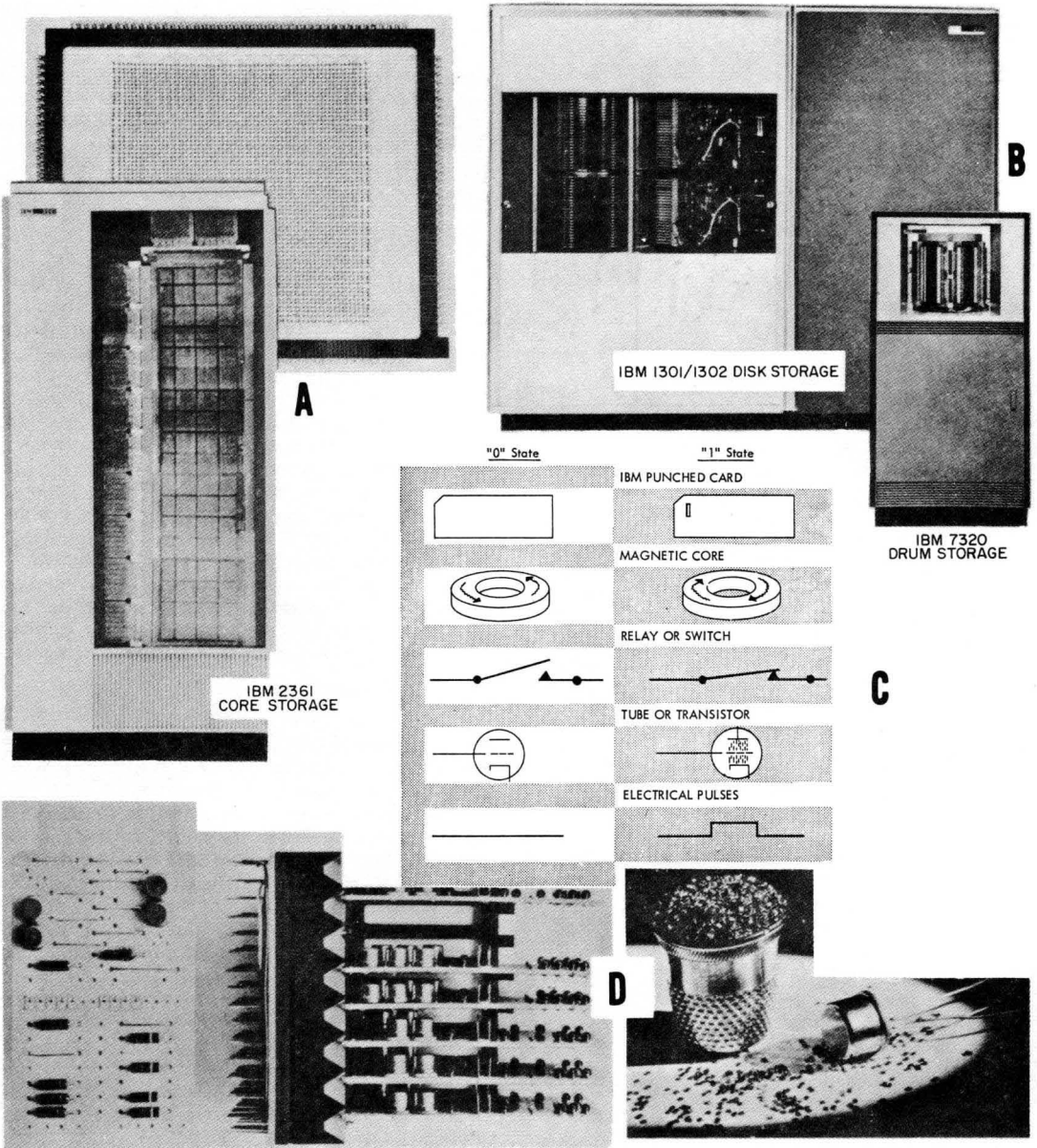
IBM 7320
DRUM STORAGE

IBM 2361
CORE STORAGE

"0" State   "1" State

IBM PUNCHED CARD

MAGNETIC CORE

RELAY OR SWITCH

TUBE OR TRANSISTOR

ELECTRICAL PULSES

A. MAGNETIC CORE STORAGE

B. ADDITIONAL MAGNETIC STORAGE DEVICES

C. TWO-VALUE OR BINARY SYSTEM

D. SOLID-STATE CIRCUITRY AND TRANSISTORS

R49.203X

Figure 2-36.—Some of the essentials in making a computer work.

How Does It Work?

To answer this question, suppose we compare the simple adding machine to its larger counter-part—the electronic computer (figs. 2-37 through 2-43).

Input.—We use the term INPUT to describe the act of introducing data into a system. Since the keyboard is used to feed data into the adding machine, we can call it an INPUT DEVICE (fig.

2-38). The SOURCE MEDIA, or documents from which information is obtained, could have been an invoice, pay record, or supply requisition. Unlike the adding machine, wherein data is in-troduced directly through the keyboard from the source media, a computer system necessitates the conversion of data onto a type of medium that will lend itself to automatic processing prior to its being read into the system. Therefore, INPUT DATA is data that has been recorded from
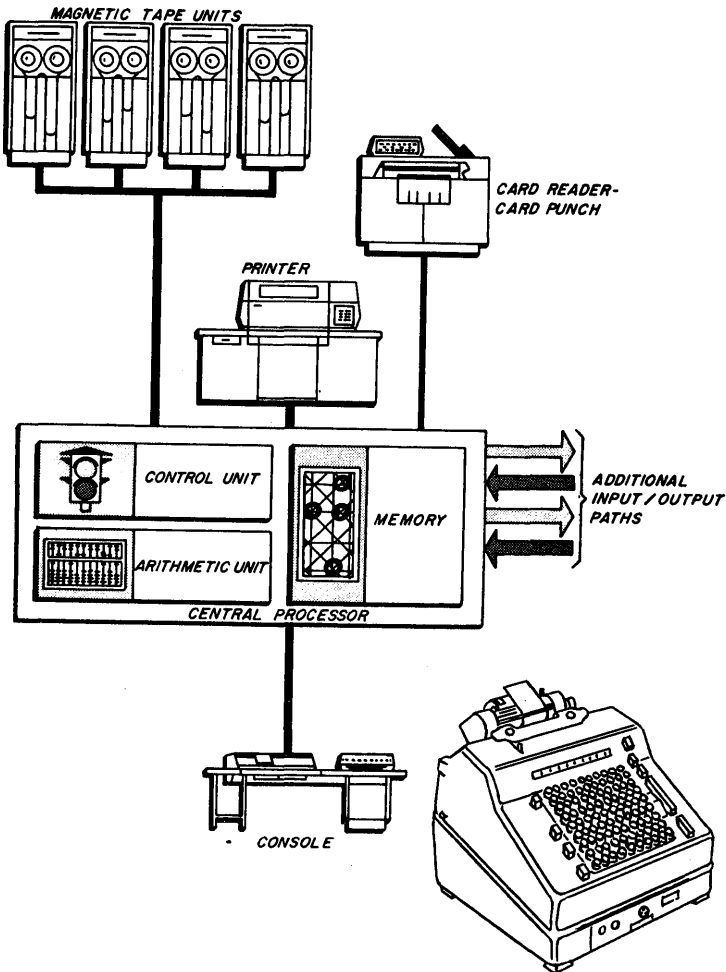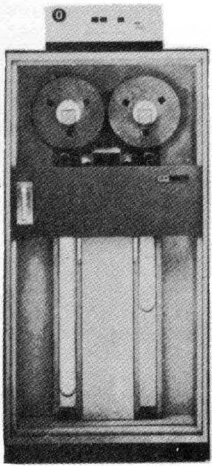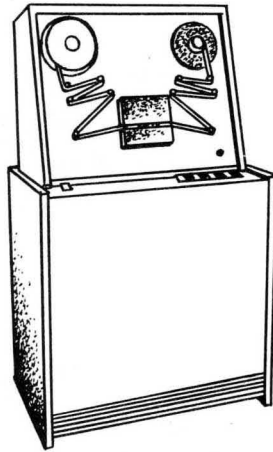

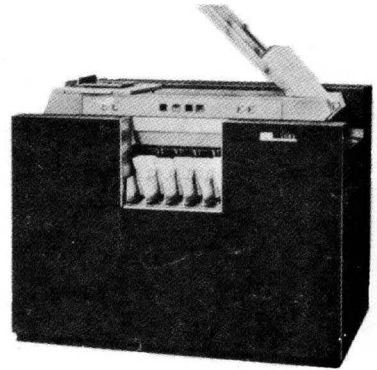49.204X

Figure 2-37.—The adding machine and the computer.

43

IBM 2401
MAGNETIC TAPE UNIT

MODEL 322
RCA PAPER TAPE READER

IBM 1402
HIGH-SPEED
CARD READER

R49.205X

Figure 2-38.—EDP input units.

a source medium onto a type of INPUT ME-DIUM acceptable to a system. Computer input devices read data from their prescribed media, and translate that data into electronic impulses for transmittal into the computer. Input devices, among others, could consist of high-speed card readers, paper tape readers, or magnetic tape units.

Processing.—Racks, gears, counting wheels, and so forth are used by the adding machine to compute the data fed into it. The CENTRAL PROCESSING UNIT (fig. 2-39) is the computing center of the electronic data processing system and is made up or five functional units: CONTROL, ARITHMETIC, MEMORY, INPUT, and OUTPUT. The acronym "CAMIO" is formed when the first letter of each functional unit is taken.

The CONTROL UNIT (fig. 2-40) automatically directs the step-by-step operation of the entire system, including the operation of input and output devices as well as the selection, inter-pretation, and execution of instructions from me-mory. Areas of the adding machine keyboard that contain buttons (plus, minus, total, and others) used by its operator to exercise control over the machine, might be likened to the control panel of

the computer CONSOLE. The console itself pro-vides external control over the entire system, for through it, the operator can monitor the central processor (fig. 2-41) and maintain manual control over all operations. Remember, the com-puter does not rely on the operator to feed it data and initiate its every command; the control panel and electric typewriter (provided by some sys-tems) of the console simply permit human beings to communicate with the various units that make up a total computer system.

Looking closely at the adding machine mech-anism, you will find a set of rachets used to turn the counting wheels and cause the arithmetic functions to be performed. Likewise, the ARITH-METIC UNIT of the computer (fig. 2-42) performs arithmetic operations of adding, sub-tracting, multiplying, and dividing. Through its logical ability, it can also test various conditions encountered during processing and take action called for by the results.

Because the counting wheels store the results of arithmetic operations until changed or totaled, they might be thought of as the memory unit of the adding machine. However, the MEMORY UNIT of a data processing system differs in that it can be used to store data and/or program-med instructions for an indefinite period of time.
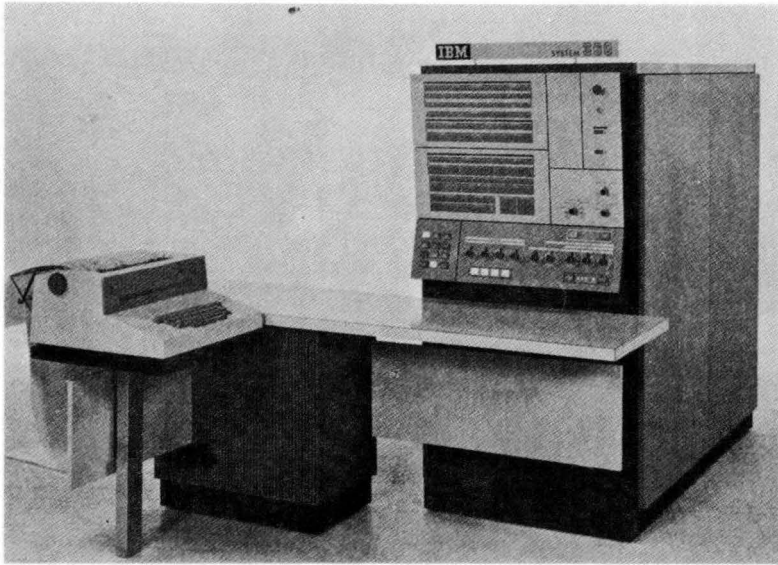
44

R49.207.3

Figure 2-39.—Central processing unit and console.

Output.—We define OUTPUT as data that has been processed or the act of extracting such data from the central processor. Results of the adding machine's calculations are printed by its OUTPUT DEVICE, a printer (fig. 2-43), onto a listed tape or inserted document. The basic function of a computer output device is to receive, convert and record output data onto its particular medium. The most commonly used output devices are card punches, magnetic tape units, paper tape punches, and printers; their output media being punched cards, coded magnetic spots on magnetic tape, punched paper tape, and printed reports.

What Are Its Tools?

Components or tools of a computer system are categorized as either hardware or software. Hardware includes all the mechanical, electrical, electronic, and magnetic devices within a computer system. Software consists of the automatic programming techniques developed for the most efficient use of the hardware and is usually supplied by the manufacturer of particular systems.

Hardware.—Computer hardware falls into two categories, peripheral equipment and the central processor. PERIPHERAL EQUIPMENT includes all input and output devices associated with specific recording media such as, a card reader and punch, or magnetic tape units. This peripheral equipment can operate ON-LINE, under direct control of the central processor (see fig. 2-44) or OFF-LINE, independently of the central processor. (See fig. 2-45.)

During on-line operations, data can be transferred to and from peripheral devices and the central processor via CONTROL UNITS. These units may be free-standing, or built into either the central processor or the peripheral device, and receive their signals or instructions from the stored program.

In off-line or AUXILIARY operations, the input and output devices are used in conjunction with other peripheral devices not directly connected to the system. Since input and output data conversion operations are relatively slow compared to the speed of the central processing unit, off-line operations free the computer of time-consuming procedures and provide more time for the computing and processing of data by the
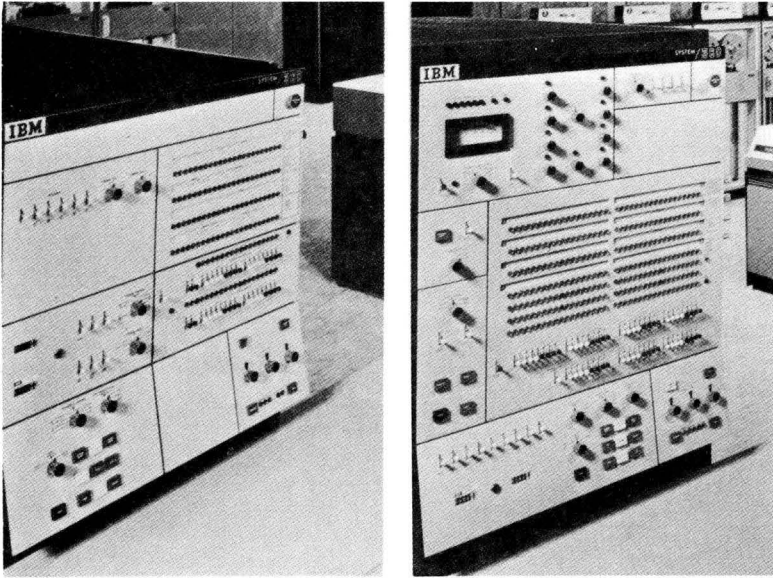
R49.207X

Figure 2-40.—Typical control panels of computer consoles.

R49.208
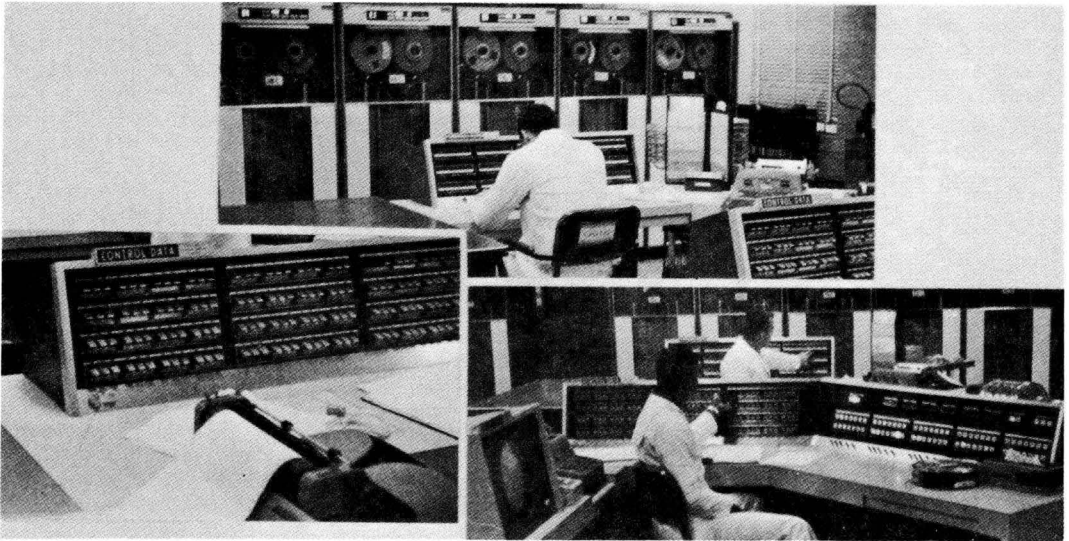
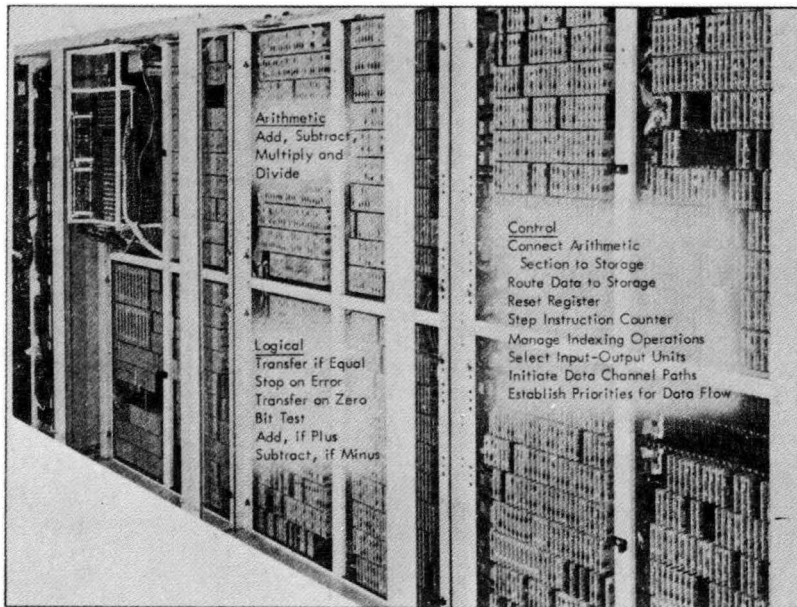Figure 2-41.—Monitoring and communicating with the central processor.

R49.209X

Figure 2-42.—Control and arithmetic-logical sections.

central processor. For example, a system's output data could be written on magnetic tape and converted to some other record form in an off-line operation while the computer continues processing new data.

Software.—This consists primarily of general purpose programs that are common to many computer installations. Included among them would be assemblers and compilers (which aid in producing machine language routines from a relative or nonmachine language source), plus sort, control, and other utility programs.

Card Oriented System

A system whereby information is fed into its input unit only by means of cards, and with its output also in the form of cards and/or printed reports, is commonly referred to as a CARD SYSTEM. These systems are usually relatively small, especially in their memory capacity and other storage facilities. Input data must be prearranged before being fed into the system but

can remain in its memory unit until the programmed instructions call for its release, or replace it with new information. (See fig. 2-46.)

Tape Oriented System

Systems whose source of input data is from almost any medium, but essentially from perforated paper or magnetic tape, are referred to as TAPE SYSTEMS. Because these systems are large and complex, they demand more processing ability, and therefore require faster input media than the much slower punched card input. In addition to larger memory capacities and other storage facilities, input and output devices may vary as to the type of media used and consist of several or many in number.

Real Time Processing System

REAL TIME COMPUTER SYSTEMS, designed to keep pace with "live" operations, can store enormous masses of information and act upon any item within thousandths of a second.
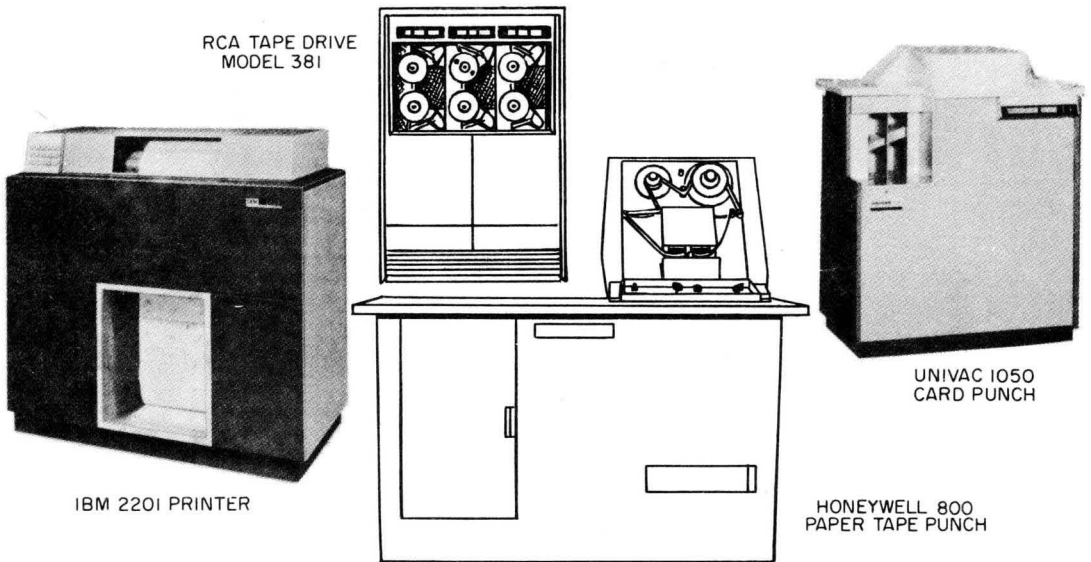
47

RCA TAPE DRIVE
MODEL 381

UNIVAC 1050
CARD PUNCH

IBM 2201 PRINTER

HONEYWELL 800
PAPER TAPE PUNCH

R49.210X

Figure 2-43.—Various EDP output devices.

Data is received and transmitted between locations at remote points, and priorities are automatically assigned to different operations to ensure that action and response are in proportion to the urgency of the need. Through the system's input devices, data is entered into the system and acted upon at the time of occurrence. The need for original source documents is being eliminated, and due to its communication facilities, centralized control of decentralized operations is now possible over areas of thousands of miles.

"How fast?" has been the factor of primary importance in computer operations. Recently, however, "How far?" has become significant. To move data from distant locations with the same relative speed with which it is processed is of growing importance, for where it is needed is in many cases far from where it originates. To move data between locations around the country, computer information under the REAL TIME PROCESSING TECHNIQUE is now being transmitted over telephone, telegraph, and teletype lines. These fast communication systems between a central computer and hundreds of remote points are eliminating the old problems of time

and distance, which until now, had a direct bearing on computer applications. (See fig. 2-47.)

Time Sharing

Time sharing is the cooperative use of a computer in a central location by more than one user (activity, government agency, division, company). Many jobs are performed simultaneously on one computer system as each user receives a share of the time available.

Two computers may also be joined to permit the sharing of each other's facilities.

ELECTRIC ACCOUNTING VERSUS
ELECTRONIC DATA PROCESSING

Electronic data processing systems should not be thought of as replacements for electric accounting machine systems. The EDP systems are capable of performing functions which EAM systems cannot perform. While it is true, however, that EDP systems can carry out the accounting operations of an EAM system, these operations are still most economically carried

PERIPHERAL DEVICE	RECORDING MEDIA	INFORMATION TRANSFER
Magnetic Tape Unit	Magnetic Tape	READ from tape / WRITE on tape — Central Processor
Card Reader	80-Column Cards	READ cards — Central Processor
Card Punch	80-Column Cards	PUNCH cards — Central Processor
Printer	Paper Stock	PRINT documents — Central Processor

49.211X
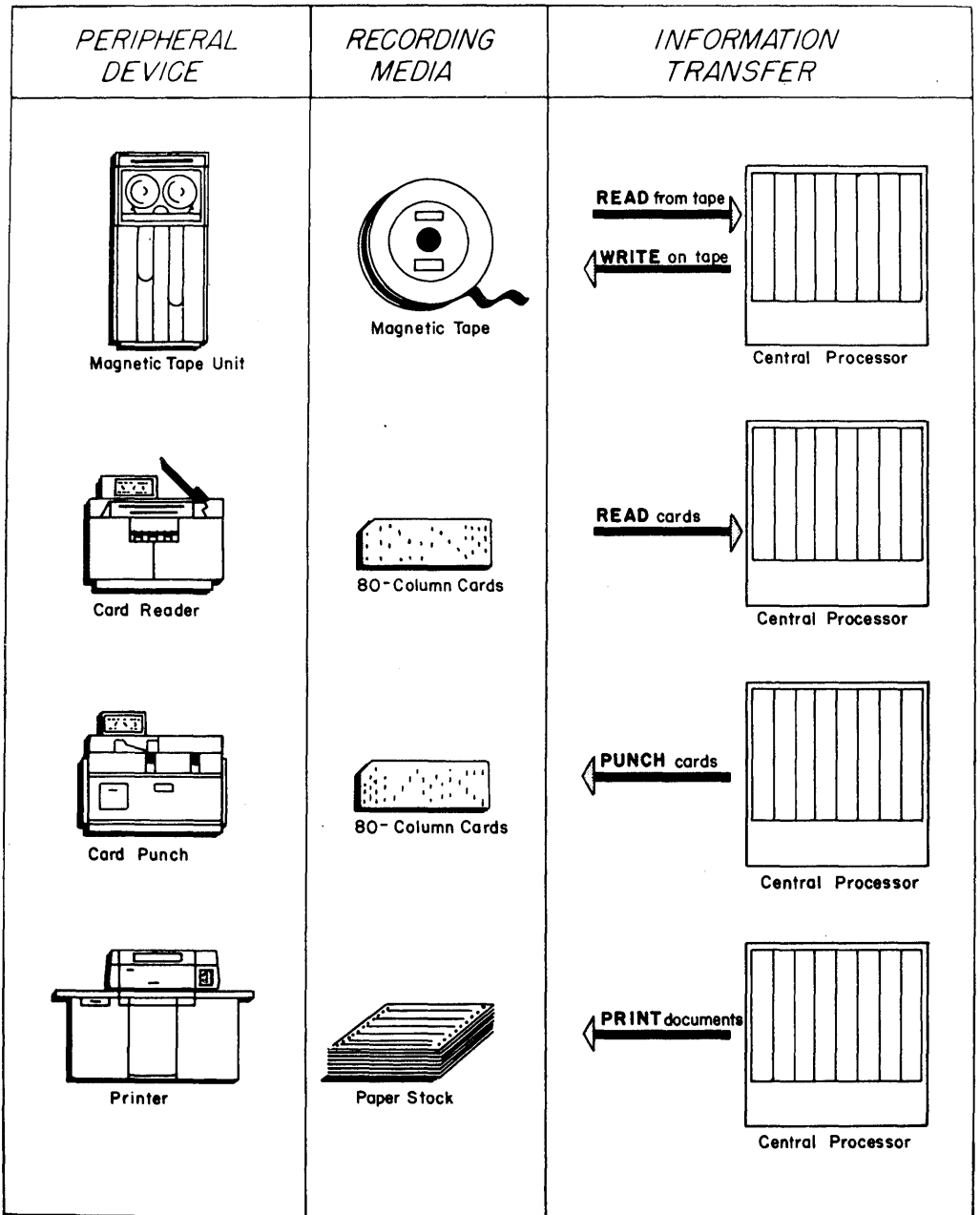
Figure 2-44.—On-line peripheral equipment and recording media.

49

| IBM 714 Card Reader | IBM 759 Card Reader Control | IBM 727 or IBM 729-I Magnetic Tape Unit |

| IBM 727 or 729-I Magnetic Tape Unit | IBM 758 Card Punch Control | IBM 722 Card Punch |

| IBM 727 or 729-I Magnetic Tape Unit | IBM 757 Printer Control | IBM 717 Printer |

| IBM 727 or 729-I Magnetic Tape Unit | IBM 760 Control and Storage | IBM 720 or IBM 730 Printer |
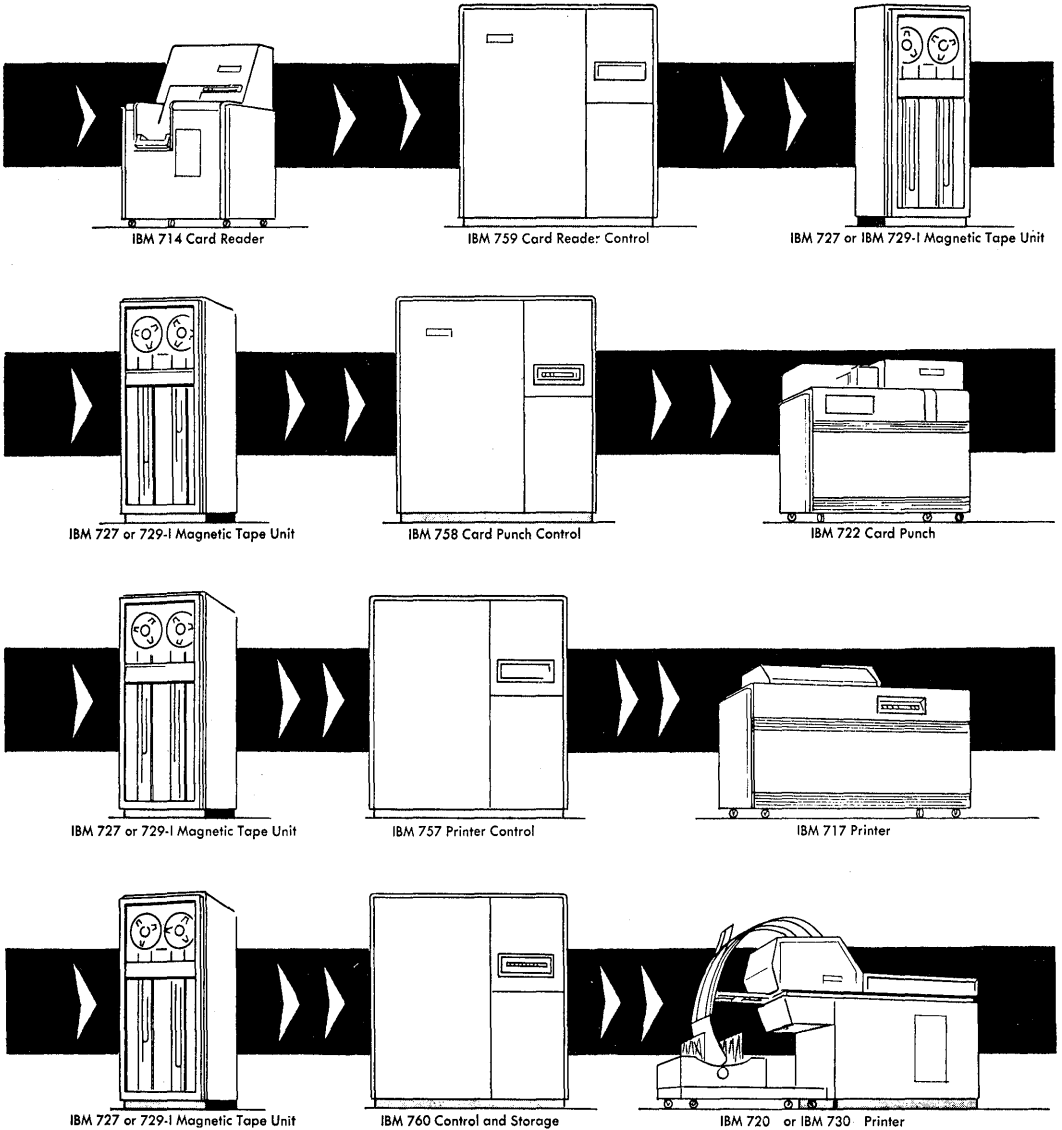
R49.212X

Figure 2-45.—Off-line data conversion operations.

| CARD/ READ/ PUNCH | CENTRAL PROCESSING UNIT | PRINTER |
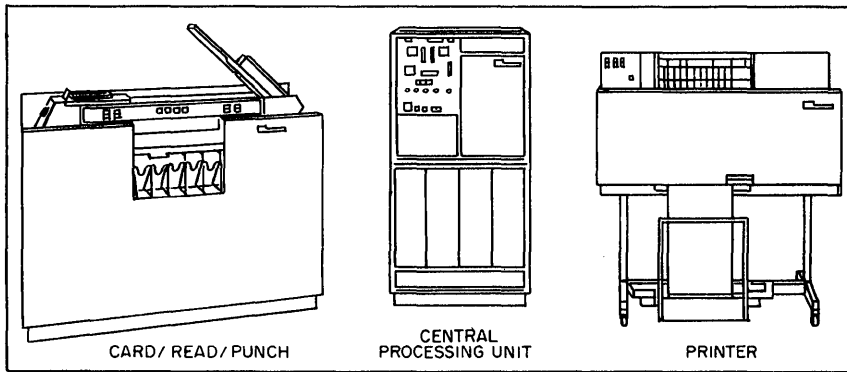
ESSENTIAL COMPONENTS OF A CARD ORIENTED SYSTEM.
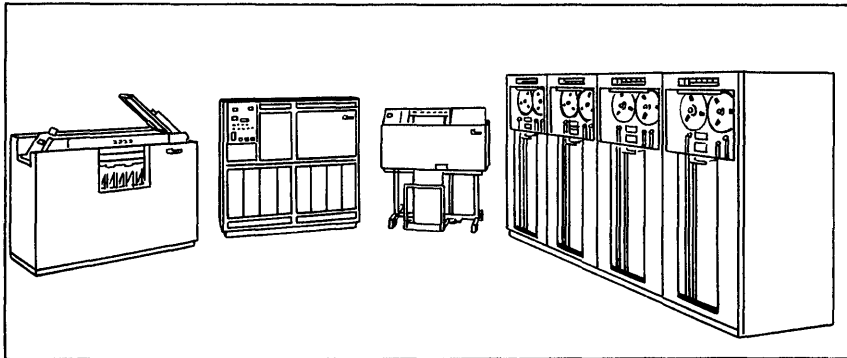
THE SAME COMPONENTS WITH THE ADDITION OF TAPE UNITS, FORMING A TAPE ORIENTED SYSTEM TO INCREASE THE SCOPE, AS WELL AS THE INPUT AND OUTPUT SPEEDS, OF THE SYSTEM. NOTE THE INCREASED SIZE OF THE CENTRAL PROCESSOR.

R49.213X

Figure 2-46.—Card and tape orientated systems.

out in many places by electric accounting machines. Furthermore, electric accounting machines are used in support of automatic computer systems—they are the peripheral equipment on-line to the central processing unit of an automatic computer system.

If we compare an electric accounting machine system with the central processing unit of a computer as they execute the same accounting function, we shall see that the chief difference between the EAM system and the central processing unit is in the speed at which this function is carried out. The central processing unit completes the job in much less time.

It is easy to see why the central processing unit is more efficient than the electric accounting machine system. First, the amount of data that can be held in the storage component and in the registers of the central processing unit far exceeds the storage capacity of the electric accounting machine system, so that data transfers and arithmetic and logic operations are carried out faster by the central processing unit. Second, no intervention is required during the operation of the central processing unit, while stacks of

51
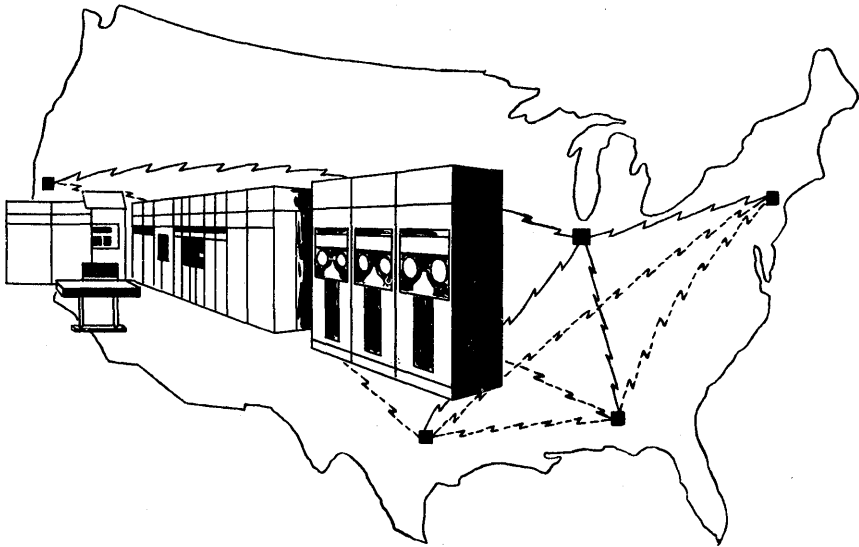
49.214

Figure 2-47.—Remote communication linkage affords real time processing.

cards must be shifted between the various accounting machines to complete the EAM operation. Third, when magnetic tapes constitute the input and output media of the EDP system, faster input to, and output from, the central processing unit are possible.

Scope of Data Processing

Data processing performed by Data Processing Technicians has greatly expanded and become extremely diversified since the establishment of the Machine Accountant rating in 1948. Models and types of data processing equipment employed by the Navy today, vary in size, dimension, and performance.

You may at present be serving a tour of duty in an installation using some of the aforementioned machines and devices. Subsequent orders may place you in a naval activity where

a knowledge of EAM equipment is all that will be required, such as a naval training center or naval station electric accounting machine unit (EAMU), or filling a billet in a stock control system aboard ship. You might find yourself in a shipboard maintenance and material management system (3M system) operating the Univac 1500 data processing system or filling any number of billets within a fleet PAMI, a statistical or guided missile unit, or in supply, security, communications, or personnel research activity. In any of these you may, with a reasonable amount of on-the-job training, be expected to operate and program some of the more complex computer systems of today. Once you learn and understand the fundamental concepts and principles of automatic data processing as presented here and in the detailed chapters to follow, you will recognize the similarities of the data processing systems of various manufacturers.

CHAPTER 3

CARD PUNCHES, VERIFIERS, DATA COMMUNICATIONS

The basic operating unit in any punched card data processing application is the punched card. Once cards have been correctly punched, they may be used in many different ways by various types of machines to produce a wide variety of results. There is a good possibility that one of your early assignments as a DP striker will be operating a card punch or card verifier to convert information contained in source documents into punched card data, and to verify that data. This may not seem like a very important job to you, but of all the machine operations that take place where you work, keypunching and key verifying are among the most important. Cards correctly punched help ensure that reports prepared and other operations performed with the cards are correct. Cards incorrectly punched mean that wrong information will be placed in files or reports, or that time-consuming research must be devoted to obtaining the correct information and repunching the cards.

This chapter will familiarize you with the operation of machines that record data in punched cards, verify that data, and send or receive data to or from locations physically removed from each other.

CARD PUNCHES

Operations which may be performed on card punch machines include manual punching by depression of the proper keys, duplicating data contained in any card into the following card, and skipping over card columns in which nothing is to be punched. Card punches are equipped with a program unit which provides for automatic duplicating and skipping of certain fields in the card. Each setup, or program, is made by punching a card and mounting it on a program drum, which is inserted in the machine. The same program card can be used repeatedly for a routine punching operation.

CARD PUNCHES, TYPES 24 and 26

Two of the common card punch machines in use are the IBM types 24 and 26. These machines are essentially alike in design, features, and operation. The major difference is that the type 26 has a printing mechanism that allows for printing data on the card at the same time the card is being punched. Figure 3-1 pictures the IBM type 26 printing card punch, with the operating features indicated.

Duplication under program control occurs at the rate of 20 columns per second on the type 24, and 18 columns per second on the type 26. Without program control, duplication proceeds at the rate of 9 or 10 columns per second and occurs only as long as the duplicate key is held down.

Card Hopper

The card hopper, with a capacity of approximately 500 cards, is on the right side of the machine. Cards are placed in the hopper face forward, with the 9 edge down. A sliding pressure plate ensures uniform feeding. A card may be fed from the hopper automatically, or by depression of the card feed key. The first two cards must be fed by key depression, but all other cards in the hopper may be fed automatically by proper switch settings.

Punching Station

Punching is performed at the first station along the card bed. At the beginning of an operation, two cards are normally fed into the card bed. As the second card is being fed, the first is automatically positioned (registered) for punching. While the first card is being punched, the second waits at the right of the card bed. When column 80 of the first card passes the
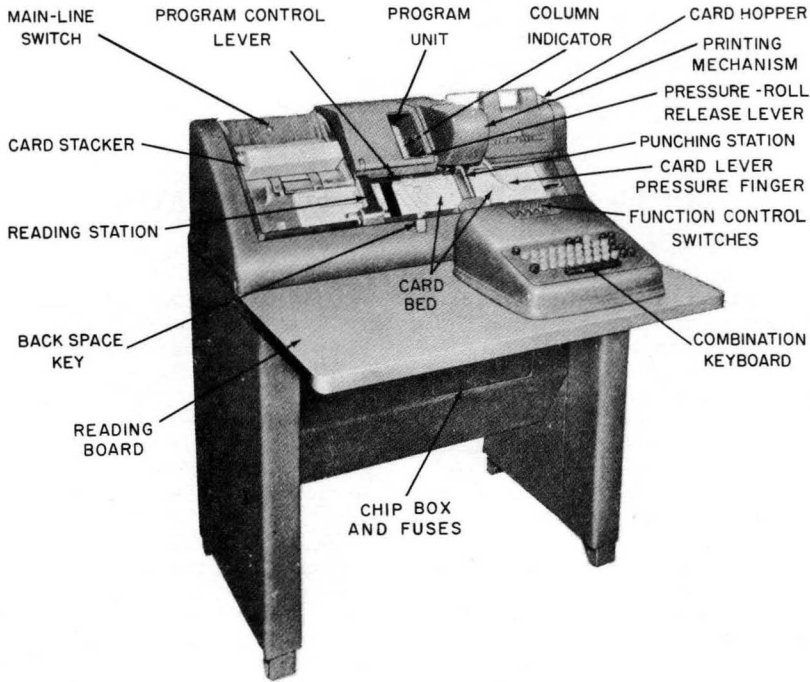
R49.5.1X

Figure 3-1.—IBM type 26 printing card punch.

punching station, that card moves on to the reading station, and the second card is positioned for punching. At the same time, a third card is fed from the hopper into the right side of the card bed.

Reading Station

The reading station is located to the left of the punching station. A card moves through this station in unison with the next card at the punching station. Thus, when a card at the reading station is at column 60, the card at the punching station is at column 60. Data in the card at the reading station may be duplicated into the card at the punching station, either by depression of the duplicating key, or by program control setup.

Card Stacker

As cards move from the reading station, they are stacked in the card stacker with the 12 edge down, and the backs of the cards facing the operator. Cards remain in their original sequence when removed from the stacker.

Main Line Switch

The main switch is located at the rear of the stacker. There is a delay of approximately one-half minute after the switch is turned on before punching can be started, in order to allow the electronic tubes time to warm up. When the stacker becomes full, this switch is automatically turned off.

Backspace Key

The backspace key is located below the card bed, between the reading and punching stations. As long as it is held down, cards at both stations are automatically backspaced until column 1 is reached. Backspacing should not be attempted after column 78 is passed without

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first removing the card from the right side of the card bed.

Column Indicator

The column indicator is located at the base of the program drum holder. The column numbers are written around the base of the drum which turns synchronously with the cards being read and punched. The pointer on the indicator always indicates the next column to be punched or read at the punch and read stations. You will find this indicator especially useful for locating a specific column when spacing or backspacing.

Pressure Roll Release Lever

Cards may be removed manually from either the punching or the reading station by depressing the pressure roll release lever. Care should be exercised in removing a card from either station to prevent tearing the card. If you should tear a card, use another card or a smooth edged metal blade to push out the pieces while holding down on the pressure roll release lever. Saw edged metal blades should not be used for removing pieces of cards.

KEYBOARDS

Figure 3-2 illustrates two kinds of keyboards which may be used with card punch machines. The numerical keyboard contains keys for punching numerical characters and two special characters. The combination keyboard contains keys for punching numerical, alphabetic, and either three or eleven special characters. Keyboards are interlocked so that no two character keys can be depressed simultaneously. The home keys are more concave than the other keys to facilitate accurate touch operation.

Depression of a standard typewriter key will print a letter on a piece of paper. Depressing a key on a card punch will result in a hole or combination of holes being automatically punched into a card, as shown in figure 3-3.

Alphabetic characters and certain special characters can be punched when the combination keyboard is in alphabetic shift, and numbers and other special characters can be punched when the keyboard is in numerical shift. For instance, depression of the dual purpose 7M key (key #27 in fig. 3-4) will punch a 7 in numeric shift or an M when in alphabetic shift.

NUMERICAL KEYBOARD

AUTO AUTO-SKIP PRINT
FEED AUTO-DUP

COMBINATION NUMERICAL AND ALPHABETIC KEYBOARD

R49.240X
Figure 3-2.—Card punch keyboards.

This action is comparable to upper or lower case shifting on a standard typewriter. Shifting from alphabetic to numerical punching, and vice versa, is controlled either by depressing the appropriate shift key, or by program control. When program control is used, the keyboard is normally in numerical shift. When program control is not used, the keyboard is in alphabetic shift.

Since the combination keyboard is the one you will be most likely to use, let us examine this keyboard as illustrated in figure 3-4 and see what it contains. Notice that the letter keys are arranged to facilitate use of the typewriter touch system. However, because card punching operations primarily involve numerical information, the digit keys (unlike the typewriter),
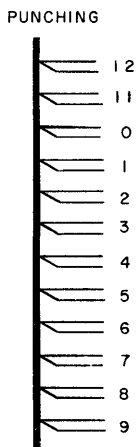
PUNCHING

SCHEMATIC OF PUNCH DIES ON AN IBM 24 OR 26 CARD PUNCH.
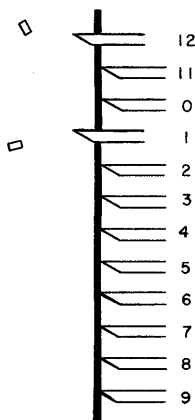
SCHEMATIC OF PUNCH DIES IF THE LETTER A IS BEING PUNCHED.

49.241

Figure 3-3.—Punching the letter A.

are closely grouped for a one-hand, ten key operation. This arrangement affords a right hand three finger touch system, freeing the left hand for document handling. Each key is numbered for illustration purposes only; these numbers do not appear on the keyboard.

Functional Keys

Keys 30 through 39, and key 44, control the functions of the machine, and are described as follows:

30. NUM (numerical shift) puts the combination keyboard in numerical shift for as long as it is held down. It is normally depressed to allow punching of numbers in an otherwise alphabetic field.

31. ALPH (alphabetic shift) places the combination keyboard in alphabetic shift for as long as it is held down. Depression of this key allows alphabetic punching in a numerical field.

32. DUP (duplicate) operates in two ways. With program control, one depression of this key causes the field for which it is depressed to be duplicated from the same field of the preceding card at the read station. Without program control, duplication occurs for as long as the key is held down.

33. DASH SKIP (or) DASH also operates in two ways. When the keyboard is in numerical shift, depression of this key will punch an 11 and cause skipping. When the keyboard is in alphabetic shift, punching of an 11 without skipping will occur.

34. REL (release) causes the cards at the punching and reading stations to be moved completely past those stations. Fields programmed for automatic duplication beyond the point of release will be punched in the card at the punching station as the card advances. If the automatic feed switch is ON, a card will also feed from the hopper.

35. FEED (card feed) causes one card to feed from the hopper, registers a second at the punching station, registers a third at the reading station, and stacks a fourth card.

36. SKIP causes skipping of the particular field for which it is depressed. It is normally used for skipping over unused columns in an alphabetic field.

37. REG (card register) is used primarily when inserting cards into the card bed manually. Depression of this key registers the cards at the punching and reading stations, and stacks another card from the left of the card bed, but does not cause card feeding.

38. AUX DUP (auxiliary duplicate) is supplied only if the machine is equipped with the auxiliary duplication feature. When depressed, this key causes duplication from a master card, mounted on the auxiliary duplicating
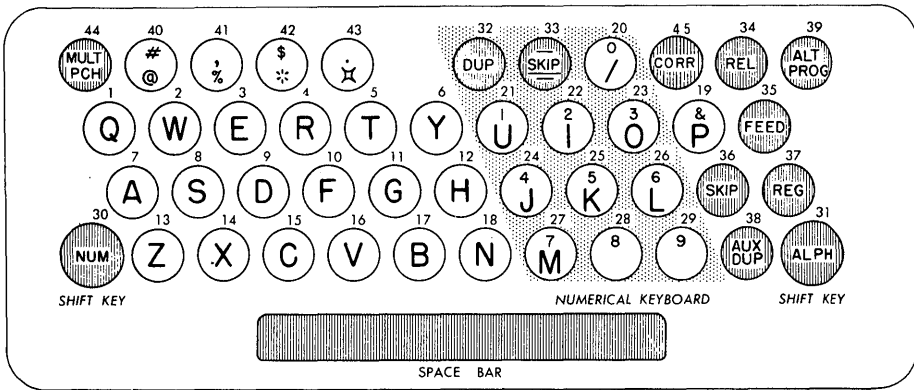
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Figure 3-4.—Combination keyboard chart.

drum. With program control, one depression duplicates an entire field from the master card. Without program control, only one column is duplicated from the master card for each key depression.

39. ALT PROG (alternate program) is supplied only if the machine is equipped with the alternate program unit. This key is depressed either at the beginning of, or during the card cycle for each card that requires alternate program control instead of normal program control. The alternate program is effective for the remainder of the card, and drops out at the end of that card.

44. MULT PCH (multiple punch) is held down to prevent normal spacing, so that more than one digit can be punched in any one particular column. The keyboard is in numerical shift when this key is depressed.

45. CORR (card correction) is installed only on those machines having the card correction feature. Upon detecting an error, depression of this key moves the error card to the read station and duplicates the information (up to the error column) into a new card at the punch station.

Punching Keys

Keys numbered from 1 through 18 can be depressed only when the keyboard is in alphabetic shift, to punch the alphabetic characters indicated. If one of these keys is depressed

while the keyboard is in numerical shift, the machine locks. Operation can be resumed by releasing the card, or by depressing the back space key or the alphabetic shift key. The letter will punch if the alphabetic shift key is depressed.

Combination keys 19 through 29 can be depressed when the keyboard is in either alphabetic or numerical shift. When the keyboard is in alphabetic shift, the characters printed at the bottom of the keys may be punched. When in numerical shift, the characters printed at the top of the keys may be punched. The numbers 8 and 9, located on keys 28 and 29, may be punched with the keyboard is in either alphabetic or numerical shift.

Keys 40 through 43 are additional special character keys. When the keyboard is in alphabetic shift, the characters at the bottom of the keys may be punched. When in numerical shift, the characters at the top of the keys may be punched.

Space Bar

The space bar can be depressed at any time to cause spacing over unused columns except when automatically skipping or duplicating. If the machine is not equipped with a multiple punch key, this bar can be held down to permit multiple punching in one column.

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Function Control Switches

By referring to figure 3-2, you will notice three switches located on the keyboard. These switches control machine operations as follows:

When the AUTOMATIC SKIP and DUPLICATE SWITCH is turned on, codes punched in the program card to control automatic skipping and duplicating are effective. When turned off, automatic skipping and duplicating are suspended.

With the AUTOMATIC FEED SWITCH turned on, whenever column 80 of the card passes the punching station, either by punching, skipping, or releasing, a new card is fed automatically. At the same time, the card at the left of the card bed is stacked, the card at the center is registered at the reading station, and the card at the right is registered at the punching station.

When the PRINT SWITCH on the type 26 card punch is turned on, printing occurs across the card directly above the columns being punched. When turned off, all printing is suppressed.

PROGRAM UNIT

The card punch program unit controls automatic skipping over columns not to be punched, automatic duplicating of repetitive information and the shifting from numerical to alphabetic punching mode and vice versa. Each of these operations is controlled by a specific code punched in a program card. The program card is fastened around a program drum. When the drum is inserted in the machine, the codes punched in the program card are read by a set of star wheels in the sensing mechanism. The drum revolves in step with the movement of the cards past the reading and punching stations so that the program codes can control the operations being performed, column for column. These program codes also control printing functions of the 26 printing card punch. Figure 3-5 illustrates a program card fastened around a program drum and the relationship of the drum to the program unit.

Program Card

A program card, which is the basic part of the program unit, is prepared for each different type of punching application. One such application is shown in figure 3-6. Each row of punches in the program card controls a specific function as follows:

BLANK (Numeric Shift) A blank column at the beginning of a field in a punched program card identifies it as one to be manually punched with numeric information. With a completely blank card on the program drum, the card punch remains in numerical shift.

12. (Field Definition.) A 12 punch is placed in every column, except the high order position, of every field to be skipped, duplicated, or manually punched. These 12 punches define the length of the field or operations and serve to continue any skip or duplication, started within a field, to the end of that field. Consecutive fields that are to be treated the same way should be programmed as a single field. A field consisting of a single column should not be programmed with a 12 code.

11. (Automatic Skip.) An 11 punch is placed in the high order position of any field which is to be skipped automatically. Skipping is continued over that field by the 12 punches in the remaining columns of the field. The automatic skip and duplicate switch must be ON in order for automatic skipping to be effective.

0. (Automatic Duplication.) A zero punch is placed in the high order position of any field which is to be duplicated automatically. Duplication is continued over that field by the 12 punches in the remaining columns of the field. The automatic skip and duplicate switch must be ON.

1. (Alphabetic Shift.) The combination keyboard is normally in numerical shift when the program card is in the machine, and depression of a combination key causes a number to be punched. In order to punch a letter, the keyboard must be shifted to alphabetic punching. This shifting is done automatically by a 1 punched in the program card for each column of the alphabetic field. When duplicating alphabetic information, the 1 punches permit automatic spacing over blank columns, valid only in alphabetic fields, and prevent skipping when letters containing 11 punches are duplicated.

2. (Left Zero Print.) With program control effective, the type 26 card punch will not print zeros to the left of the high order significant digit in a numerical field unless a special code is placed in the program card. In order to print these zeros, a 2 must be punched in each column of the field in the program card.

CLAMPING
STRIP HANDLE

CLAMPING STRIP

ALIGNMENT
CHECK HOLES

ALIGNING PIN
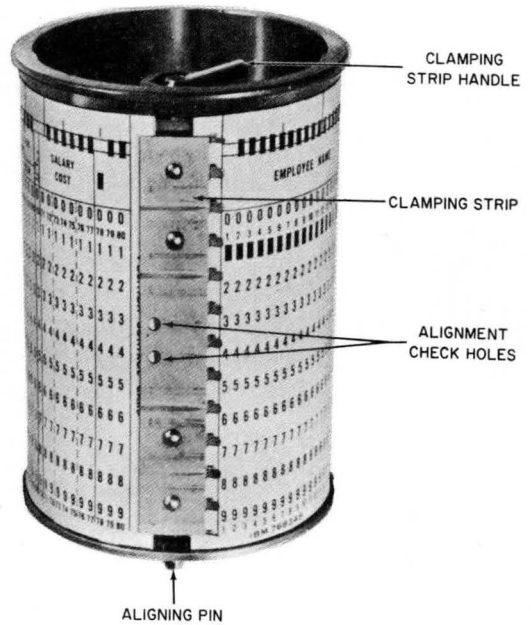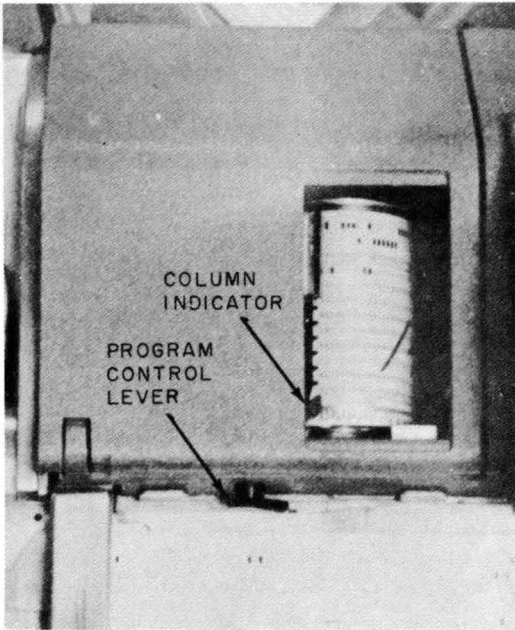
A.—Relationship between the program card, program drum, star wheels, and program control lever.

B.—Program card wrapped around a program drum.

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Figure 3-5.—Program unit.

A zero in the units position of a field will always print, unless all printing is suppressed. These same rules of left zero print also apply to special characters.

3. (Print Suppression.) When the print switch is ON, printing normally occurs for each column that is punched. Printing can be suppressed by punching a 3 in the program card for each column in which print suppression is desired.

Effects of these last two codes can be seen in figure 3-7. Columns 76 and 78 would be blank on the program card and 12's would be punched in columns 77 and 79. To print the zeros of employee No. and social security No., 2's would be punched in each column of those fields on the program card. Punching

3's in columns 34-40 of the program card suppressed the printing of the "rates" field.

Alternate Program

An alternate program unit can be installed in card punch machines as an optional feature, so that two program setups can be punched in one program card. Coding for alternate program consists of 4-9 codes used in the same manner as the 12-3 codes for normal program. Alternate programming is especially useful when two different types of cards are to be punched from the same source document in one keypunching operation. This permits punching of both types of cards without changing program cards. The program card is set up with normal programming for punching one type of card,

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Figure 3-6.—Program card.

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Figure 3-7.—Character printing.

and alternate programming for the other. Both normal and alternate program codes are summarized as follows:

Normal Code	Alternate Code	Function
12	4	Field Definition
11	5	Start Automatic Skip
0	6	Start Automatic Duplication
1	7	Alphabetic Shift
2	8	Left Zero Print
3	9	Print Suppression

Program Drum

The program card is mounted on a program drum for placement in the machine. (Refer to fig. 3-5B.) Note that the program drum has a clamping strip which holds the card, and a handle on top to tighten or release the strip. The following steps describe the procedure for placing a program card around the program drum.

1. Turn the handle on the program drum counterclockwise as far as it will go. This loosens the smooth edge of the clamping strip.

2. Place the column 80 edge of the card under the smooth edge of the clamping strip. Two alignment check holes in the strip make it possible to see that the card is flush with the metal edge under the strip. The card should be positioned so that the 9 edge is against the rim of the drum.

3. Turn the handle to the center position. This tightens the smooth edge of the clamping strip and loosens the toothed edge.

4. Wrap the card tightly around the drum and insert the column 1 edge under the toothed edge of the clamping strip.

5. Turn the handle clockwise as far as it will go. This fastens the toothed edge of the clamping strip. The drum is now ready to be inserted in the machine.

Program Control Lever

Operation of the program unit is controlled by the PROGRAM CONTROL LEVER which raises and lowers the sensing mechanism. (See fig. 3-5.) When this lever is turned ON (left side of lever down), the program sensing mechanism is lowered so that the star wheels of the mechanism rest on the program card placed around the drum.

The drum has 12 grooves in the same positions as the punching positions of the card. The star wheels, upon detecting holes in the program card, fall through and close contact points that direct the card punch to perform specific operations. These operations are then continued for the required number of columns as per program card codes.

The star wheels should never be lowered (program control ON) when the drum does not hold a card. This would result in the star wheels reacting as though they had detected holes in several rows simultaneously, and would damage the card punch by giving it contradictory instructions.

Also, to prevent damaging the star wheels, the program control lever should be turned OFF (right side of lever down-star wheels raised) when inserting or removing the drum.

Remember, the card punch is in alphabetic shift when program control is off. Contrariwise, with program control ON, the card punch is in numerical shift IF a card is on the program drum. Use of the two shift keys is necessary to punch letters or numbers out of shift, if not programmed to do so.

When inserting the program drum in the machine, (program control OFF) place the drum on its spindle under the center cover of the machine, positioned so that the aligning pin falls in the aligning hole in the column indicator dial. Turn the program control lever ON and depress the release key to engage the sensing mechanism fully.

CARD PUNCH, TYPE 29

The IBM type 29 card punch, pictured in figure 3-8 is essentially like the types 24
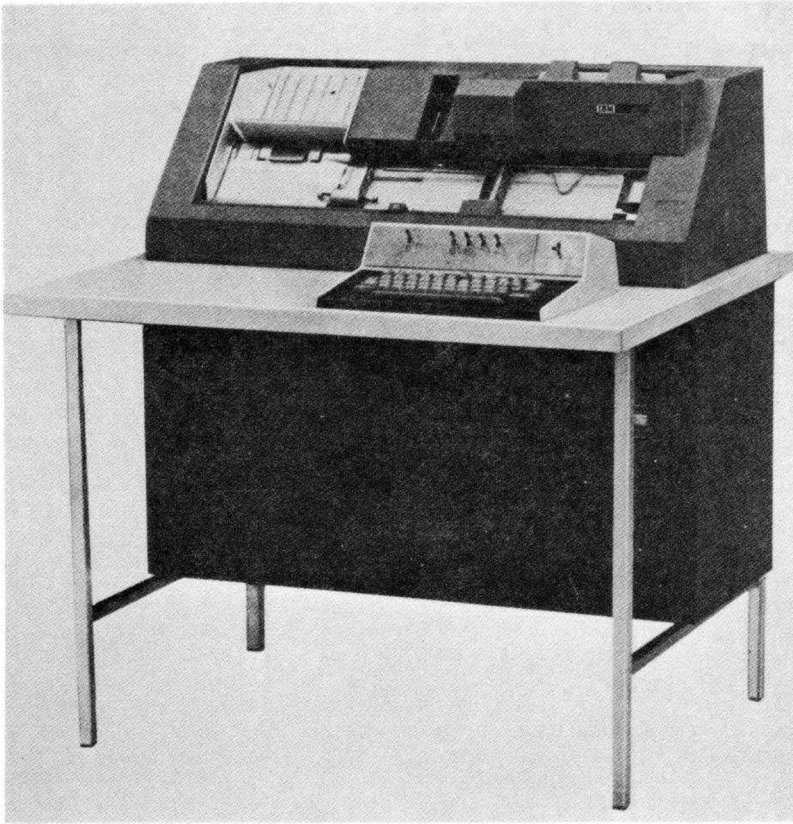
Figure 3-8.—IBM type 29 card punch.

and 26 in design and operation, with additional features such as the unlimited use of two program levels and expanded character keyboards. Other differences are noted below.

Card Stacker

The card stacker, when filled to a capacity of approximately 500 cards operates a switch that interlocks the card feed. Power is not turned off, however, and the machine is ready for immediate operation as soon as the cards are removed from the stacker.

A scale is in the stacker so that an estimate can be made of the number of cards processed.

Main Line Switch

The main line switch is located on the front right side of the cabinet under the keyboard. The machine is ready for immediate use when the main line switch is turned on.

KEYBOARDS

Figure 3-9 illustrates the numeric and combination keyboards that are used on the type 29. The combination keyboard can be either a 48-character or a 64-character model. Figure 3-10 shows a 64-character keyboard, and the characters that can be punched by a single key depression. These 64 characters are arranged to be compatible with the IBM System/360.
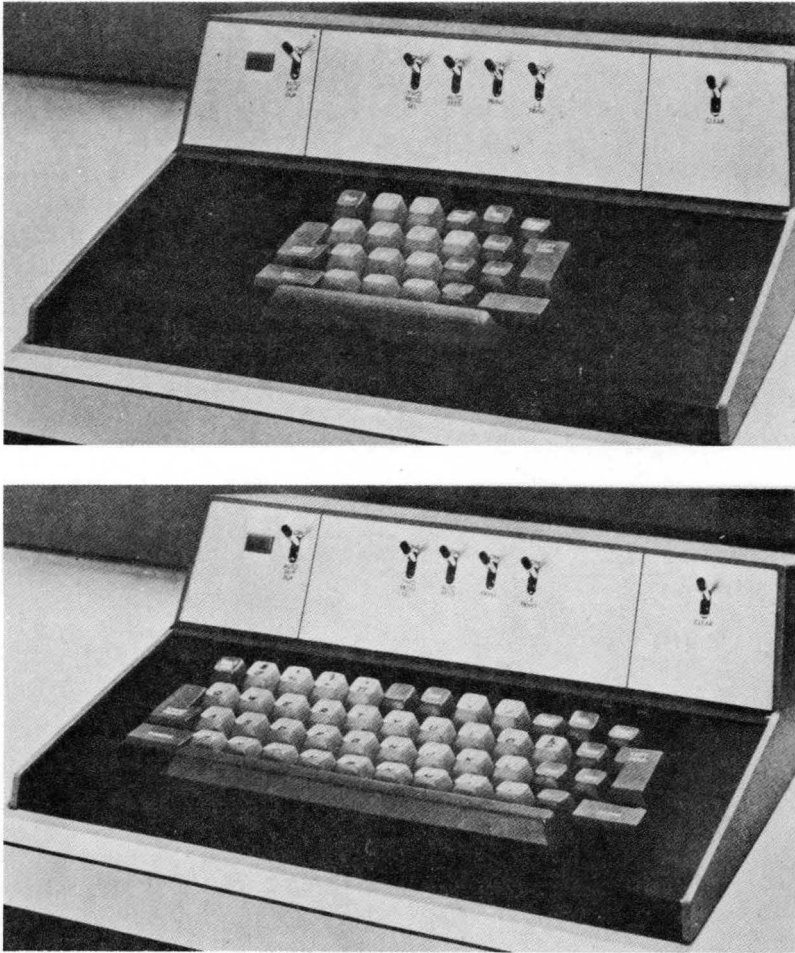
R49.5.2X

Figure 3-9.—Type 29 numeric and combination keyboards.

Figure 3-11 is a chart of the keytop graphics and punched-hole codes associated with each key.

Note that key 5 punches a combination of the zero, two, and eight holes in the card. No graphic has been assigned to this combination.

Functional Keys

The functional keys perform all operations previously described for the type 24 and 26.

They differ somewhat, as indicated in figure 3-10, and as explained below.

34. REL (release) and register cycles are not required to clear the card bed of cards. Use the clear switch for this operation.

35. FEED (card feed) if held depressed, moves two cards from the hopper into the punch and preregister stations. When a card is registered at the punch station it is inoperative.

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Figure 3-10.—64-character combination keyboard.

Key Number	ALPHABETIC		NUMERIC	
	Card Code	Graphic	Card Code	Graphic
1	11–8	Q	12–8–6	+
2	0–6	W	0–8–5	
3	12–5	E	11–8–5	)
4	11–9	R	12–8–2	¢
5	0–3	T	0–8–2	0–8–2
6	0–8	Y	12–8–7	l
7	12–1	A	none	none
8	0–2	S	0–8–6	>
9	12–4	D	8–2	:
10	12–6	F	11–8–6	;
11	12–7	G	11–8–7	¬
12	12–8	H	8–5	'
13	0–9	Z	none	none
14	0–7	X	0–8–7	?
15	12–3	C	8–7	"
16	0–5	V	8–6	=
17	12–2	B	11–8–2	l
18	11–5	N	12–8–5	(
19	11–7	P	12	&
20	0–1	/	0	0
21	0–4	U	1	1
22	12–9	I	2	2
23	11–6	O	3	3
24	11–1	J	4	4
25	11–2	K	5	5
26	11–3	L	6	6
27	!1–4	M	7	7
28	0–8–3	,	8	8
29	12–8–3	.	9	9
33	11	–	11	–
40	8–4	@	8–3	#
41	0–8–4	%	0–8–3	,
42	11–8–4	*	11–8–3	$
43	12–8–4	<	12–8–3	.

&	Ampersand	
–	Minus or Hyphen (Dash)	
/	Slash	
.	Period	
$	Dollar Sign	
,	Comma	
#	Number Sign	
<	Less Than Sign	
*	Asterisk	
%	Percent Sign	
@	At Sign	
¤	Lozenge	
¢	Cent Sign	
l	Exclamation Point	
:	Colon	
(	Left Parenthesis	
)	Right Parenthesis	
_	Underscore	
'	Prime or Apostrophe	
+	Plus Sign	
;	Semicolon	
>	Greater Than Sign	
=	Equal Sign	
		Vertical Bar, Logical OR	
¬	Logical NOT	
?	Question Mark	
"	Quotation Mark	

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Figure 3-11.—Key graphics and punched-hole codes.

39. PROG TWO (program two) causes the card format to be changed when under program control. Shifting between program levels 1 and 2 is unlimited during the punching of a card.

In one-program application, if the second level is not coded on the program card, depressing this key suspends programming, making it necessary to raise the starwheels for program suspension.

45. PROG ONE (program one) causes the immediate transfer to Program One.

46. MC (master card) is installed only on machines having the master card insertion device.

47. ERROR RESET unlocks an interlocked keyboard.

48. LEFT ZERO when installed, initiates zeroes to the left of a significant digit in a field when programmed for that operation.

Functional Control Switches

The switches labeled AUTO SKIP/DUP, AUTO FEED, and PRINT on the keyboard panel illustrated in figure 3-12, control automatic skipping and duplication, automatic feeding, and printing operations common to all card punches.

The CLEAR switch when operated, advances the cards in the read station, punch station, and preregister position to the stacker without card feeding taking place.

The PROG SEL (program selection) switch gives added flexibility to a program operation. Setting the switch on ONE or TWO determines the normal and alternate coding desired.

When the print switch is on, zeros, dashes, and ampersands to the left of the first significant digit in a field are suppressed unless the LZ PRINT (left zero print) switch is turned on.

PROGRAM UNIT

The operation of the program unit is similar to the types 24 and 26. The major difference is that the normal program unit is known as program level one, while the optional alternate program unit is a standard feature, and is program level two. Either program can be selected for card to card use by selecting the program selection switch. If it is desired to use both program levels to control punching on a single card, alterations from program to program can be made by program selection keys on the keyboard. Programs can be alternated at will, while punching a single card, by means of these keys.

OPERATING SUGGESTIONS

Before any keypunching operation is started, you should check to make sure that you have the correct program card mounted on the program drum, the proper type of cards in the card hopper, and the card punch cleared of all items not related to the job to be performed. The keyboard and source documents should be arranged in a manner to provide maximum reading punching ease.

There is no set procedure that governs all keypunching operations. The procedures to be followed depend upon the requirements of the particular job. The program card layout must be determined by the type of data to be punched, and the manner of punching. Factors such as duplication, skipping, and combined alphabetic and numerical punching in the same field must be taken into consideration in order to prepare a program card for maximum punching efficiency.
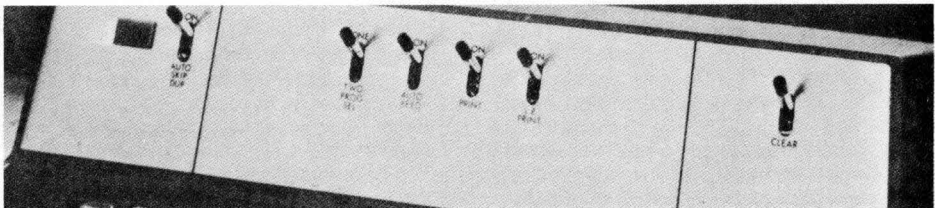
Figure 3-12.—Keyboard switch panel.

Speed and accuracy in keypunching can be attained only through practice, and observance of the best methods to be followed. The following procedures and suggestions are listed as an aid in attaining efficient operation of card punch machines.

Corner Cuts

An important point to remember about any keypunching operation is to avoid using cards with lower corner cuts. Such cards, unless the corner cut has been specially designed, will not feed through the card bed properly.

Inserting Cards Manually

In certain instances keypunching will involve only one card, such as punching a header card, making over a damaged card, or correcting an erroneous card. All that is necessary to punch a single card is to insert the card directly into the card bed to the right of the punching station, depress the register key and start punching. For such an operation, program control is not required. When program control is not used, the keyboard is in alphabetic shift. Therefore, the numerical shift key must be held down while punching numbers from the combination keys.

In order to duplicate one card, the card to be duplicated is placed in the card bed to the right of the reading station, and a blank card placed to the right of the punching station. Depression of the register key registers both cards. The duplicate key is then depressed and held down for as long as duplication is required.

Error Correction

Errors in punching will often be noticed and corrected at the time they are made. For operations involving program control, correction is easily accomplished with a minimum of re-punching, by performing the following steps.

1. Depress the release key when an error in punching is detected. The card automatically skips over fields which are coded for manual punching, and fields coded for duplication beyond the point of the error are automatically duplicated.

2. All fields to the left of the error field can be duplicated into the corrected card either by automatic duplication as set up in the program card, or by manual depression of the duplicate key for each field which is not programmed for automatic duplication.

3. Repunch the field in which the error occurred, and continue normal punching.

4. Remove the error card from the stacker and destroy.

Engaging the Program
Sensing Mechanism

When the program control lever is turned on to lower the star wheels, the sensing mechanism may not be fully engaged. Therefore, it is necessary also to depress the release key. For this reason, once the program is turned on it should be left on, and whenever possible, any temporary changes or interruptions in the punching routine should be handled by the functional switches and keys.

Multiple Punched Columns

Normal spacing is suspended when the multiple-punch key is depressed. This permits you to punch as many digits as you wish in one column, for as long as the multiple-punch key is held down. If your machine is not equipped with a multiple-punch key, the space bar can be held down for this operation. The keyboard is in numerical shift when either the multiple-punch key or the space bar is depressed.

Punching and duplicating multiple punches on the 26 and 29 card punches must be limited to printable characters to eliminate possible damage to the printing mechanism.

Checking Registration

Card punches should be checked daily to ensure that punching is being aligned correctly in the card. Visual checking of the punched card is not reliable, since the printed numbers in the cards may not be aligned perfectly. A punch should be placed in each of the 80 columns of a card. This card should then be placed on a card gage which is designed to indicate the exact location of every punching position in a card. If the cards are off-punched, the punches may not be read correctly by other machines. A customer engineer should be contacted to adjust the punching registration of the card punch.

Keyboard Locking

The keyboard will become locked under any of the following conditions:

1. When the main line switch is turned off, and then on, while a card is registered at the punching station. The keyboard can be unlocked on types 24 and 26 depressing the release key. On type 29, the clear switch should be operated to move the card to the stacker; however, the card at the punch station need not be removed. Depressing the feed key once will bring a second card down without advancing the first card, and restores the machine to operating condition.

2. When an alphabetic key, other than a combination key, is depressed in a field programmed for numerical punching. The keyboard can be unlocked either by depressing the back-space key (then manually space to the next column), the release key (the card is released without punching), or the alphabetic shift key (the alphabetic character is punched).

3. When a blank column is duplicated in a field programmed for numerical punching. This acts as a blank column detection device to assure that a digit is punched in every column of a numerical field which is being duplicated. The keyboard can be unlocked by depressing either the backspace key or the alphabetic shift key.

4. When a card is not registered at the punching station. Punching or spacing cannot be accomplished unless a card is in position to be punched. When the automatic feed switch is ON, either the register, feed, or release key can be depressed to move a card into punching position.

5. When the register key or the feed key is depressed while a card is registered at the punching station. The keyboard can be unlocked by depressing either the release or backspace key.

NOTE: On the type 29, the backspace key is not used for resetting a locked keyboard. The error reset key serves this function.

Ribbon Replacement

The ribbon on Printing Card Punches feed between two spools, through ribbon guides, and under the punch die, as shown in figure 3-13. The old ribbon is removed and a new one is inserted as follows:

1. Turn off the main line switch.
2. Remove the ribbon-spool retaining-clamp.
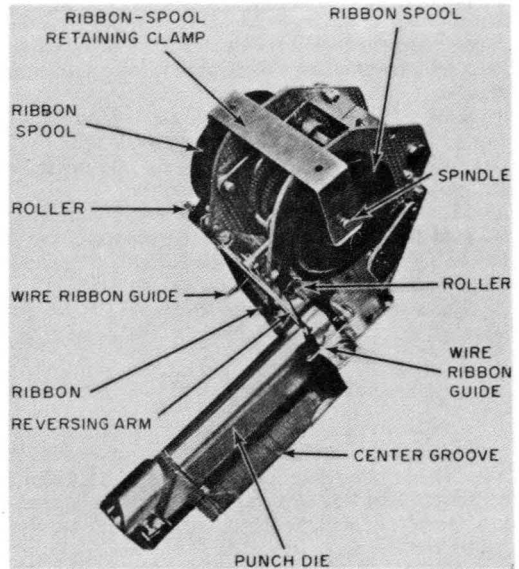
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Figure 3-13.—Ribbon replacement.

3. Cut or break the old ribbon.
4. Remove both spools from their spindles and pull out the two pieces of ribbon. Empty one of the spools.
5. Place the spool of new ribbon on the right-hand spindle, positioning it so that the ribbon feeds from the top of the spool toward the front of the machine. Lift up the right end of the ribbon-reversing arm, if it is not already up, and unroll about a foot and a half of ribbon; then push down the right end of the ribbon-reversing arm to hold the spool steady.

6. Feed the metal leading-end of the ribbon between the punch die and the card bed, sliding it through the groove in the center of the card bed (between the "3" and "4" punching positions). The groove permits the extra thickness of the metal end and the reversing eyelet to pass between the punch die and the card bed. Be sure to keep the ribbon straight, with the "top" side up at all times.

7. Hook the metal leading-end of the ribbon in the slot in the center of the empty spool and wind the ribbon onto the spool until the reversing eyelet is on the spool.

8. Place the spool on the left spindle, positioning it so that the ribbon feeds onto the spool over the top. Be sure that the ribbon is not twisted and that the "top" side of the ribbon is still up.

9. Hook the ribbon around the right and left wire ribbon guides, and slide it through the right and left ends of the reversing arm and over the rollers in front of the ribbon spools.

10. Slide the ribbon up under the punch die so that it is in the upper groove provided for it in card-printing position (above the "12" punching position), and take up the slack.

11. Replace the ribbon-spool retaining-clamp.

CARD VERIFIERS

Card verifying is simply a means of checking the accuracy of the original keypunching. A second operator verifies the original punching by depressing the keys of a verifier while reading from the source document that was used to punch the cards.

CARD VERIFIER, TYPE 56

The IBM type 56 card verifier closely resembles the 24 card punch in design and operation. Card feeding, stacking, and program control operate the same in both machines. It should be noted, however, that though program cards are interchangeable between machines, the "O" code will initiate automatic verification (versus duplication); that is, designated fields may be automatically compared with the same fields of the card at the reading station. (Automatic verification is often used in the verification of fields that were duplicated in the original punching operation.) The automatic skip and verify functional control switch must be ON to make the "O" coding effective. Other features differing from the card punch and illustrated in figure 3-14 will be discussed.

Verifying Station

Verification is performed at the first station in the card bed. Instead of punch dies, the verifier contains a sensing mechanism consisting of 12 pins. (See fig. 3-15). So long as the verifier operator depresses the same key as the card punch operator depressed in punching the original hole(s), the card will proceed to the next column to be verified. However, if the hole pattern detected by the pins of the sensing mechanism does not agree with the key depressed, an error is signaled. When a card is verified and found correct, a notch is automatically cut into the right end of the card. If the card is incorrect, a notch is cut in it over the column containing the error.

Error Light

The card verifier is equipped with an error light in place of a backspace key. When an error is detected, the light goes on, and the keyboard becomes locked. The procedure to be followed in such a situation is described under Operating Suggestions.

COMBINATION KEYBOARD

All keys on the type 56 card verifier operate the same as the corresponding keys on the type 24 card punch, with the exception of the following functional keys. Refer to figure 3-4 and 3-14 for location of these keys.

32. VER DUP (verify duplication) causes verification of the card at the verifying station by comparing it with the preceding card. With program control, a single key depression causes the field for which it is depressed to be verified at the rate of 20 columns per second. Without program control, verification is performed at the rate of 10 columns per second for as long as this key is held down.

38. AUX VER (auxiliary verify) operates only if the machine is equipped with the auxiliary verification device. This key causes verification by comparing the card at the verifying station with a master card mounted on an auxiliary program drum.

44. MP-ER (multiple punch, error release) performs two functions. It prevents normal spacing of the card in order to verify two or more punches in one column. It also releases the keyboard when the keyboard becomes locked during a verifying operation. The keyboard is in numerical shift when this key is depressed.

Function Control Switches

Referring to figure 3-14, you will notice that the automatic skip and verify switch replaces the automatic skip and duplicate switch of the card punch.

The AUTOMATIC FEED SWITCH performs the same functions as the card punch except
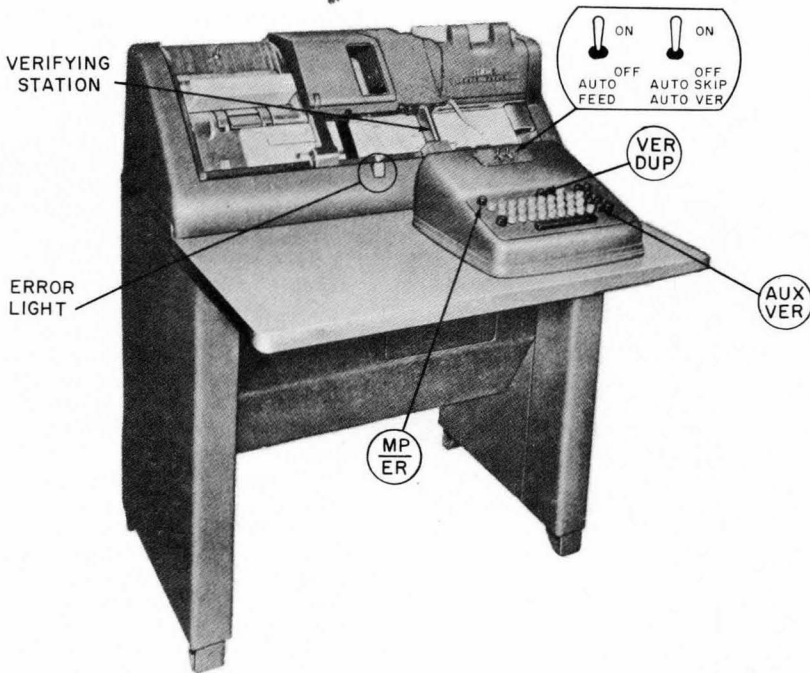
R49.5.1AX

Figure 3-14.—Differences of the verifier.

feeding is suppressed when an error card moves from the verifying station. This allows the error card to stop between the verifying station and the reading station so that the correct information can be written on the card.

With the AUTOMATIC SKIP and VERIFY SWITCH turned ON, codes punched in the program card to control automatic skipping and verification (11 and 0) are effective. When turned OFF, the codes are nullified and these operations are suspended.

CARD VERIFIER, TYPE 59

As the type 56 card verifier closely resembles the type 24 card punch, the IBM type 59 verifier shown in figure 3-16 is the same in design and features at the type 29 card punch. The operation of the two generations is very similar. The type 59 card verifier however, uses fiber-optics and phototransistors

for sensing holes in the card. Other differences will be discussed.

Automatic Verification

Depending on the program level, a 0 (zero) or a 6 punched in the first column of any field, starts automatic verification which operates at the rate of 50 columns per second. High speed automatic verification at the increased speed of 80 columns per second is programmed by addition of a 3-punch or a 9-punch, depending on the program level, to the original 0-punch or 6-punch (0-3, 6-9).
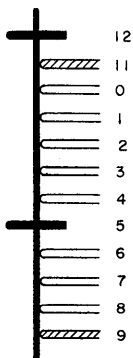
Keyboards

The NOTCH key causes an error notch to be cut in the 12 edge of the error column. The only condition in which this key is operative is in a high speed error condition.

VERIFYING
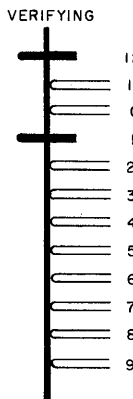
SCHEMATIC OF SENSE PINS IN AN IBM 56 VERIFIER CHECK-
ING HOLES IN A CARD UPON DEPRESSION OF THE A KEY.
IN THIS CASE THERE IS AGREEMENT SO THE CARD WILL
ADVANCE TO THE NEXT COLUMN TO BE CHECKED.

▰▰▰ SCHEMATIC OF PINS DETECTING AN E ETC.

▨▨▨ R-KEY IS DEPRESSED BY VERIFIER INSTEAD OF
E, CAUSING THE ERROR LIGHT TO COME ON
ETC.

R49.245X

Figure 3-15.—Sensing pins of the verifier.

The error light on the keyboard is turned
off by depressing the error-reset key. In a
high speed automatic verification operation,
the light does not go out when the error-reset
key is depressed; it remains on to signal a
high speed error. The Clear, Release, or Notch
key must be depressed, following the error-
reset key depression, to continue the error
handling routine.

OPERATING PROCEDURES

The operating principle for verifiers is the
same as for the card punches, with the excep-
tion of the error routine. Errors may be com-
mitted either in the punching of a card or in
the verification. Therefore, provision is made
for three trials in the verification of a column.
If an error is made while verifying, you have
two more chances to depress the correct key.
When the error light comes on, the following
routine should be followed.

1. Depress the error release/reset key to
free the keyboard.
2. Make a second attempt to verify the
column. If on this trial the card registers
correct, the error light goes out and verifica-
tion can be continued. If it registers incorrect,
the error light remains on and the keyboard
becomes locked again.
3. Depress the error release/reset key
again.
4. Make a third attempt to verify the col-
umn. At this time the light goes off and verifica-
tion can be continued whether the card is correct
or not. If it is incorrect, the column is error
notched. When it is evident that a character
has been omitted, the skip key can be de-
pressed in lieu of making the second or third
attempt to verify the error column. The error
column is then notched, the error light turns
off, and the remaining portion of the field is
skipped. (see fig. 3-17A.)

OPERATING SUGGESTIONS

The procedures to be followed for setting
up a verifying operation are the same as for
keypunching. Therefore some of the sugges-
tions listed under keypunches, such as starting
a punching operation and engaging the program
sensing mechanism, apply equally to verifying.
Other suggestions for verifying are listed be-
low.

Multiple Punch Verification

The multiple punch key, when held de-
pressed, prevents normal spacing of the card,
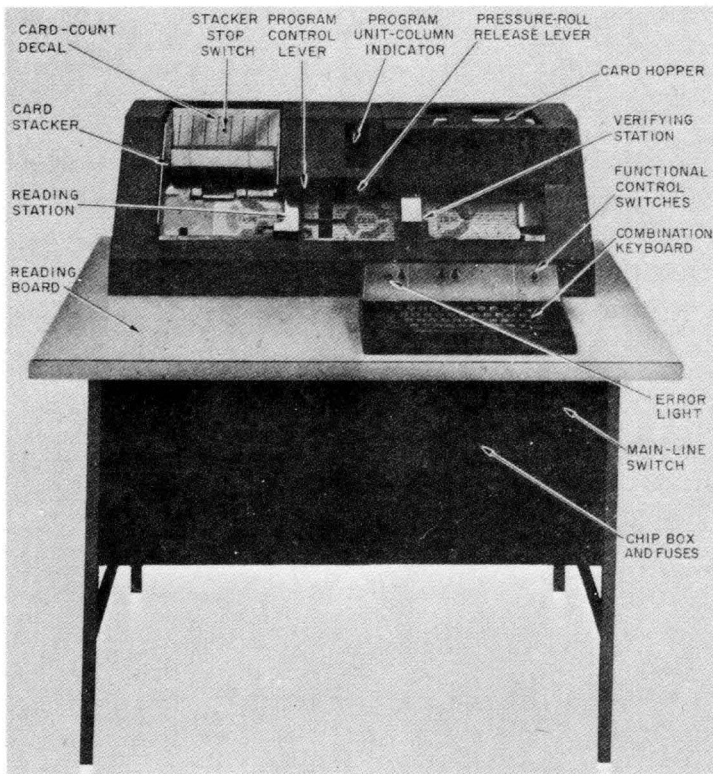thus permitting the verification of two or more

Figure 3-16.—IBM type 59 verifier.

punched holes in one column. All punches in a column must be verified unless the machine is equipped with a verification-elimination device.

OK Notch

When a card is verified, a notch is cut in the right end of the card. Every field of the card must be either verified or programmed to skip in order for the final OK notch to be cut. The card is not notched if released. Therefore,

if a card is to be verified without program control, each column must be keyed, spaced, or automatically verified in order to obtain the OK notch.

Since cards passing the verifier test are notched on the column-80 end of the card between the 0 and 1 rows (fig. 3-17B), separating the incorrect cards (those not having the OK notch) for re-punching is simplified. An upper right corner cut card should not be used for a program card as it may interfere with the check notching.

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A. ERROR CARD

B. CORRECT CARD

R49.246X

Figure 3-17.—Verification notches

Inserting Cards Manually

Improper manual registration of a card at the reading station may cause false errors during an operation. Therefore, when manually inserting a card at the reading station, do not push the card in all the way to the stop. Insert the card about 1 inch beyond the pressure roll so the card will be machine registered by the pressure roll when the register key is depressed.

Keyboard Locking

If a key is depressed which does not correspond to the hole punched in the card, the keyboard will lock. The procedure for unlocking the keyboard and re-verifying the column is described under Operating Procedures. Other locking of the keyboard may be caused by any one of the following situations.

1. When the main line switch is turned off and then on while a card is registered at the verifying station. The keyboard may be unlocked by depressing the release key.

2. When a card is registered at the verifying station, and the register key is depressed unnecessarily. This causes the feed and release keys to lock. They are unlocked either by depression of a character key, the space bar, or the error release/reset key.

3. When a card is registered at the verifying station, and the feed key is depressed unnecessarily. This causes the register and release keys to lock. They are unlocked either by depressing a character key, the space bar, or the error release/reset key.

DATA COMMUNICATIONS

Because data collection by mail or messenger is slow, many new types of communications have been developed for rapid collection, processing, and subsequent use of information. A special form of communication whereby information is conveyed over a distance is called telecommunications. Telephone, radio, and television are examples of modern telecommunications.

Data communication systems may be employed in any situation which calls for rapid transmission of data between activities physically removed from each other. This data may be transmitted either by telephone or telegraph lines.

As a Data Processing Technician you may be assigned to duty in an installation which has data transceivers, such as a Personnel Accounting Machine Installation, designed to send data over telephone lines to other locations containing telecommunication systems, and to receive data from other locations by the same method.

An example of such data exchange is the transmission of data to the Bureau of Naval Personnel on personnel that are due for transfer from sea duty to shore duty and the receiving of assignment data from BuPers for use by the local personnel distributor concerned.

Because the systems are designed to send as well as receive, only one machine is required at each station to provide data exchange in both directions.

DATA TRANSCEIVER, TYPE 66

The IBM 66 data transceiver illustrated in figure 3-18 is a modified card punch, which is cable connected to a signal unit. When the transceiver is set to transmit, the card unit reads a card one column at a time, much as the standard card punch performs duplication, and sends the data to the signal unit. The signal unit then converts the punched holes to electrical impulses which can be sent along a telephone or telegraph line. When the transceiver is set to receive, the signal unit receives the electrical impulses from the telephone or telegraph line, converts them to punched card codes, and sends the codes to the card unit for punching. (See figure 3-19.)

SIGNAL UNITS

Since punched holes as such cannot be transmitted over communication lines, they must be converted to electrical impulses. This is the job of the signal unit. While one type of unit is used for transceiving over telegraph lines, another type is required for telephone lines.

Telegraph Signal Unit

Over telegraph lines, only one transmission can be made per line. The speed of transmission is controlled by a pluggable speed selector in the signal unit. Either one of three different speed

selectors may be used, depending upon the class of service available. The number on the handle of the speed selector in the transmitter must match the one in the receiver.

Telephone Signal Units

Up to four independent transmissions can be made at one time over the same telephone line, provided each transmission has its own transceiver at each end of the line. Channel selectors are used to select the tone frequency which will be assigned a pair of transceivers. These selectors are used to divide a voice telephone channel into four transmission channels. They operate in the center of a 500-cycle bandpass, with center frequencies of 800, 1300, 1800, and 2300 hertz (cycles per second).

Machines which are paired for sending and receiving must use the same channel selector number. This two-digit number is engraved on the handle of each selector to identify the channel number, and to indicate whether the selector will work with a 2-wire or a 4-wire telephone circuit.

Telephone lines are available in either 2-wire or 4-wire terminations. If a 4-wire signal unit is furnished, it can be used on a 2-wire telephone line by the insertion of a 2-wire channel selector. If a 2-wire signal unit is furnished, it must be modified to operate on the 4-wire telephone lines. In order to distinguish between the 2-wire and 4-wire channel selectors, the following numbers are designated for each frequency:

Telephone Channel Selector	Frequency	Channel Number	
		2-Wire	4-Wire
1	800 Hz	21	41
2	1300 Hz	22	42
3	1800 Hz	23	43
4	2300 Hz	24	44

CARD UNIT

The card unit is a modified card punch, arranged for automatic operation. Since it does not contain a keyboard, additional data cannot be entered into a card as it is being transmitted or received. Operation of the card unit is performed on a small control unit. A program unit is also provided to control the transceiver functions.

The POWER SWITCH is located on the left front panel of the card unit under the reading board. This switch supplies power to the machine, and must be ON for all machine operations.

The STACKER switch is located at the rear of the stacker, in the same position as the main line switch on card punch machines. This switch turns off automatically and stops transceiver operation when the stacker is filled.

Control Unit

The control unit, which is cable connected to the card unit, may be positioned at any desired location on the reading board. The operating switches, keys, and lights are illustrated in figure 3-20, and described as follows:

Print Switch.—Some card units are equipped with a printing feature, which allows for printing information across a card as it is being received. When the switch is turned on, printing is controlled by the program card. When turned off, all printing is suppressed.

Transmit-Receive Switch.—This switch controls transceiver operation. As transceivers are always used in pairs, the transmitter must have this switch set to TRANSMIT, and the receiver to RECEIVE.

Interlock Key.—This key must be depressed before either the TEL or END-OF-TRANSMISSION key can be operated. When the transceiver is operating, the interlock key must also be used with the release key. This interlock is provided to prevent accidental operation of any of the other keys.

Tel Key.—This key is depressed, along with the interlock key, to request the operator at the other end of the line to change from transceiver operation to telephone communication. Both operators can then operate the switches provided for alternate service, causing the transceivers to remain idle until both switches are again turned back to transceiver operation. The tel key should be depressed only when cards are not being transmitted. Depression of this key lights the tel light on both machines, turns out both start lights, and rings their buzzers.
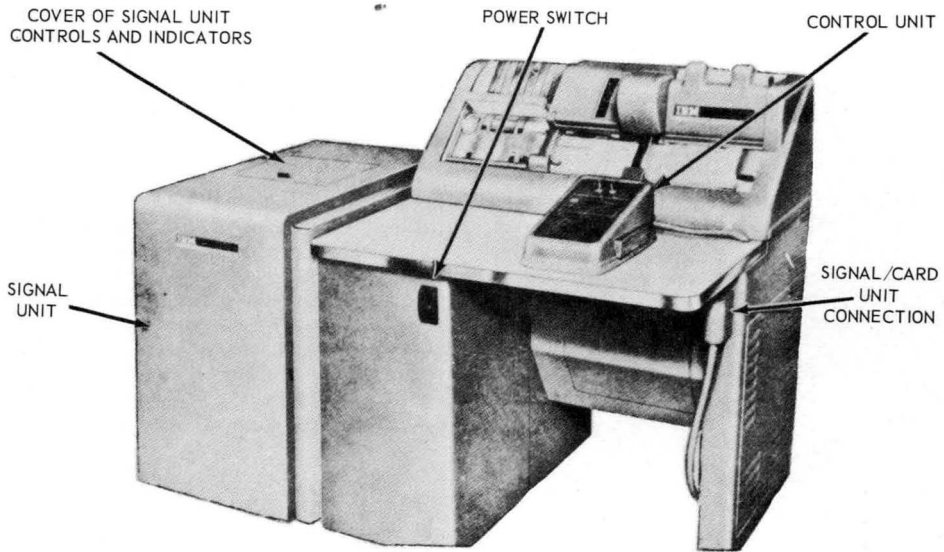
R49.247X

Figure 3-18.—IBM 66 data transceiver and signal unit.

R49.248X
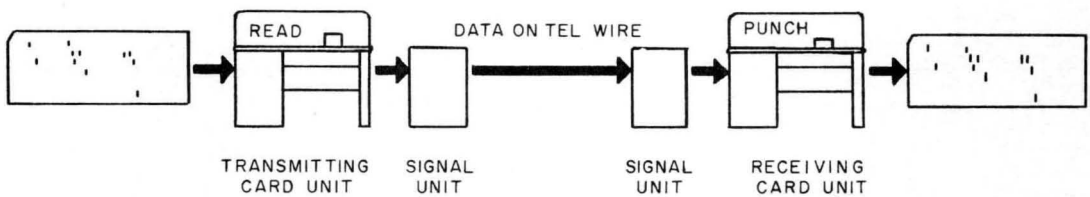
Figure 3-19.—Flow of information.

End-Of-Transmission Key.—This key is depressed, along with the interlock key, when transmitting is completed. Depression of this key lights the end-of-transmission light on both machines, to signal that transmitting is complete. This key may also be used to indicate the end of a group of cards so that the operator at the receiver can change program cards or take any other action required. Depression of this key at either machine will turn off the start lights on both machines and ring their buzzers.

Reset Key.—Depression of the reset key at either the receiver or the transmitter turns off the buzzer, the tel light, and the end-of-transmission light. Depression of the interlock key and the reset key at the receiver turns out the start light and prevents further card reception until the start key is again depressed.

Start Key.—This key serves two purposes. When the machine is used to receive, depression of this key lights the start light on both machines as a signal that the receiver is ready to operate. When the machine is used to transmit, depression of this key starts operation, provided the start light is ON and cards have been fed into both machines.
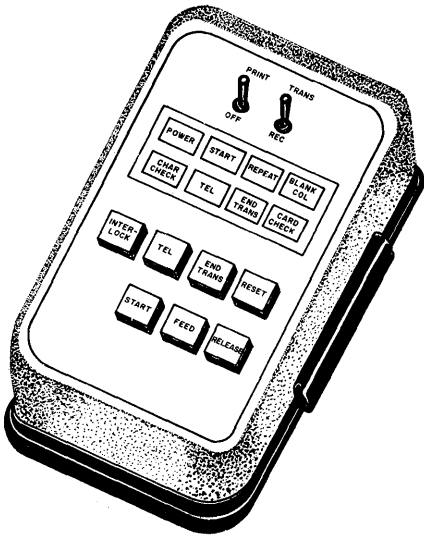
R49.7X
Figure 3-20.—Transceiver control unit.

Feed Key.—Depression of this key causes a new card to feed from the hopper into the card bed. Before any operation can be started, this key must be depressed twice in order for one card to be at the punching station and a second card at the preregistration station.

Release Key.—The release key must be depressed to feed a third card into the transceiver after the feed key has been used to feed the first two cards. Before the operation can proceed, the receiver must have a card at the reading station, a second card at the punching station, and a third card at the preregistration station. The transmitter needs a card only at the reading station.

The release key is used during an operation to clear the card bed. If the repeat light is OFF, depression of this key on either machine releases one card and feeds the next. Any columns which are programmed for duplication in either program card are duplicated during release. If the repeat light is ON, depression of this key on the transmitter automatically ejects all three cards from the card bed to the stacker without feeding any new cards, thus clearing the card bed. Duplication is suspended unless the blank column light is ON, in which case any columns which are programmed for duplication will be duplicated only into the first card released.

Power Light.—Approximately one minute after the power switch has been turned on, the power light will glow, indicating the machine is ready for use.

Start Light.—The start lights on both the receiver and transmitter will glow when the start key at the receiving unit is depressed, provided three cards have been positioned in the receiving card bed. The lights go off when transmitting begins. The start light at the receiver goes off when the reset or release key and the interlock key are depressed at the receiver. The start lights on both machines may be turned off by depressing the end-of-transmission or tel key, along with the interlock key, at either machine.

Repeat Light.—The repeat light glows on both machines when any check or transmitting failure occurs. The light will come on at the transmitter after any 2-second delay during transmission and at the receiver after 4 seconds. A buzzer also rings to draw the attention of the operator to the condition.

Blank Column Light.—This light glows whenever a blank column is transmitted or received. Operation of the blank column check may be suspended by appropriate control punching in the program card.

Character Check Light.—This light will glow in the receiver whenever the character check is not satisfied, thus stopping the receiver before it punches the column in error. The transmitter stops at the end of the card, and the repeat light glows after a 2-second delay. The repeat light at the receiver will come on after a 4-second delay. The character check light in the transmitter also glows if the transmitter fails to receive the correct code for either the start signal at the beginning of a card or the restart signal at the beginning of a field. The character check light may be turned off by depressing the release key.

Tel Light.—The tel light glows on both machines and the buzzers ring when the tel key of either the transmitter or the receiver is

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depressed. This light is a signal that communi-cation by alternate service is desired. This light and the buzzer are turned off by depressing the reset or release key.

End-Of-Transmission Light.—The end-of-transmission lights on both machines will glow and the buzzers will ring when the end-of-trans-mission key on either machine is depressed. Depression of the reset or release key on either machine turns this light out and the buzzer off.

Card Check Light (receiving only).—This light comes on when the internal card check in-dicates that an incorrect number of columns has been received. The transmitter stops at the end of the card being transmitted and the repeat lights on both machines come on. The card check light can be turned off only by depressing the release key.

Program Unit

All functions of the data transceiver are con-trolled by a program card mounted on a program drum. The operation of the program unit is similar to that in card punches. The difference lies in the functions that each of the program card codes control. Two program cards are re-quired for each transmission. One card is used with the transmitter, and the other with the re-ceiver. The control punching required in the pro-gram cards depends on the functions to be con-trolled, such as transmitting, skipping, and duplicating. The following is a summary of the program codes used for data transceiving:

Code	Transmitting	Receiving
12	Field Definition	Field Definition
11	Skip	Skip
0	Duplicate	Duplicate
1	Space Check	Space Check
2	Left Zero Print	Left Zero Print
3	Print Suppress	Print Suppress
4	Skip Control	Skip Control

Code	Transmitting	Receiving
5	End of Card	End of Card with X Punch
6	Variable End of Card	End of Card
8	Transmit	Delayed Start
9	Restart	Restart

12. (Field Definition.) A 12 is punched in the program card for every column of each field ex-cept the high order position. These 12 punches serve to continue to the end of the field any trans-mission, skip, or duplication started within that field.

11. (Skip.) An 11 punched in the program card in the high order position of any field starts a skip, which is continued over the field by the 12 punches in the remaining columns of the field. In the transmitting program card, the 11 punch should accompany the 5 end-of-card punch, and the 12 punches should be punched in all remaining columns in order to skip the cards out to column 81. (Column 81 is that portion of the card just to the right of column 80. It is not used for normal card punching.)

0. (Duplicate.) A zero punched in the high order position of any field in the program card starts duplication, which is continued over that field by the 12 punches in the remaining columns of the field. No more than 30 consecutive columns should be duplicated.

1. (Space Check.) An attempt to transmit blank columns normally turns on the blank column check light and stops transmission. When blank columns are to be read in the transmitted card or spaced over in the received card, it is necessary to place 1 punches in both program cards in all card columns where this might occur. Otherwise, both machines will stop and signal a blank column error.

2. (Left Zero Print.) To print zeros to the left of the high order significant digit in a field, a 2 is punched in each column of the field in the program card. A zero in the units position of a field always prints, unless all printing is sup-pressed.

3. (Print Suppress.) Even with the print switch ON, printing can be prevented for one or more columns of the card. Print suppression is

controlled by a 3 punched in the program card in each column for which print suppression is desired. Printing by the transmitter is internally suppressed except during duplication, at which time it is under the control of the print switch or the program card.

4. (Skip Control.) Skipping can be controlled whenever an 11 punch is read or punched in a transmitted or received card, either singly or in combination with other punches. This type of skipping occurs when a 4 is punched in the program card in the column where X skipping is to be started.

5. (End-of-Card.) A 5 punched in the transmitting program card causes the end-of-card signal to be sent. This control is punched in the program card in the column following the last column to be transmitted. When column 80 is transmitted, the signal is sent automatically; thus no punching in the program card is necessary.

5. (End-of-Card with X-punch.) A 5 is punched in the receiving program card in the column following the last column in which punching is to occur. If the end-of-card signal is received at this column, an 11 is punched in the received card in the same column as the 5 punch in the program card, to indicate that all check circuits were satisfied. A 12 punch is also placed in column 81. If the signal is received at any other column, the machine signals an error and stops.

6. (End of Card.) A 6 may be punched in the receiving program card in place of a 5. In this case, if the end-of-card signal is received at a column containing the 6, the card is released automatically without punching an 11. If the signal is received at any other column, the machine signals an error and stops.

All receiving cards which satisfy the machine check circuits are punched with a 12 in column 81, regardless of the column at which the check is applied.

6. (Variable End-of-Card.) When a varying number of columns are to be transmitted from the same group of cards, the transmitter must be signalled that the end-of-card test will be made at two or more positions of the cards. An 11, punched in the card being transmitted, is used to send this signal. This may be an 11 punch alone, or in combination with other punches.

Each card to be transmitted is prepunched with an 11 punch in the column following the last

column to be sent. A combination 6 and 4 code is punched in the transmitter program card at each check position. Upon reading the 11 punch in the transmitted card and the 6 punch in the program card, the transmitter will send the end-of-card signal and skip the card to column 81.

At the receiver, reception of the end-of-card signal at a column of the program card punched with either a 5 or 6 will satisfy this check. If the signal is received at any other column, an error will be signaled.

7. (Transmit.) Transmission starts automatically at any column in which an 8 is punched in the transmitting program card. Transmission is continued over that field by the 12 punches in the remaining columns of the field.

8. (Delayed Start.) If skipping or duplicating is to be performed at the receiver before transmission can start, the receiver end-of-card signal must be delayed until the card to be punched is in position to receive the punching. An 8 punch causes the signal to be sent at the column in which it appears in the receiving program card, which is the first column to be punched through transmission.

9. (Restart.) This control allows for duplicating or skipping the received card independently of the transmitted card. For example, punching of transmitted data can be delayed between fields while the receiver duplicates or skips over a field. A 9 in the receiver program card, in the column following the last one programmed for skipping or duplicating, causes a restart signal to be sent to the transmitter. When the transmitter receives this signal, it resumes transmission at the column in which a 9 is punched in the transmitting program card.

OPERATING PROCEDURE

Before any cards can be transmitted or received, the operators at the two locations must communicate by telephone or telegraph-printer in order to coordinate the work and to agree on a channel. After selection of the channel, a test must be transmitted in order to obtain the best receiving level. This is done by adjusting the RECEIVE LEVEL KNOB, shown in figure 3-21, which has a scale from 0 through 10. The following procedure should be followed to set the receiver levels:
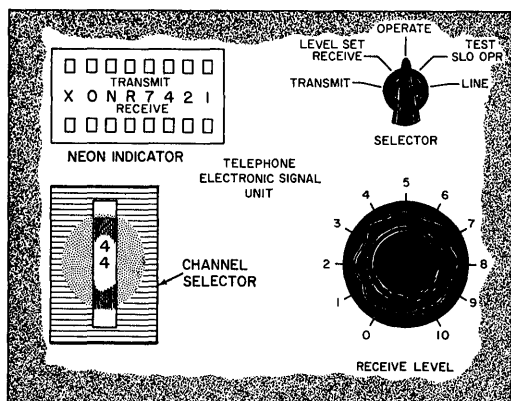
49.8
Figure 3-21.—Telephone signal unit controls.

1. Set the receive level knob on both machines to zero.
2. Move the SELECTOR switch, shown in figure 3-21, to RECEIVE on one machine and to TRANSMIT on the other. The transmit neon indicators 0, R, 4, and 1 should now be ON in the machine set to transmit, indicating that the transmitter is sending the correct signal.
3. Rotate the receive level knob on the receiving machine clockwise one step at a time until the receiving neon indicators just begin to glow.
4. Reverse the selector switch settings on both signal units and repeat step 3 on the other signal unit.
5. Set the selector switches to OPERATE after the levels on both signal units have been correctly set.

After the work has been coordinated and the receive levels set, transmission can proceed as follows:

1. Set receiver switch to RECEIVE and transmitter switch to TRANSMIT.
2. Insert program drums, with proper program cards, into the machine.
3. Receiver operator then feeds three cards into position, and sends the start signal.
4. Transmitter operator feeds three cards into position, and depresses the start key. Automatic transmission then begins.
5. After the last card has been transmitted, the start lights on both machines will glow. The

transmitter operator depresses the end-of-transmission key, and the operation is finished.

ERROR CORRECTION

Whenever the repeat light goes on during transmission, the following steps should be taken.

Transmitter Procedure

1. Depress the release key. This turns off the buzzer and the repeat light, and clears the card bed.
2. Replace the last three released cards in front of the cards in the feed hopper.
3. Depress the feed key twice and the release key once to feed three cards into position.
4. Automatic operation may be continued when the start light comes on.

Receiver Procedure

1. Depress the release key. This turns off the buzzer and repeat light, and releases one card. The card in error will not be punched in column 81, and may be easily removed from the correct cards later.
2. Signal the transmitter to proceed with automatic operations by depressing the start key.

OPERATING NOTES

1. If either the tel light or end-of-transmission light is ON, the reset key must be depressed before the operation can be resumed.
2. If automatic operations must be stopped in the middle of a group of cards, the stacker switch should be used. This ensures that the card being transmitted will be completed correctly.
3. If the stacker switch in the receiver is turned off, cards in both the transmitter and receiver will stop in column 81, and the 12 will not be punched in the receiving card. The card check light glows in the receiver immediately. The repeat light and buzzer will come on in the transmitter after a 2-second delay, and in the receiver after 4 seconds. To restart automatic operations, turn the stacker switch ON and follow normal error correction procedure.
4. If the stacker switch in the transmitter is turned off, the start lights in both machines will glow. To restart automatic operations, turn the stacker switch ON and follow normal error correction procedure.

5. If the transmitter operator requests a manual start signal because of failure to receive a start signal, the receiver operator should void the last card received, even though the start light is ON and 12 punch in column 81 indicates the card is correct. This card will be transmitted again when the three cards at the transmitter are released and placed in the hopper.

6. Cards with lower corner cuts should not be used, since a lower left corner cut will fail to register, and a lower right corner cut will cause the card to slip and possibly off-punch the 12 in column 81.

CHAPTER 4

CARD SORTERS

One of the basic requirements for preparing any type of report is that the documents to be used in the report must be in some sort of sequence. This may require rearranging the documents into a sequence other than that in which they are ordinarily maintained. For instance, they may be arranged alphabetically but need to be sorted into numerical sequence, or vice versa. Or they may be filed in numerical sequence by one set of numbers but may be needed in a sequence determined by another set. They may have to be arranged in ascending sequence; that is, starting with the lowest control numbers or letters and proceeding to the highest. Or, they may have to be arranged in descending sequence, which means that the control numbers or letters must go from high to low.

Such operations are called SORTING. Manual sorting or arranging documents into numerical or alphabetic sequence is a tedious and time consuming operation. However, where punched card data processing systems are employed, the sorting of punched cards into any desired sequence can be performed easily and rapidly by high speed card sorting machines like the one shown in figure 4-1.

Card sorting is a simple operation, but it is important for you to know just what your sorter is capable of doing, and the proper sorting procedures to be followed, in order to make the most effective use of your sorting time. Operating a card sorter requires more skill and know-how in card handling than any other machine you will be operating. This skill can be attained only through practice and application of the best techniques to be used for a particular sorting operation.

A brief description of the operations which may be performed on card sorters is presented in the following paragraphs.

1. NUMERICAL SORTING. Cards may be arranged in numerical sequence by sorting each column in the control field. A control field can be any field common to all cards used in an operation to control the particular job being performed, such as service number, job order number, or stock number.

2. ALPHABETIC SORTING. Cards may be arranged in alphabetic sequence by sorting each column of the control field twice. Two sorts on each column are required since alphabetic chararacters are composed of two punches, a numeric punch and a zone punch.

3. CONTROL SORTING. This is the operation in which the sorting sequence is arranged within two or more control fields. For example, consider a report arranged by name within activity. Each field is referred to as a control group. In sorting for this report, you would first sort to name sequence and then to activity sequence.

4. BLOCK SORTING. When the volume of cards is so large that it would be too slow and impractical to complete all sorting before the cards are forwarded to the next processing step, considerable overall time can be saved by separating the cards into blocks. Each block can then be sorted separately, and used for other job steps before all sorting has been completed.

5. SELECTIVE SORTING. Not all the cards in a file need be sorted, if only those cards with particular digits are to be used. Selection switches provide a means for selecting only those cards required without disturbing the sequence of the remainder of cards in the file.

You may be required to operate sorters of a different type. Since each type in common use has characteristics which differ from the others, each will be discussed separately in this chapter. However, you will find that certain principles pertaining to one type will apply equally to the others. For example, a thorough understanding of the IBM type 82 sorting operations will help
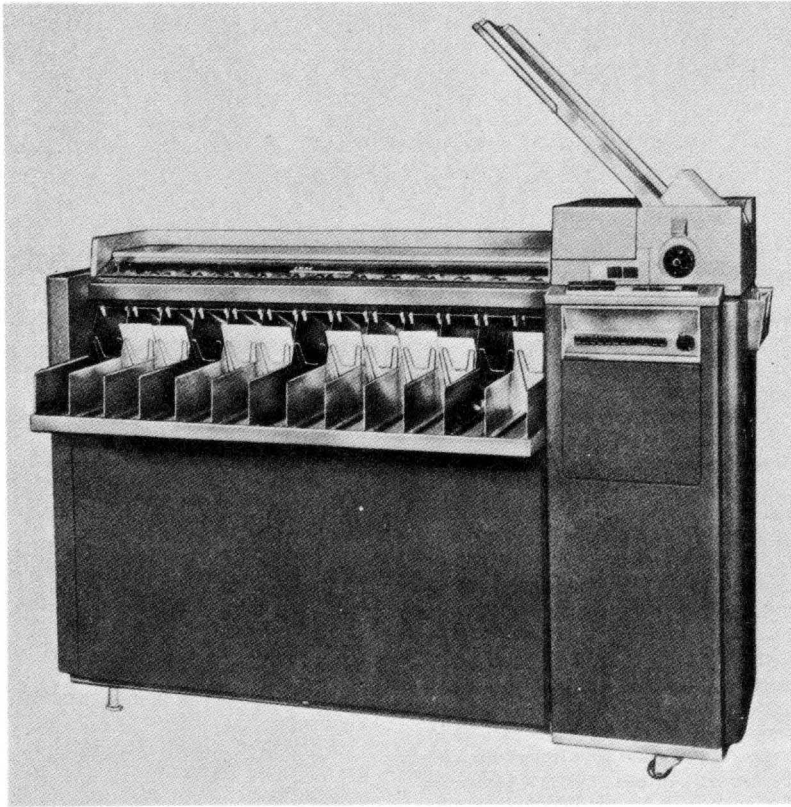
Figure 4-1.—IBM type 84 sorter.

you to understand the operation of the IBM types 83 and 84.

CARD SORTER, TYPE 82

The IBM type 82 card sorter, as illustrated in figure 4-2, sorts cards at the rate of 650 cards per minute. Sorting is accomplished by placing a group of cards in the feed hopper, setting the sort brush on the desired column, and depressing the start key. Thirteen pockets receive the sorted cards; one pocket for each punching position and a reject pocket for cards

that are not punched or are rejected during a sorting operation.

Machine Controls

The lower part of figure 4-3 illustrates the machine controls which are located on the front of the sorter. The MAIN LINE SWITCH supplies power to the machine. After this switch has been turned on, about one minute is required for the electronic tubes to warm up before sorting can be started. Then, the START KEY can be depressed to start card feeding, and the STOP
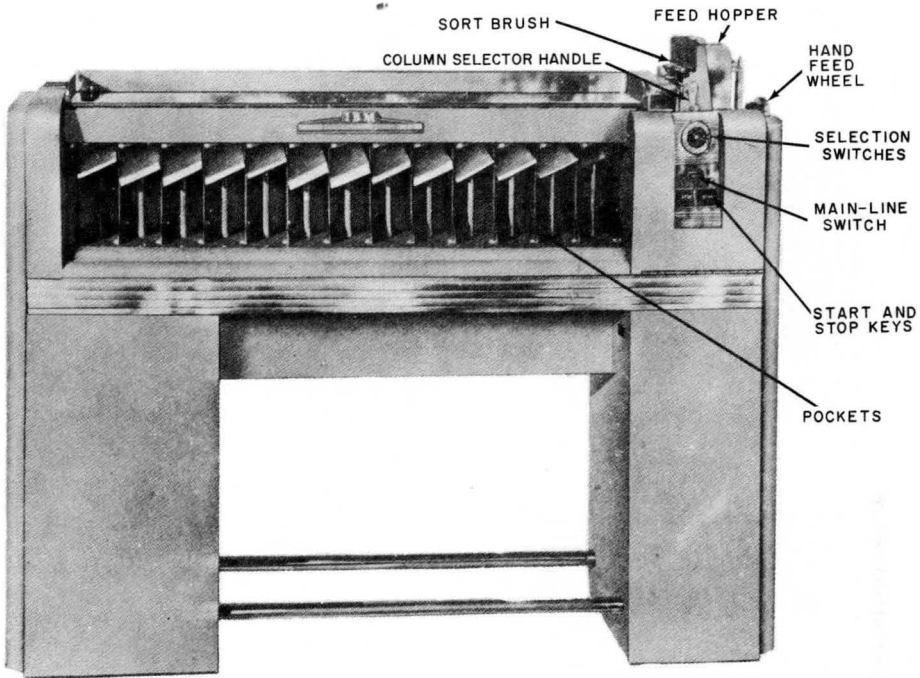
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Figure 4-2.—IBM type 82 sorter.

KEY can be used to cause card feeding to stop. Once the start key is depressed, sorting continues automatically until the card feed hopper becomes empty, a stacker pocket is filled, a card feed failure occurs, or the stop key is depressed.

Selection Switches

In normal sorting operations, all cards are directed to a specific pocket, corresponding to the particular digit punched in the card. In certain sorting applications you may wish to sort out only those cards containing certain digits and leave the remaining cards in their original sequence. Selection switches make this type of selective sorting possible.

The selection switches are visible in the upper part of figure 4-3. The 12 digits selection switches represent the 12 punching positions in a card. For normal sorting without selection, these switches must be set in the outer position, away from the center. When any of these switches is set toward the center, the reading of the corresponding digit in the card is nullified and the card will sort into the reject pocket.

The large switch in the selection switch group is the alphabetic sorting switch. Setting this switch toward the center has the same effect as setting toward the center all digit selection switches 1 through 9. The alphabetic sorting switch allows sorting on zone punches only, and cards without a zone punch in the column being sorted will be rejected.
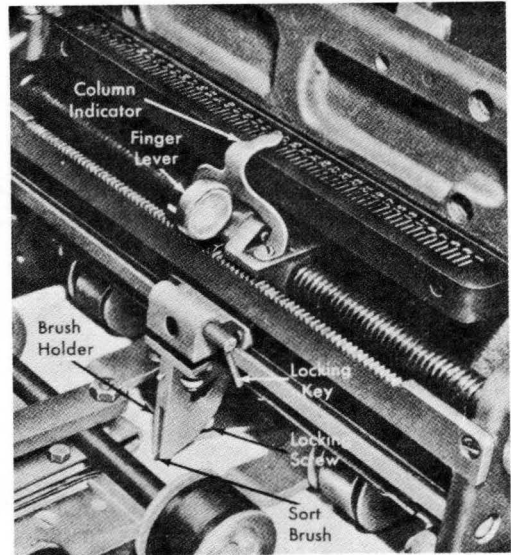
Sort Brush and Column Indicator

The actual sorting of cards is controlled by a sort brush, as illustrated in figure 4-4. The brush is mounted in a holder. Cards feed under the brush, and over an electrical contact-roller. When the brush makes contact with the
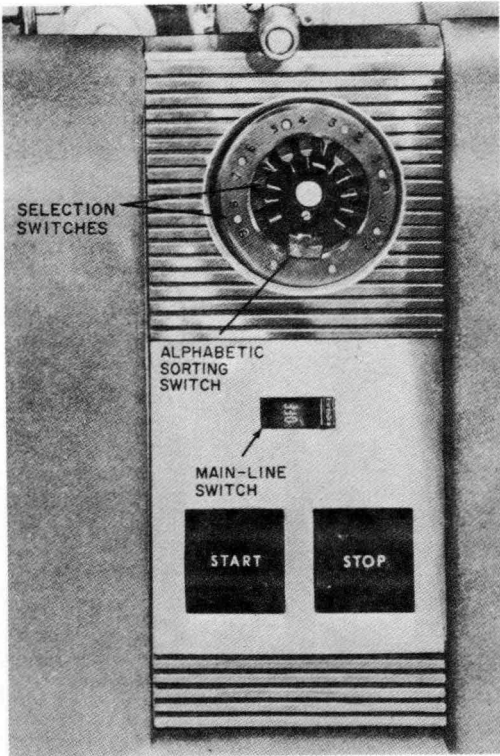
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Figure 4-3.—Machine controls and selection switches.

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Figure 4-4.—Sort brush assembly.

roller through a punched hole, an electrical impulse causes a chute blade to open, and the card is directed by the chute blade to the appropriate pocket. The brush may be set on any column desired by rotating the column selection handle. If the column selection handle is rotated clockwise, the sort brush is moved from the column 1 end of the card toward the column 80 end of the card, one column per full turn. If the brush is to be moved across several columns, the selection handle may be turned to the raised position and by depressing the finger control lever the brush can be moved to the desired column A column indicator guide and pointer are located above the brush to provide convenient setting of the brush on any of the 80 columns desired.

Pockets and Pocket Stops

The 13 receiving pockets, as shown in figure 4-2, are arranged from left to right as follows; 9, 8, 7, 6, 5, 4, 3, 2, 1, 0, 11, 12, and reject. Each pocket has a capacity for approximately 550 cards. When a pocket becomes full, a pocket stop lever automatically stops the machine. Card feeding may be resumed after the pocket has been emptied by depressing the start key. Normally, cards should be removed from a pocket only when the machine is stopped, since removing cards while the machine is in operation may result in a card jam.

Hand Feed Wheel

The hand feed wheel, located on the right end of the machine, can be turned manually when timing the sort brush or removing card jams. This wheel should never be touched while the machine is in operation because internally it has teeth which are engaged when the wheel is pushed in. If the hand feed wheel is touched or pushed in while the machine is running, these teeth could be sheared off, requiring costly replacement.

PRINCIPLES OF OPERATION

Cards are placed in the card feed hopper face down, with the 9 edge toward the throat of the hopper. The capacity of the hopper is approximately 1200 cards. The 82 is a continual feeding machine; therefore additional cards may be placed in the hopper while the machine is operating, provided necessary care is exercised in doing so.

As cards pass through the machine (fig. 4-5), presence of a punch is detected by the sort brush dropping through a hole and making contact with the roller. This allows an electrical impulse to travel from the contact roller, through the brush, and energize the sorting magnet. When this occurs, the sorting magnet attracts the armature, which in turn allows all chute blades not held up by the card to drop. The

card then passes over the chute blade corresponding to the digit punched, and is directed to the appropriate pocket. If an unpunched card is fed into the machine, the card acts as an insulator preventing the brush from making contact with the roller. The card then passes under all chute blades and falls into the reject pocket.

In figure 4-5, a card punched with a 4 is being sorted. In the upper half of the illustration, the 4 punch has not yet reached the brush, thus causing the leading edge to pass under the ends of the chute blades. In the lower half of the illustration, the 4 punch is read just after the leading edge of the card has passed under the tip of chute blade 5. The electric impulse passing from the contact roller through the brush energizes the sorting magnet, which pulls down the armature. All remaining chute blades—4
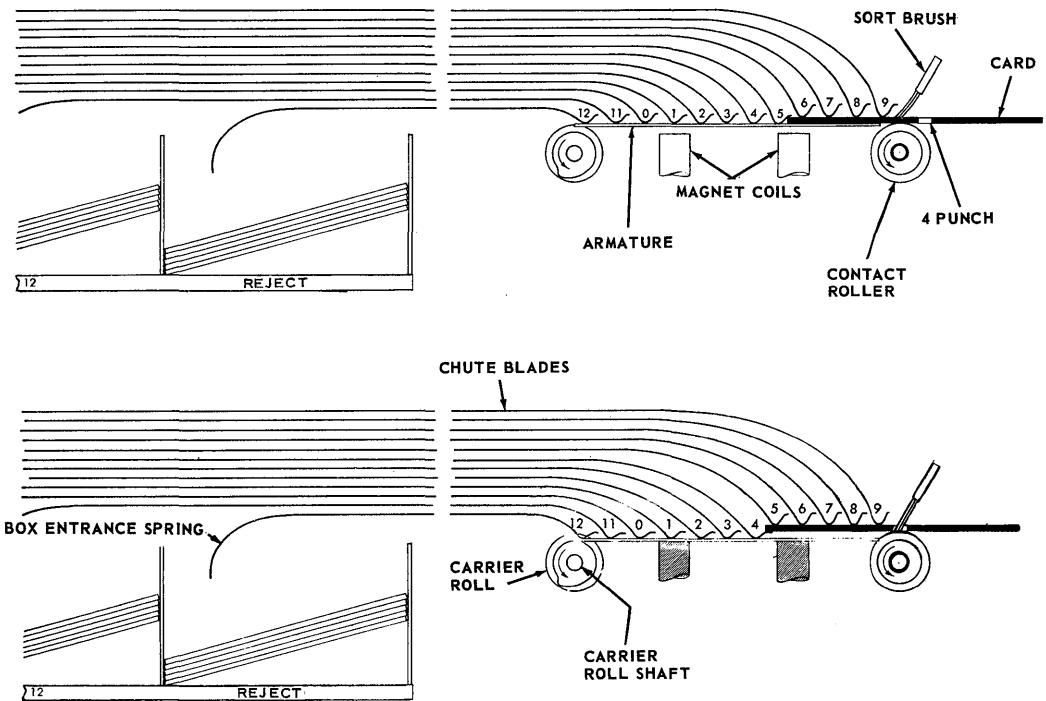

Figure 4-5.—Sorter operating principle.

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through 12—not held up by the card will drop, allowing the card to be transported by the carrier rolls over chute blade 4 to the 4 pocket.

SORTING OPERATIONS

Before any sorting operation is begun, you should check all switches to ensure they are set in accordance with the job you are about to do. Improper switch settings may result in getting a file of cards out of order, thus requiring a repeat sort. It is also important to have a thorough understanding of the sequence in which the cards are to be sorted. Many valuable hours have been wasted in report preparation because the sorter operator misunderstood the sorting sequence required, or neglected to ensure that the sorting was performed in the correct sequence.

Numerical Sorting

In order to arrange cards in numerical sequence, each column in the control field requires one sort. Sorting begins with the units or low order position and progresses from right to left through the high order position. The sort brush is set to read the first column to be sorted.

In figure 4-6, the left panel illustrates the sequence of events for the first sort of a 2-column sorting operation.

1. Part (A) indicates the original sequence of the cards before sorting is begun.

2. Part (B) indicates the cards in the stacker after the completion of the first sort, on the units position. The cards are removed from the stacker pockets in ascending sequence, so that the zeros will be stacked first, followed by the 1s, 2s, and so on through 9.

3. Part (C) indicates the sequence of the cards after the completion of the first sort.

"OBSERVE THE NUMERICAL SEQUENCE OF THE RIGHT-HAND COLUMN!"

Upon completion of the first sort, the brush must be advanced to read the second column, and so on.

The right panel in figure 4-6 illustrates the sequence of events for the 2nd (and last) sort of a 2-column sorting operation.

1. Part (A) indicates the sequence of cards after the first sort has been completed.

2. Part (B) indicates the cards in the stacker after the completion of the second sort, or the tens position. Cards must be removed in the same sequence as the first sort.

Part (C) indicates the sequence of the cards after the completion of the second sort. "OBSERVE THE NUMERICAL SEQUENCE OF THE LEFT-HAND COLUMN AND ALSO THE ASSENDING SEQUENCE OF BOTH COLUMNS!"

Control Sorting

In certain sorting operations, the desired sequence may involve more than one field. For instance, assume you have been given the job of sorting a file of personnel status cards to service number, rate code, and activity code sequence. First you must determine the sequence of these fields in relation to one another. If the cards are to be sorted to service number within rate code within activity code sequence, service number would be your minor field, and must be sorted first. The intermediate field would be rate code, and must be sorted next. Since activity code would be your major field, it must be sorted last. An apt rule to remember, is that the major field is determined by its degree of importance in relationship to other fields to be sorted. Consequently the minor control field would always be the lowest subdivision of the major, with the intermediate control field falling between the two.

If two or more reports are to be prepared from the same file of cards, but the cards are to be sorted differently for each report, considerable sorting time can be saved by first analyzing the control fields required for each report and then sorting for these reports so that duplicate sorting of one or more control fields is avoided. For example, assume you must sort one file of cards for three reports. (Fig 4-7) The first report is to be prepared in rate code sequence within activity, the second in name sequence within rate code, and the third in name sequence only. Further assume that these reports do not have to be prepared in the order shown. If you sorted for each report in the order shown, you would sort rate code twice and name twice.

Now take a closer look at the sorting requirements. (Fig 4-8) The third report is to be prepared in name sequence only, so it should be sorted first. Then, the cards can be sorted for the second report simply by keeping the cards in name sequence and sorting to rate code. Sorting for the first report can be accomplished last by keeping the cards in rate code sequence and sorting to activity.

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Figure 4-6.—Numerical sorting.

Block Sorting

Cards are usually sorted by beginning with the low order position of a field and continuing to the high order position. Sorting in this manner means that only one sorter can be used, and all sorting must be completed before the cards can be used for another job. When a large volume of cards must be sorted, it may be advisable to break the cards down into small groups. To do this, sort first on the high order position of the field. This will result in a maximum of ten blocks of cards. Each block can then be sorted individually in the usual manner. See figure 4-9.

Block sorting reduces the overall time required to prepare a report by permitting the processing of completed blocks through other machines while the remaining blocks are being sorted. Block sorting also permits the use of more than one sorter to get the job done (fig. 4-10).

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① ACTIVITY	RATE	NAME
0131	DPC	ABELL, B.
0131	DPC	MONROE, C.
0131	TD3	KING, J.
0141	DPC	ADAMS, T.
0440	PN1	CONNORS, W.
0440	TDAN	FOX, A.V.
7090	SN	MEANS, C.

② RATE	NAME	
DPC	ABELL, B.	0131
DPC	ADAMS, T.	0141
DPC	MONROE, C.	0131
PN1	CONNORS, W.	0440
SN	MEANS, C.	7090
TD3	KING, J.	0131
TDAN	FOX, A.V.	0440

③ NAME		
ABELL, B.	DPC	0131
ADAMS, T.	DPC	0141
CONNORS, W.	PN1	0440
FOX, A.V.	TDAN	0440
KING, J.	TD3	0131
MEANS, C.	SN	7090
MONROE	DPC	0131

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Figure 4-7.—Reports sequence before analyzing.

① NAME		
ABELL, B.	DPC	0131
ADAMS, T.	DPC	0141
CONNORS, W.	PN1	0440
FOX, A.V.	TDAN	0440
KING, J.	TD3	0131
MEANS, C.	SN	7090
MONROE, C.	DPC	0131

② RATE	NAME	
DPC	ABELL, B.	0131
DPC	ADAMS, T.	0141
DPC	MONROE, C.	0131
PN1	CONNORS, W.	0440
SN	MEANS, C.	7090
TD3	KING, J.	0131
TDAN	FOX, A.V.	0440

③ ACTIVITY	RATE	NAME
0131	DPC	ABELL, B.
0131	DPC	MONROE, C.
0131	TD3	KING, J.
0141	DPC	ADAMS, T.
0440	PN1	CONNORS, W.
0440	TDAN	FOX, A.V.
7090	SN	MEANS, C.

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Figure 4-8.—Reports sequence after analyzing.

In operations involving more than one field, block sorting is accomplished by first sorting the high order position of the major fields. Each major block of cards can then be treated as a separate group and sorted individually.
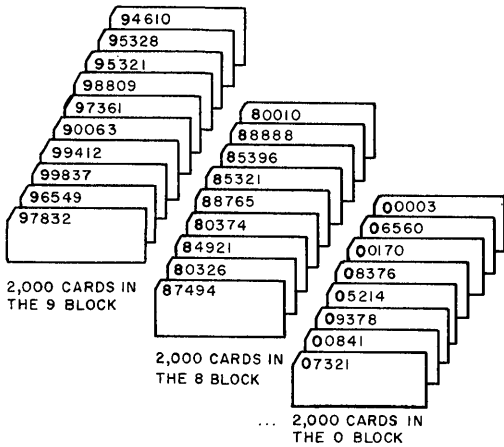
Alphabetic Sorting

Since alphabetic characters consist of two punches, sorting of alphabetic information requires two sorts on each column. Sorting proceeds from the low order to the high order position, as in numerical sorting. Each column must first be sorted into numerical order and then into zone order before moving to the next column. With all selection switches in the outer position, cards are first sorted into their respective numerical pockets. This places all cards with A and J in pocket 1, cards with B, K, and S in pocket 2, cards with C, L, and T into pocket 3, and so on. Before moving to the next column, the alphabetic sorting switch is set toward the center, and the cards are passed through the sorter again. All cards punched with A through I sort into the 12 pocket, J through R sort into the 11 pocket, and S through Z sort into the zero pocket. The alphabetic sorting switch is then set in the outer position, and the sort brush is advanced to the next column.

reject pocket again. After completing the zone sort for each column, place these rejects in front of the file before sorting the next column.

Alphabetic Block Sorting

To block sort a file of cards on an alphabetic field, set the alphabetic sorting switch toward the center and sort the zone punches in the high order position of the field. This results in three groups of cards, which are sorted separately in the usual manner on the remaining columns in the field except the high order position, which is sorted last on the numeric punches only. Or, if you wish to block the cards by letter, first sort the zone punches in the high order position of the field and then sort each of the three groups separately on the numeric punches in the high order position. This results in a maximum of 26 groups of cards which can be sorted normally on the remaining columns in the field.

Short Cut Alphabetic Sorting

About 16 percent of the usual time required for an alphabetic sort can be saved by using a short cut method. For the first sort on each column, place the cards in the feed hopper face up, with the 12-edge toward the throat. Set the 9 selection switch toward the center. Since the cards enter the sorter 12-edge first, a 12 zone is recognized as a 9, and 11 zone as an 8, a zero zone as a 7, a 1 punch as a 6, and so on through 9, which is recognized as a 12. However, since the 9 selection switch is set toward the center, a 12 zone punch is not read, thus allowing all cards punched A to sort into pocket 6, B into pocket 5, and so on up to I, which sorts into pocket 12. The 11 zones sort into pocket 8 and the zero zones into pocket 7. Remove the A through I cards from pockets 6 through 12 so that the A's are on top, and the rest follow alphabetically. Place them FACE DOWN in the sorter rack.

For the second sort, set the 9 selection switch to the outer position. Remove the 11 zones from the 8 pocket and the zero zones from the 7 pocket. Sort each group separately in the normal numerical manner, face down with the 9-edge toward the throat. After each group has been sorted, place them face down on top of the A through I cards so that all cards are in sequence from A through Z.

For the first sort on each succeeding column, you must start from the back of the file and

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Figure 4-9.—Block sorting.
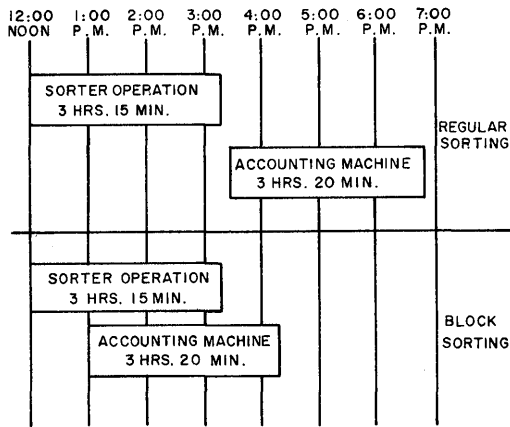
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Figure 4-10.—Reducing the overall elapsed time through the earlier use of other equipment.

Alphabetic fields may contain spaces between words. These unpunched columns will cause a card to fall into the reject pocket on the numerical sort. It is not necessary to sort these cards on the zone sort, since they would fall into the

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work toward the front, placing the cards in the feed hopper face up with the 12-edge toward the throat. For the second sort on each column, the 11 and zero zone cards are sorted in the normal manner, face down with the 9-edge toward the throat.

This method of alphabetic sorting may be used also to speed the task of blocking a file of cards alphabetically. The high order position of the field is sorted first, and all cards for each letter are stacked as a separate group. Then each group can be sorted separately, using either the short cut method or the normal sorting method.

Selective Sorting

Cards punched with certain digits can be selected from a file without disturbing the original sequences of the remainder. All selection switches representing digits not to be selected are set toward the center. This causes unselected cards to sort into the reject pocket and all selected cards to sort into their respective pockets.

In some instances it may be desirable to select cards containing specific digits without disturbing the sequence of the selected cards. In this case, the selection switches representing digits to be selected are set toward the center. This causes selected cards to sort into the reject pocket and unselected cards to sort into their respective pockets. This method can be used only when all cards are punched in the column being selected. If any cards are unpunched, they will sort into the reject pocket with the selected cards.

OPERATING SUGGESTIONS

The operating efficiency of card sorters depends upon their condition, and the care with which cards are handled. The following operating suggestions are listed to assist you in attaining the best results during a sorting operation.

Handling Cards

Most of the difficulty that occurs in a sorting operation is a result of improper card handling. Edges of the cards are sometimes damaged while they are being joggled or placed in the feed hopper. Damaged cards may cause a jam or mis-sort as they pass through the machine.

They may wrinkle or fold at the throat, under the brush, or between the chute blades and rollers.

Edges of cards should be checked to see that they are not bent, nicked, or torn. The feed hopper should be checked to make sure it does not contain any dirt, card dust, pieces of cards, or any foreign matter which might hinder proper card feeding.

Cards should be fanned (by grasping one end of a group of cards, drawing the other end back, and allowing a few cards at a time to "fan" to the normal position), in order to remove static electricity before they are placed in the feed hopper. Static electricity causes cards to stick together, especially in damp weather. Fanning also allows any foreign matter between the cards to fall out. Keep the hopper well supplied with cards to assure continuous machine operation.

Cards Jams

Even with proper card handling, jams will sometimes occur. If the sort brush is not timed properly, the chute blades may tear the leading edge of the card and cause it to jam. If the machine fails to stop when a pocket becomes full, a jam will occur.

In the event of a card jam, depress the stop key immediately, and turn off the main line switch. If the jam has occurred at the throat, remove the cards from the hopper, turn the column selection handle to the raised position, and remove the brush holder. Care should be exercised in removing the brush to avoid damaging it. The brush should be replaced if it is bent, or if the wire strands are spread. Remove the damaged cards and replace the brush holder.

If the jam has occurred in the chute blades above the stacker pockets, raise the glass cover over the pockets. Remove the damaged cards by a steady pull, being careful not to damage the chute blades. The hand feed wheel may be used to assist in removing jams.
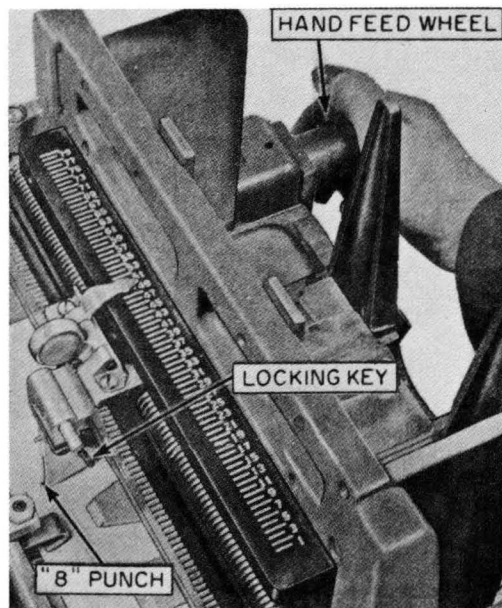
The process of making damaged cards over will be made easier if you make every effort not to tear them any more than necessary when removing them from the sorter. Slightly damaged cards can be reproduced or duplicated, while badly torn cards must be manually repunched. All damaged cards must be made over to avoid card jams or misfeeding in later machine operations.

Timing The Sort Brush

The sort brush should be replaced when it becomes too worn to assure proper sorting, or when it has been damaged. The brush must be checked to make sure it is properly timed whenever a new brush is inserted, or any time that missorting or nicking of cards occurs.

To time the brush, (fig. 4-11) place a card in the machine with an 8 punched in each end. Set the column indicator so that the brush reads a column, and turn on the main line switch. Rotate the hand feed wheel to feed the card. When the brush drops into the 8 punch of the card, you will hear a click. At this time the card should be about 1/32nd of an inch under the first, or number 9, chute blade. Depress the start key. If the card falls into the 8 pocket, the brush is properly timed. If it sorts into the 7 pocket, the brush is too long. The brush is too short if the card sorts into the 9 pocket.

If the brush is not timed correctly, raise the locking lever and remove the brush assembly from the sorter. Loosen the locking screw and adjust the brush. Tighten the locking screw and replace the brush assembly. The timing process must be repeated on both ends of the card until you are sure that the brush is properly timed.

Checking and Stacking Cards

Off-punched or damaged cards may result in missorting. If cards appear to be off-punched, check several of them with a card gage. It may be necessary to duplicate off-punched or damaged cards in order to assure proper card feeding and sorting.

After removing cards from each pocket, check the accuracy of the sorting. Joggle the cards so that they are in perfect alignment. Hold them in front of a source of light and look through the hole corresponding to the pocket from which they were removed. If the cards have been sorted properly, you can see light through the hole. If you cannot see light, remove the missorted cards and file them in their correct sequence.

Missorted cards can be quickly detected by using a sorting needle (fig. 4-12). Simply place the needle in the hole you are checking and push it gently through the cards. The needle will

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Figure 4-11.—Timing the sort brush.
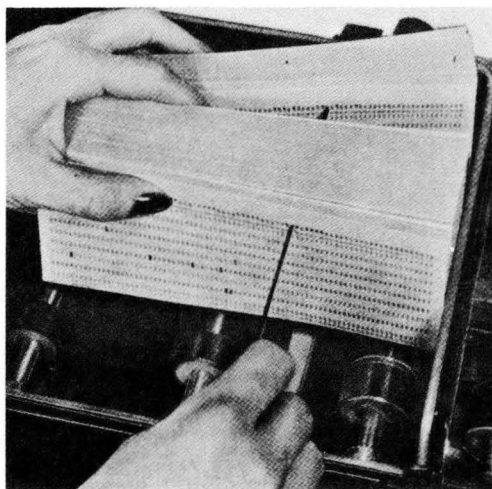
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Figure 4-12.—Using a sorting needle.

stop when it reaches the missorted card. Remove the missorted card and continue pushing the needle until it has passed completely through all the cards.

The sorting needle can also be used for manually sorting a large volume of cards when the punching in any given column to be sorted will almost always be the same. For example, if you are sorting an amount field and the high order position of all but a few cards contains a zero, this position can be needle sorted by passing the needle through the zero punching position and manually selecting all cards punched with other than zero.

After checking the sorting accuracy of each group of cards, place them face down in sorter racks. These racks are usually attached to the back of the sorter. If the volume of cards being sorted is small, the top of the sorter may be used for temporary stacking of cards.

A good card handling rule to follow is, "FACE UP GOES IN, FACE DOWN, COMING OUT".

CARD SORTER, TYPE 83

The IBM type 83 card sorter, illustrated in figure 4-13 operates at a speed of 1000 cards per minute. Since it is very similar in appearance and operation to the type 82, only the major differences will be described.

Digit Suppression Keys

Figure 4-14 illustrates the digit suppression keys used for selective sorting. There are 12 keys, one for each punching position in a card. Depression of any one of these keys causes the key to lock, and all cards punched with that particular digit will sort into the reject pocket.
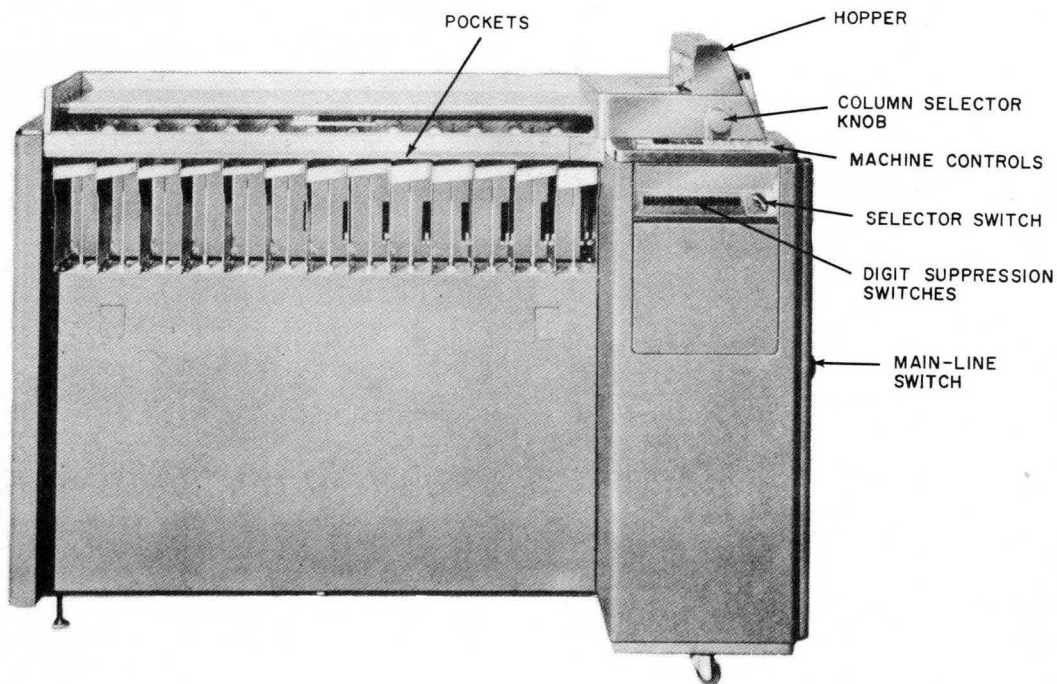

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Figure 4-13.—IBM type 83 sorter.
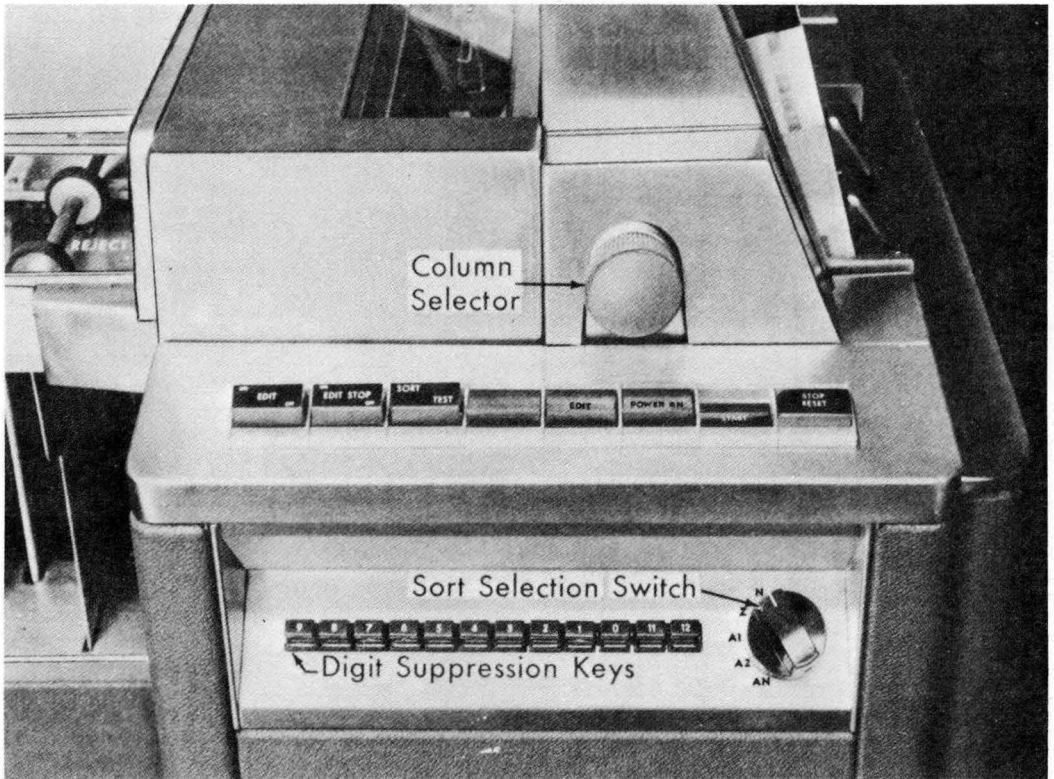
Figure 4-14.— Machine controls.

All other cards sort into their respective pockets. These keys may be released by running your fingertip along the bottom edge of the keys.

Sort Selection Switch

By referring to figure 4-14, you will notice a sort selection switch located to the right of the digit suppression keys. This switch may be rotated to any one of five positions to control the particular sorting operation involved. The function of each switch setting is described as follows:

N. (numerical.) Cards are sorted on the first punch read, and blanks are rejected. Double-punched cards are rejected as errors if either the edit switch or edit stop switch is ON.

Z. (Zone.) Cards are sorted on zone punches only. Cards without a zone punch are rejected. Any card with more than one zone punch is rejected as an error if either the edit switch or edit stop switch is ON.

A-1. (Alphabetic Sort 1.) Cards punched with a digit and a 12 zone (A through I) are sorted on the digits 1 through 9. Cards punched with an 11 zone sort into the 11 pocket, and zero zones sort into the zero pocket. Blank cards, and cards punched with only a digit or a 12 zone are rejected. Cards with multiple digit or zone punches are rejected as errors if either the edit switch or edit stop switch is ON.

A-2. (Alphabetic Sort 2.) Cards punched with a zero or 11 zone are sorted on the digits. Blanks, cards with a zero or 11 zone only,

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cards with digits only, and cards with letters A through I are rejected. Multiple digit or zone punches are rejected as errors if the edit or edit stop switch is ON.

A-N. (Alpha-Numerical.) Cards containing digits 0 through 9, but no zone, are sorted into their respective pockets. Zero zone cards are rejected. Cards with 11 zones are sorted into the 11 pocket, and the 12 zones are sorted into the 12 pocket. Multiple digit or zone punches are rejected as errors if the edit or edit stop switch is ON.

Figure 4-15 summarizes the sorting pattern established by each setting of the sort selection switch.

Editing

The editing device (fig. 4-14) detects extra punches in a card that do not conform to the sorting pattern as determined by the sort selection switch. Such cards are treated as errors and are rejected. When the EDIT SWITCH is ON, errors are rejected without stopping card feeding. When the EDIT STOP SWITCH is ON,

errors are rejected, the EDIT LIGHT goes ON, and card feeding stops. The stop key must be depressed to reset the error detection circuits when the machine has stopped with the edit light ON.

Test-Sort Switch

The customer engineer sets the test-sort switch to TEST when checking the timing of the machine. Your only concern with this switch is to ensure it is set to SORT for all sorting operations.

Sort Brush

The sort brush, illustrated in figure 4-16, operates the same as for the type 82, but with a different timing procedure involved. A sort brush gage is located just to the left of the brush assembly. To time the brush, remove the brush assembly by turning the column selector knob so that the brush holder is in a raised position. Unlock the locking lever and remove the holder. Adjust the brush as illustrated in

SORT SELECTION SWITCH SETTING	POCKETS												REJECTS REGARDLESS OF EDIT	ERRORS (When Edit or Edit-Stop is ON)
	9	8	7	6	5	4	3	2	1	0	11	12		
Numerical (N)	9	8	7	6	5	4	3	2	1	0	11	12	Blanks	Multiple-punched cards (incl. letters)
Zone (Z)										0	11	12	Any card without a zone punch	Any card with more than one zone punch
Alpha-1 (A−1)	I	H	G	F	E	D	C	B	A	0 S-Z	11 J-R		Blanks and cards with a 12-zone punch but no digit punch. Digits 1 to 9.	Any card with more than one zone punch or with more than one digit punch
Alpha-2 (A−2)	R,Z	Q,Y	P,X	O,W	N,V	M,U	L,T	K,S	J 0-1				Cards with 0 or 11-zone only. Blanks. Letters A to I, and 12-zone spec. char. Digits 1 to 9.	Same as A-1
Alpha-Numerical (A−N)	9	8	7	6	5	4	3	2	1	0 (digit)	11 J-R	12 A-I	Blanks, 0-zone (S-Z)	Same as A-1

R49.16X

Figure 4-15.—Sorting pattern for standard 83 sorter.

figure 4-16, so that it is firmly seated in the
V notch of the gage when the clamp nut is
tightened. Replace the assembly.

Pocket Stops

Each pocket is equipped with a pocket stop
lever which causes card feeding to stop when a
pocket becomes full. The capacity of the pockets
may be adjusted by a control lever, located at
the rear of the sorter. This lever can be set
at either one of four positions to allow approxi-
mately 400, 565, 735, or 800 cards per pocket
before the pocket stop lever causes card feed-
ing to stop.

SORTING OPERATIONS

The operation of the type 83 sorter is similar
to the 82 in that the sort brush makes contact
with the roller through a hole in the card and
an electrical impulse travels from the roller
through the brush and causes a chute blade to
open. The manner in which the blade is opened,
however, differs somewhat from the type 82,
as you can see in figure 4-17.

The chute blades are controlled by 12 selector
pins, with each pin centered above the exposed
portion of its corresponding chute blade tab.
When a punched hole is sensed, a magnet
armature is attracted, which in turn pushes
down the appropriate selector pin and separates
the chute blades. The card is then transported

Figure 4-16.—Sort brush holder and gage.
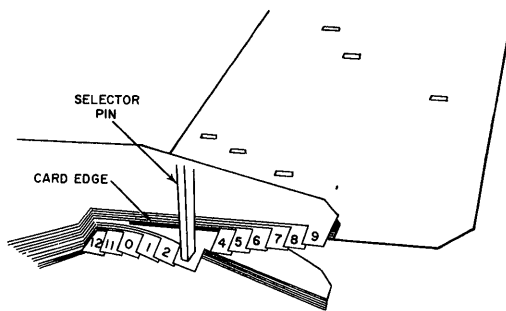
R49.18X

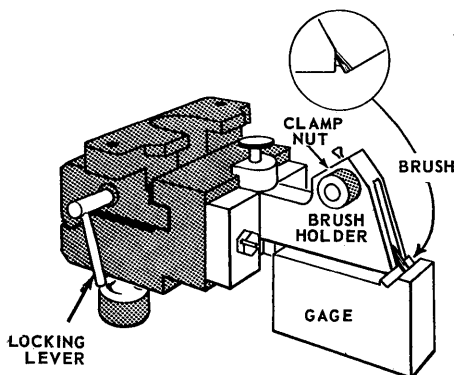R49.18X

Figure 4-17.—Chute blades, type 83.

by the carrier rolls over the opened chute blade
to the appropriate pocket.

Most sorting operations are performed the
same as on the type 82. However, a different
method of sorting alphabetic data is made pos-
sible through the use of the sort selection
switch.

Alphabetic Sorting

Not all cards need be sorted twice on the
same column, as seen in the following proce-
dure.

1. Set the sort selection switch to A-1, and
turn on the edit stop switch. Letters A through
I sort into pockets 1 through 9 respectively.
Eleven zones sort into the 11 pocket, and zero
zones sort into the zero pocket. Cards that
are blank, or punched with a 12 zone or digit
only, sort into the reject pocket. Multiple zone
or digit punches reject and stop the sorter.

2. After sorting on A-1, stack the cards in
order from the 1 through 9 pockets. These
represent A through I, and do not have to be
sorted again on that column. Stack the cards
from the 11 and zero pockets separately. Re-
jects may be left in the reject pocket, or you
may check them for valid punching and hold
for the next column to be sorted.

3. Change the sort selection switch to A-2,
but do not change the column setting. Do not
sort the rejects or A through I cards.

4. Sort the 11 zone cards, which will fall
into pockets 1 through 9. These represent J
through R, and are stacked behind the A through
I cards.

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5. Sort the zero zone cards, which will fall into pockets 2 through 9. They represent S through Z, and are stacked behind the J through R cards.

6. Place valid rejects in front of the file and proceed to the next column.

Alpha-Numerical Sorting

Sorting of card columns that may contain either letters or numbers is controlled by setting the sort selection switch to A-N. This setting separates the alphabetic from the numerical cards. The digits 0 through 9 sort into the 0-9 pockets. The 12 zones sort into the 12 pocket, 11 zones into the 11 pocket, and zero zones into the reject pocket. Any digit under a zone punch is ignored. Cards not punched in the column being sorted will sort into the reject pocket.

The digit cards are now in sequence, and the alphabetic cards are separated into three groups. The 12 zones are then sorted on A-1, and the 11 and zero zones on A-2.

You may wonder how zeros sort into the zero pocket one time and into the reject pocket another time. The editing device provides for checking a column to see if there are two punches in it. For example, if only a zero is punched, it is recognized as a numerical zero, and the card sorts into the zero pocket. If any letter S through Z is punched, the numbers 2 through 9 are sensed but not sorted, and the card sorts into the reject pocket.

CARD SORTER, TYPE 84

The IBM type 84 sorter that was shown in figure 4-1 has many of the same features as the type 83. Sorting operations are performed in the same manner, but at the rate of 2000 cards per minute. This increased speed in sorting is made possible through the use of several additional features, including a photoelectric method of card sensing in place of a sort brush.

Full Stacker Light

The full stacker light (fig. 4-18) signals that a stacker is approaching its maximum holding capacity of approximately 1650 cards. When this capacity is reached, card feeding is automatically stopped.

Vacuum Light

The type 84 sorter is equipped with a vacuum-assist feed. When the vacuum level has fallen too low to assure proper card feeding, the vacuum light (fig. 4-18) comes on and card feeding stops. When this happens, the condition should be corrected only by a customer engineer.

File Feed

A file feed with a capacity of 3600 cards is provided as standard equipment. The file feed automatically joggles the cards as they are fed into the hopper, thus reducing the amount of manual joggling to a minimum. Cards are fed by the high-speed vacuum-assisted feed mechanism surely and accurately without a card weight.

Brushless Card Feeding

The sensing of holes in a particular column is accomplished by a movable one-watt light bulb shining from beneath the card, through a hole in the card, and onto a light sensitive diode (fig. 4-19). The card is directed to the appropriate stacker by a chute blade. Turning the column-selector knob moves the bulb and diode assembly from column to column. The column indicator is directly above the column selector knob (fig. 4-18). The light source should be cleaned daily with a dust cloth to minimize rejects. More frequent cleaning may be required if the sorter is running for extended periods. Any adjustments to the sensing mechanism should be made by a customer engineer. If a jam occurs which requires removal of the sensing mechanism, call a customer engineer. Do not attempt removal of the mechanism yourself.

Radial Stackers

Cards are sorted into 13 radial stackers, as illustrated in figure 4-20, each with a capacity of approximately 1650 cards. Instead of cards being stacked face down, as in other types of sorters, they are stacked on the column 80 end, with the face of the cards toward the front of the machine Card retaining levers prevent the cards from falling backwards into the stacker. As the stacker fills, the card deck is pushed forward until it activates the stacker-stop switch and turns on the full-pocket light. When
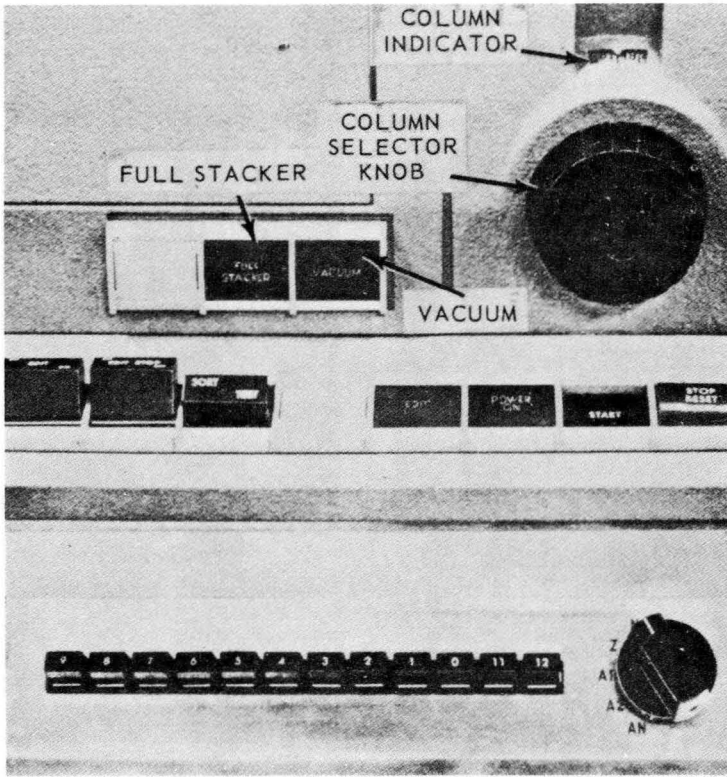
R49.9.3X

Figure 4-18.—Machine controls, type 84.

more cards enter the stacker, this switch stops the machine. Cards may be easily removed from the stackers without stopping the machine.

OPERATING SUGGESTIONS

The photoelectric sensing mechanism may read staple holes and heavy erasures. Oil spots on cards should be avoided also, since they make the card translucent and causes the machine to read the spots.

The mainline switch should be turned off when the sorter is not in use, to conserve the light source and vacuum pump. The 84 can be used immediately after the mainline switch is turned on.

SPECIAL FEATURES

There are several special features which may be added to card sorters to extend the application possibilities of the machines. While you are not expected to be an expert on all these features, there are certain ones that you should be familiar with.

Auxiliary Card Counter

An electrically operated card counter can be mounted to the left of the feed hopper to count the number of cards that pass the sort brush or sensing mechanism. The sorting speed and method of operation are not affected when the

Sensing Head
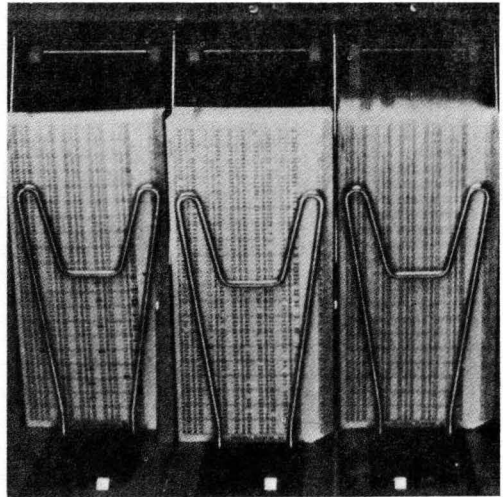
Light Bulb
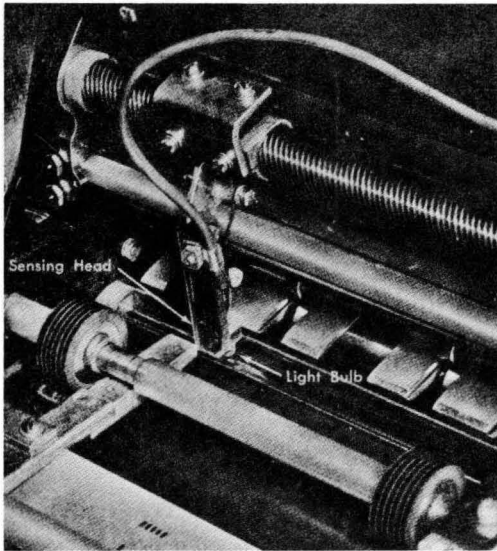
R49.341X

Figure 4-19.—Sensing mechanism, type 84.

R49.342X

Figure 4-20.—Radial stacker.

card counter is used. The maximum capacity of the counter is 99,999 for the type 82, and 999,999 for the types 83 and 84.

While the card counter is normally used for counting the total number of cards that pass through the machine, it may also be used to count by pockets. On the first sort, a total of all cards is accumulated. On the second sort, each pocket is sorted and counted separately. The sum of the pockets is then crossfooted to the overall total to assure that card counting has been performed correctly.

Sort Suppression

If cards with different punches are to be selected from a file, it is customary for the selected cards to sort into their respective pockets while all other cards are rejected, or vice versa, depending upon the method of selection employed. For example, if the type 83 sorter is used to select all cards punched with a 1, 3, or 5, and the digit suppression keys for all other digits are depressed, any cards punched with a 1, 3, or 5 will sort into

their respective pockets while all other cards sort into the reject pocket.

With the sort suppression device installed, the selected and unselected cards are placed in two groups without disturbing the sequence of either. In the example stated above, the selected cards punched with a 1, 3, or 5 will sort into the 12 pocket, and all other cards sort into the reject pocket.

Cards may be edited on the types 83 and 84 sorters during a selection operation without disturbing their sequence. With the sort selection switch set to N and the edit stop switch and sort suppression switch ON, cards are separated and errors fall into the reject pocket in sequence with other rejected cards. The edit stop switch will stop the machine when an error card falls into the reject pocket.

Still another use for the sort suppression device on the types 83 and 84 sorters is checking a single column for blanks or double punches without disturbing the sequence of the cards. Set the sort selection switch to N, and turn the edit switch and sort suppression switch ON. Cards punched with only one digit will sort into the 12 pocket, while double punched cards or cards not punched will sort into the reject pocket. Setting the edit stop switch to

the OFF position allows continuous card feeding without causing the machine to stop each time an error is detected.

Alphabetic Sorting Feature

An alphabetic sorting feature can be installed on the types 83 and 84 sorters to speed the operation of alphabetic sorting. When this device is installed, the sorting patterns normally established when the sort selection switch is set to A-1, A-2, and A-N are changed permanently. The sorting pattern established by this device is shown in figure 4-21. This pattern is based on the frequency that certain letters appear in proper names.

Alphabetic Sorting.—To sort a column alphabetically, all cards are fed through the sorter once and a part of the cards a second time. On the first sort 10 letters, including all vowels, are sorted and may remain in their respective pockets while the balance of cards are sorted a second time.

On the first sort, set the sort selection switch to A-1. This causes all cards punched A, C, E, G, I, L, O, R, U, and X to sort into pockets zero through 9 respectively. Cards punched with B, D, F, H, J, M, P, S, V, and Y sort into pocket 12, while those punched with K, N, Q, T, W, and Z sort into pocket 11. Blanks, and cards not punched with an alphabetic letter, sort into the reject pocket.

On the second sort, change the sort selection switch to A-2, but leave the sorted cards in pockets zero through 9. Place the cards from pocket 12 in the hopper, followed by those from pocket 11. Upon completion of the second sort, all cards in pockets zero through 9 will be in sequence from A through Z. Remove them in ascending sequence from pockets zero through 9.

Alpha-Numerical Sorting.—Cards which may contain either letters or numbers can be sorted by first setting the sort selection switch to A-N. The digits 0-9 sort into pockets 0-9 respectively, and all other cards sort into pockets 11, 12, and the reject pocket.

After the digit cards have been removed from pockets 0 through 9, the remainder can be sorted alphabetically in the following manner. Set the sort selection switch to A-1 and sort the cards from the reject pocket.

Without removing these cards, set the sort selection switch to A-2 and place the cards from pocket 12 to the hopper, followed by those from pocket 11. Upon completion of this sort, all cards in pockets 0 through 9 will be in sequence from A through Z.

SORT SELECTION SWITCH SETTING	POCKETS												REJECTS REGARDLESS OF EDIT	ERRORS (When edit or edit-stop is on)
	9	8	7	6	5	4	3	2	1	0	11	12		
Alpha-1	X	U	R	O	L	I	G	E	C	A	KN QT WZ	BD FH JM PS VY	Cards punched with digits only, zones only, 0-1 combination, or blank	Any card with more than one zone punch or more than one digit punch
Alpha-2	Z Y X	W V U	T S R	Q P O	N M L	K J I	H G	F E	D C	B A			Same as A-1	Same as A-1
A-N	9	8	7	6	5	4	3	2	1	0	KN QT WZ 11	BD FH JM PS VY 12	Blanks. A,C,E,G,I, L,O,R,U,X and the combination 0-1.	Same as A-1

R49.19X

Figure 4-21.—Sorting pattern for alphabetic sorting device.

CHAPTER 5

INTERPRETERS

You have learned that data processing machines read cards by sensing the punched hole. It is possible also for you to determine the contents of a card by reading the punched holes, but this is a slow and tedious process. Interpreters are designed to read the holes punched in a card and print the data across the card. This makes it possible to use punched cards for many applications which would otherwise require the use of printed forms. For example, rotation data cards can be machine prepared, interpreted, and forwarded to activities for recording of data on personnel that are due for rotation. Muster cards, statement of leave cards, paychecks, and many other types of cards can be prepared and interpreted for use outside the data processing installation. You will find many uses for interpreting within your own installation. Each file of cards you maintain is usually interpreted in some manner to provide ready reference to the contents of the cards. Interpreted cards provide assistance when you refer to a file for a particular item of information. Manual card filing is made easier when the cards in the file as well as those to be filed are interpreted.

This is the first chapter on data processing machines which deals with wiring a control panel to direct machine operations. While the interpreter is relatively simple to wire and operate, a thorough understanding of the wiring principles presented in this chapter will enable you to have a better understanding of the wiring principles involved for machines that are more complicated.

The operating principles of all popular types of interpreters are basically the same. However, in order to acquaint you with their different characteristics each machine will be discussed separately.

INTERPRETER, TYPE 548

The type 548 interpreter, pictured in figure 5-1 is designed to translate numerical and alphabetic punched card data into printed characters across the face of the card. Printing is performed by a set of 60 typebars, allowing for printing a maximum of 60 characters on one line in one pass of the cards through the machine. Data can be printed on either of two printing lines, called UPPER LINE and LOWER LINE. A space or spaces may be left between different items of information. If all the data to be interpreted cannot be printed on one line, the remainder can be printed on a second line by rotating the printing position knob and passing the cards through the machine again. Flexibility of control panel wiring provides for printing the data in any sequence desired. Interpreting proceeds at a rate of 60 cards per minute.

OPERATING FEATURES

The MAIN LINE SWITCH supplies power to the machine, and must be ON for all machine operations. A green READY LIGHT goes on to indicate that the machine is ready for operation. The START KEY is depressed to start card feeding. It must be depressed and held until three cards have been fed in order for continuous card feeding to be effective. The STOP KEY is depressed to stop card feeding.

Hopper

The card hopper holds approximately 700 cards. Cards must be placed in the hopper with the face up, and the 12 edge toward the throat of the hopper. When the last card leaves the hopper, it will be interpreted and stacked automatically.
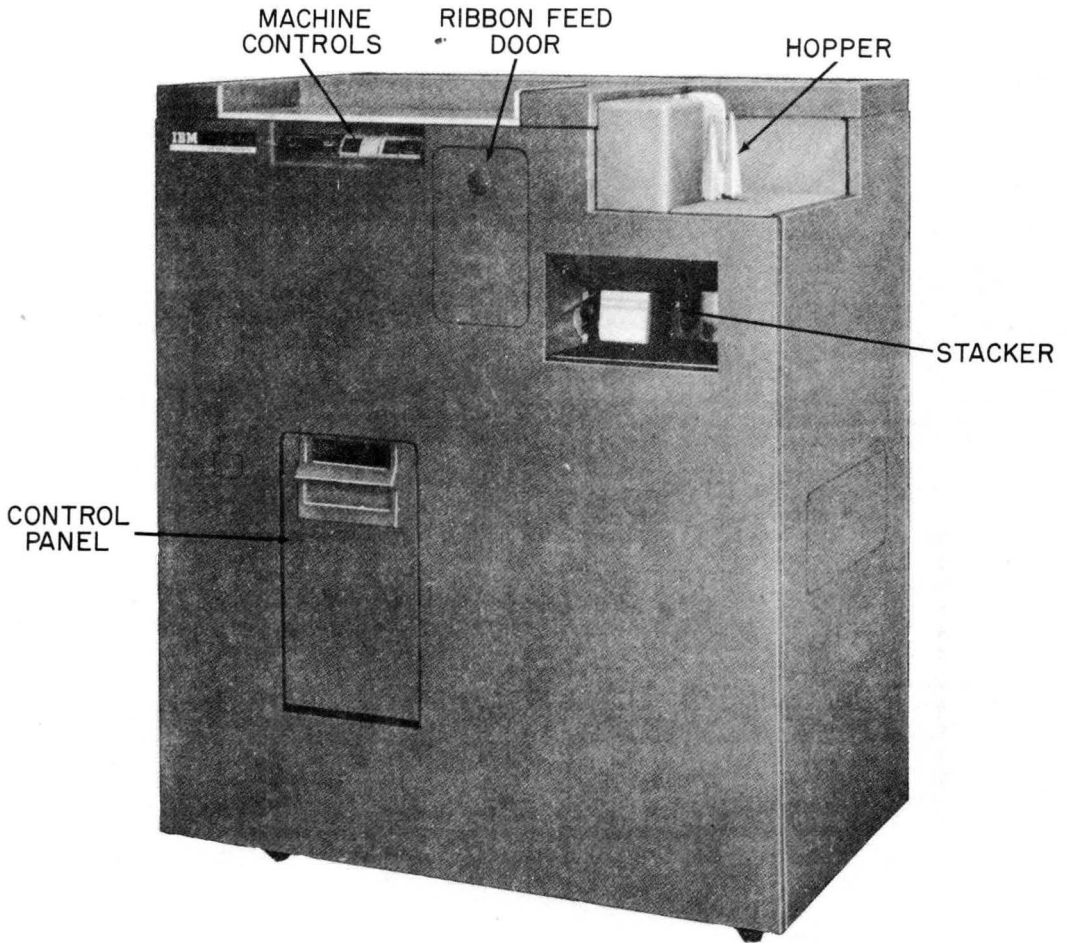
100

MACHINE CONTROLS   RIBBON FEED DOOR   HOPPER

CONTROL PANEL

STACKER

Figure 5-1.—Type 548 Interpreter.

R49.20.1X

Stacker

The card stacker, located directly beneath the hopper, holds approximately 900 cards. Interpreted cards may be removed from the stacker without stopping card feeding. If the staker becomes filled, card feeding is automatically stopped. The cards must be removed from the stacker and the start key depressed in order to resume interpreting.
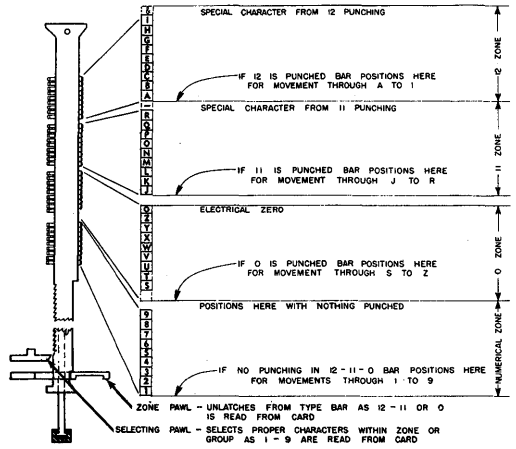
Printing Position Knob

Sixty characters can be printed on either of two lines across the face of the card. Upper line printing occurs along the top edge, above the 12 punching position. Lower line printing occurs between the 12 and 11 punching positions. The line to be printed can be manually selected by rotating the printing position knob, located in a recess on the back of the machine, to the

desired position, (see Fig. 5-2). When the knob is set at U, printing occurs on the upper line. When set at L, printing will be placed on the lower line. The printing line can be easily selected by pulling the knob and turning it clockwise for upper line printing, or counter-clockwise for the lower line.

Print Unit

The printing mechanism consists of 60 typebars, each containing 39 printing characters: 10 numerical (0 through 9), 26 alphabetic (A through Z), and 3 optional special characters. These special characters are actuated by an 11, 12, or combination 0-1 punch, as seen in figure 5-3.

In order to print in specific locations across the card, exact typebar positions must be determined before wiring the control panel. Since there are 80 columns in the card and only 60 typebars, the ratio of typebars to card columns is 60 to 80, or 3 to 4. This means that if you wired card columns 1 through 60 straight to typebars 1 through 60, typebar 3 would print


R49 255X

Figure 5-3.—Layout of 548 typebar.

over column 4, typebar 30 would print over column 40, typebar 45 would print over column 60, and so on. Figure 5-4 outlines each printing position in relation to the card columns.

Reading Brushes

A card is read by a set of 80 reading brushes, one brush for each column. As a card feeds from the hopper, it passes between these brushes and an electrical contact roller. As seen in figure 5-5 whenever a punched hole in the card is sensed by a reading brush, an electrical impulse travels from the roller through the brush, and is directed by control panel wiring to the typebar.

All punching positions 12 through 9 in any column of the card can be read as the card passes the reading brushes. All 12 punches are read first, followed by the 11 punches, then the zero punches, and so on through the 9 punches, since the cards are fed 12-edge first. However, the machine will recognize only the first zone and the first numerical punch sensed by a reading brush. Thus, if a column is punched with several zone and numerical punches, the machine will combine the first zone punch and the first numerical punch sensed by the reading brush to produce an alphabetic character. For example, if a column is punched with a 12, 11, 3, and 8, the 12 and 3 punches would be combined to print the letter C. Or, if a column is punched with
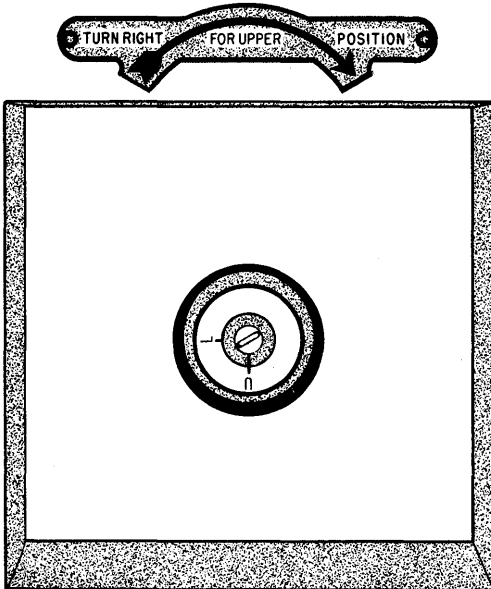
R49.254X

Figure 5-2.—Printing position knob.
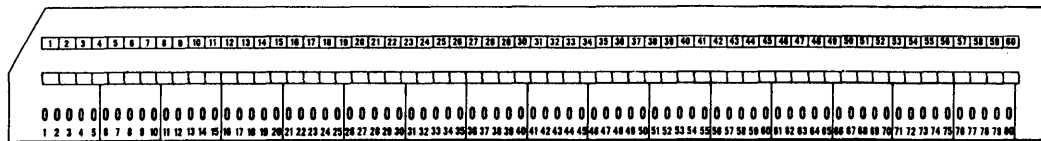
R49.21X

Figure 5-4.—Interpreter printing positions.

several numerical punches but no zone punches, the first numerical punch read will be printed. For instance, if a column is punched with a 2, 5, and 9, the 2 would print since it is the first digit read.

The brush assembly is located just under the hinged top cover of the machine, to the left of the feed hopper. Access to the brushes may be gained by raising the front part of the cover. To remove a card from under the brushes, lift the handle on the brush assembly and pull up the assembly. Replace the brushes by reversing the procedure. Make certain that the handle on the assembly is pushed down to the left before cards are fed into the machine.

You should not tamper with the brush assembly or try to remove a card jam unless you have been properly instructed in the procedure and your supervisor is satisfied you can do the job.

X Brushes, Terminal Block

Interpreting of X or NX (no X) cards can be controlled with the use of selectors impulsed from any one of five X brushes located under the top cover, just to the left of the hopper. The five X brushes, as shown in figure 5-6, can be manually positioned to cover any five-card columns. Two columns must separate adjacent brushes.

The function of the X brushes is illustrated in figure 5-7. The X brush is wired to the X brush terminal block, which is a five hub panel located near the X brush station. When the X brush reads an X punch, the current is passed through the terminal block and is available at the corresponding X brush hub on the control panel.

The X brushes are timed to read only X-timed pulses and are normally used to pick up selectors, as illustrated in figure 5-7.

Ribbon

The ribbon in the print unit is a little wider than the length of the card. It moves a little each time a card is interpreted, and reverses direction automatically. It does not normally require attention until the printing on the cards becomes too light to be legible. At this time, it should be replaced by a new ribbon, following the procedure outlined in figure 5-8.

PRINCIPLES OF CONTROL PANEL WIRING

Control panel wiring for typical operations which may be performed on the type 548 is discussed in the following paragraphs.
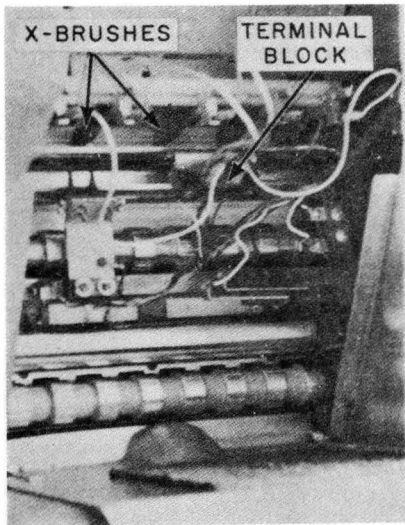
Normal Printing

The arrangement of printing on a card is determined by control panel wiring. For example, if card column 5 is to be printed in print position 51, you would connect a wire from reading brush hub 5 to print entry hub 51. If card columns 28 through 32 are to be printed in print positions 35 through 39, you would wire reading brush hub 28 to print entry hub 35, reading brush hub 29
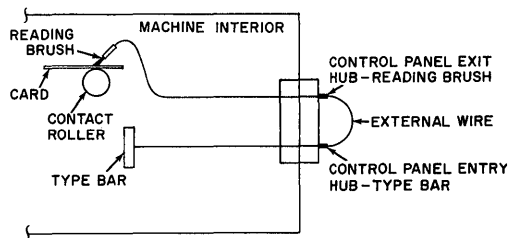
R49.22X

Figure 5-5.—Principle of interpreter operation.

103

R49.256X
Figure 5-6.—X-brushes, terminal block.

to print entry hub 36, and so on. Figure 5-9 shows the method in which the control panel is wired for normal printing.

X Elimination

Some numerical fields in a card may contain an 11 or 12 punch over one of the columns for purposes of identification or control. If the column containing the 11 or 12 punch were wired directly to a print entry, the control punch would combine with the numerical punch in that column and cause an alphabetic character to print. The control punch can be prevented from reaching the print entry hub by using the X eliminator.

The X eliminator splits a card column between the 0 and 11 punching positions. There is a common hub, a hub for 11-12 impulses, and a hub for 0-9 impulses. A connection exists between the common and 11-12 hubs whenever the 11-12 punches in the card are being read by the reading brushes. This connection automatically changes after the 11 position has been read so that the common and 0-9 hubs are connected while 0-9 punches are being read.

In figure 5-10 a card column punched with an N is entered into common (C) of an X eliminator. Notice that as the 11 punch is being read,

the magnet is not energized, thus allowing the 11 impulse, entering the common hub, to make connection with the 11-12 circuit. The 11 impulse is then available out of the 11-12 hub. After the 11 position has been read, the magnet is automatically energized. This allows the 5 impulse, entering the common hub, to become available out of the 0-9 hub.

Assume you have the credit amount of 10327 punched in card columns 53 through 57, with an 11 punch in column 57 to identify the amount as being a credit. If you wired column 57 directly to a print entry hub, a P would print. However, if you wired it first to common of the X eliminator and out of the 0-9 hub to a typebar, a 7 would print. The 11 punch can be wired from the 11-2 hub to print entry to identify the amount as a credit. The control panel switch for the X eliminator must be wired ON for this operation. If the X eliminator switch is not wired, the common hubs will be connected to the 11-12 hubs for the duration of each card cycle, and any impulse 12 through 9 entered into a common hub is available from the corresponding 11-12 hub.

Figure 5-11 shows how the wiring for X elimination is accomplished. Columns 53 through 56 are wired normally. Column 57 is wired through a position of the X eliminator so that the units position of the field will be printed numerically. The 11 punch causes typebar 10 to print a special character provided that typebar has been equipped to print a character from an 11 punch.

Selection

Selection usually means making a choice or decision. For example, you may decide to interpret data in one place on certain cards and in another place for others.

The principle of selection can be applied to operations performed with data processing machines through proper wiring of selectors on the control panel. The use of selection is similar in most data processing machines. Although operation of the selectors may differ slightly, the basic operating principle is the same. A thorough understanding of selection as presented in this chapter will help you to understand selection when presented in later chapters.

Two selectors are provided as standard equipment on the type 548. Each selector has two pickup hubs, five common hubs, five normal hubs, and five transferred hubs. They differ from the X-eliminators in that the selector magnet
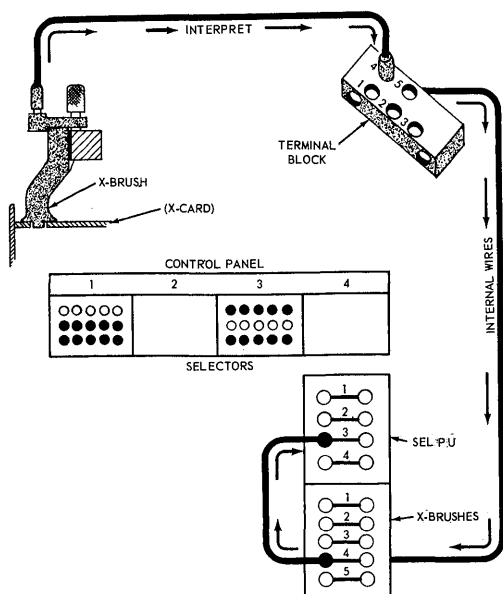
49.257

Figure 5-7.—The external, internal path of an X reading brush.

must be energized from an impulse wired to the pickup hub before a selector will transfer. The pickup hub is usually wired from an X brush hub.

Refer to figure 5-12. If the pickup hub has not received an impulse, the selector is in a normal state. At this time, there is an internal connection between each common hub and the normal hub directly above it. Any impulse wired to common is available out of normal. If the card column which the X brush is reading contains an 11 punch, and the X brush hub is wired to the selector pickup hub, the 11 impulse causes the selector magnet to be energized, thus transferring the selector. This breaks the connection between common and normal, and establishes an internal connection between the common and transferred hubs. This connection will last for the duration of the time it takes to interpret the card containing the 11 punch. The selector returns to normal after the card containing the 11 punch has been interpreted.

You can see then, how an impulse from a card column wired to the common hub of a selector becomes available out of normal when the selector is not picked up, and out of transferred when a selector is picked up. By the same token, any impulse wired to normal is available out of common if the selector has not transferred, and an impulse wired to transferred is available out of common when the selector transfers.

Thus, selection by two different methods is possible. As applied to interpreters, one method is called class selection, while the other is referred to as field selection. Class selection means that a field in a card can be printed in either one of two places on the card, depending upon the presence or absence of an 11 punch. Field selection means that either one or the other of two different fields can be printed in the same place on the card again depending upon the presence or absence of the controlling X punch.

Wiring for class and field selection is shown in figure 5-13. Assume that some cards contain an 11 punch in column 60, and X brush number 1 is set to read that column. X brush number 1 is wired to the pickup hubs of selectors 1 and 2, causing both selectors to transfer when an X-60 card is read.

For class selection, Field A is read from the card and printed in position B when NX-60 cards are read, and in position C for X-60 cards. For field selection, Field D is read from the card and printed in position F when NX-60 cards are read, and Field E is read and printed in position F for X-60 cards.

Notice that in class selection the impulses travel from the reading brushes to the common hubs, and from the normal and transferred hubs to print entry. In field selection, the impulses travel from the reading brushes to the normal and transferred hubs, and from the common hubs to print entry.

When the selector pickup hub receives an impulse, the selector transfers immediately. When wired from the X brushes, the control X causes the selector to be transferred before the card containing the 11 punch reaches the reading brushes, thereby permitting all 12 punching positions to be selected. For this reason, either alphabetic or numerical data can be selected by the same control panel wiring.

OPERATING SUGGESTIONS

Operating an interpreter is simple. Since it requires attention only about every 10 minutes, to refill the hopper and empty the stacker, you may perform other jobs at the same time. How-

ever, there are a few points you should remem-
ber about operating the interpreter.

1. Always use a test card or cards before
starting an operation. This is necessary to de-
termine if you have the right control panel, or
if the panel you have just wired is wired cor-
rectly. The use of tests cards determines also
if the machine is working properly.

2. Be sure to check the printing position
knob before you start each operation. Make cer-
tain it is turned to the line on which you wish
to print.

3. Joggle cards to arrange them in perfect
alignment before placing them in the hopper in
order to avoid card feed failures.

4. Remember that, because the cards are
fed FACE UP, the last card in the handful placed
in the hopper will be the first one of that group
to be interpreted. If you are interpreting cards
that must remain in the order they are in, you
must start at the back of the file and work to-
ward the front. You must return the interpreted
cards to the file in the same manner in which
they were removed.
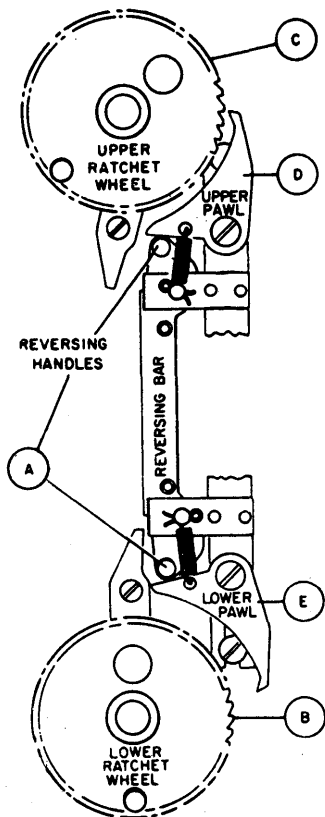
548 RIBBON CHANGING PROCEDURE

1. UNLATCH AND RAISE BRUSH ASSEMBLY.

2. OPEN FRONT DOOR EXPOSING RIBBON FEED
MECHANISM.

3. PUSH EITHER REVERSING HANDLE "A" DOWN
TO DISENGAGE LOWER PAWL E, IF IMPOS-
SIBLE TO DISENGAGE LOWER PAWL "E",
TURN LOWER RATCHET WHEEL "B" CLOCK-
WISE.

4. TURN UPPER RATCHET WHEEL "C" COUN-
TER-CLOCKWISE UNTIL RIBBON LEADER IS
WOUND AROUND RIBBON.

5. PUSH EITHER REVERSING HANDLE "A" UP
TO DISENGAGE UPPER PAWL "D".

6. TURN UPPER RATCHET WHEEL "C" CLOCK-
WISE UNTIL LEADER CLIP IS IN VIEW.

7. DISCONNECT LEADER CLIP.

8. REMOVE RIBBON BY PUSHING SPOOL TO-
WARDS REAR OF THE MACHINE.

9. INSTALL NEW RIBBON WITH NOTCHED END OF
SPOOL TOWARD FRONT OF MACHINE WITH
CONNECTING LOOP ON TOP.

10. ATTACH RIBBON LEADER CLIP TO RIBBON
LOOP.

11. TURN BOTTOM RATCHET WHEEL "B" CLOCK-
WISE APPROXIMATELY TEN TURNS.

12. LOWER AND LATCH BRUSH ASSEMBLY. CLOSE
COVERS.

R49.343X

Figure 5-8.—Ribbon changing procedure.
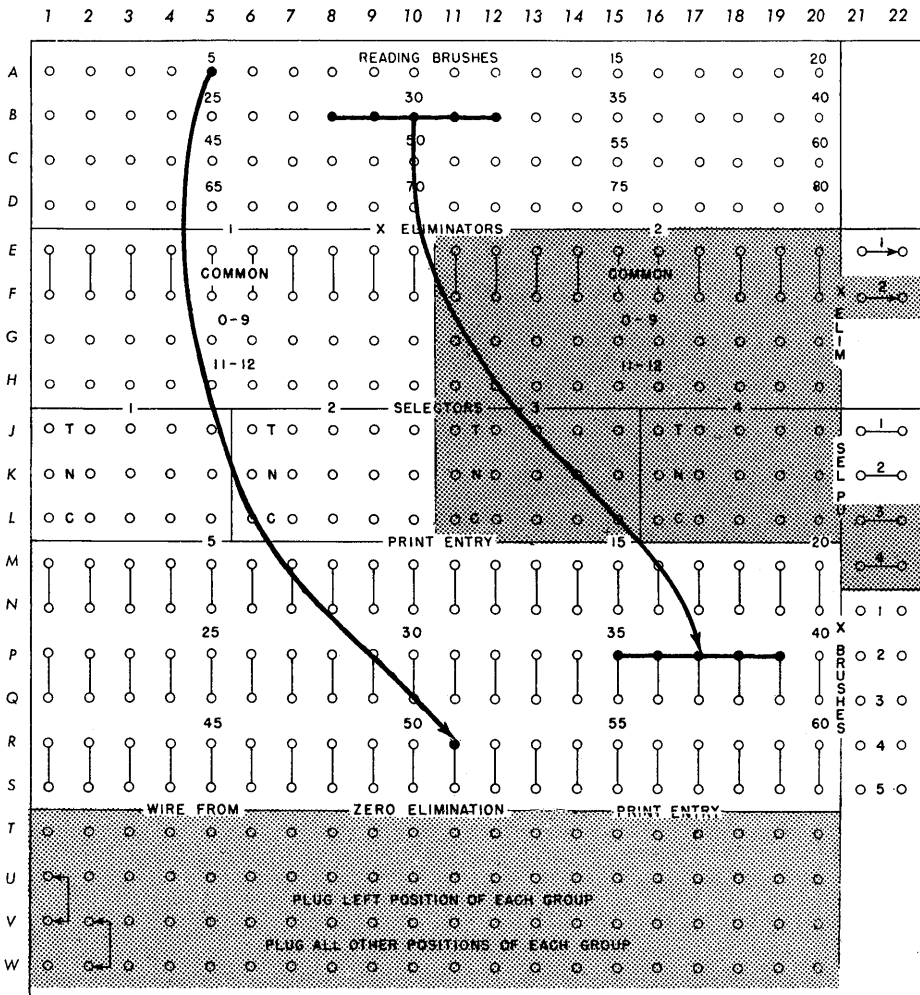
49.23

Figure 5-9.—Normal printing.

5. If the machine stops with the hopper loaded and the stacker not filled, check the last card fed into the stacker. If this card did not stack properly because of folding or pleating, remove one damaged card and check to determine if it should be repunched in order to avoid feeding trouble in later machine operations. Remember that you must check all repunched cards to ensure that they are exactly the same as the original ones.

INTERPRETER, TYPE 557

The type 557 interpreter, shown in figure 5-14, reads data punched in a card and prints that data across the card at the rate of 100 cards
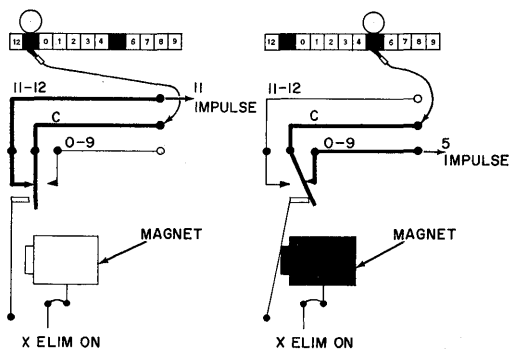
49.24

Figure 5-10.—X eliminator schematic.

per minute. Printing is performed by a set of 60 typewheels, allowing for printing a maximum of 60 characters on one line in one pass of the cards through the machine. A total of 25 lines can be printed across the card by setting the printing position dial to the desired line. Figure 5-15 illustrates the 25 lines of printing. Cards must be passed through the machine one time for each line to be printed.

However, in addition to the usual interpreting operations, the type 557 interpreter can be equipped with several special devices which broaden the range of applications that may be performed. The following paragraphs will give you an idea of some of the additional features which can be installed and the functions they perform. While you are not expected to have a thorough understanding of all these special devices and their applications, you can learn more about them by referring to the type 557 reference manual prepared by the manufacturer.
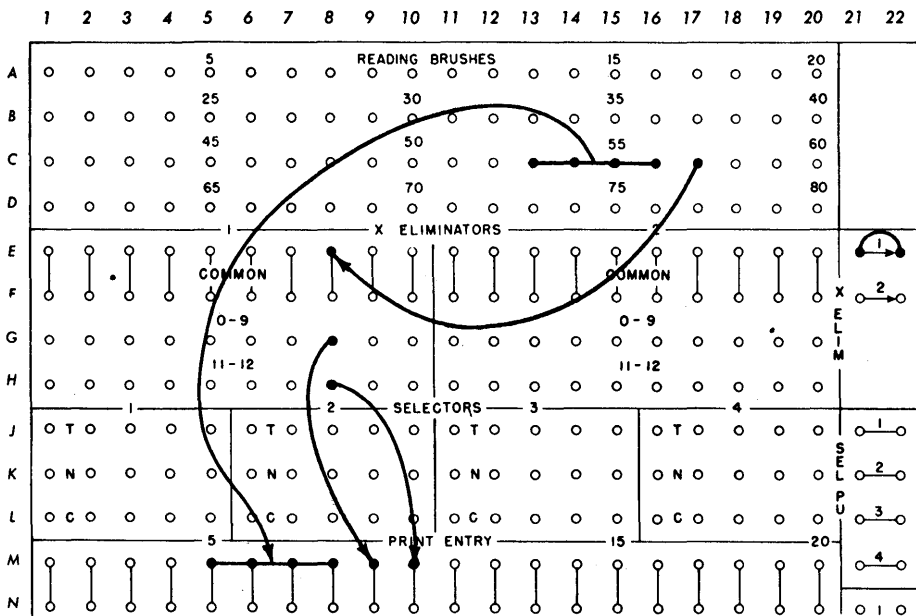
49.25

Figure 5-11.—X elimination.

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MAGNET   MAGNET

NORMAL   TRANSFERRED
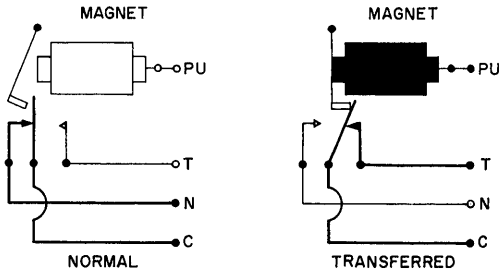
49.26

Figure 5-12.—Selector schematic.

1. REPEAT PRINT. Data can be read from a master card and printed on that card and the detail cards following it. At the same time, control data in each card can be compared to ensure that printing occurs on the proper cards.

2. SELECTIVE STACKERS. As many as four stackers can be installed on the 557. Cards are directed to the stackers by proper control panel wiring. Duplicate master or detail cards, unmatched cards, and cards containing a control punch can be selected.

3. SELECTIVE LINE PRINTING. Cards can be controlled to print on each of 25 printing lines.

When posting ledger cards, the selective line printing device automatically locates the next available posting line, and prints the data.
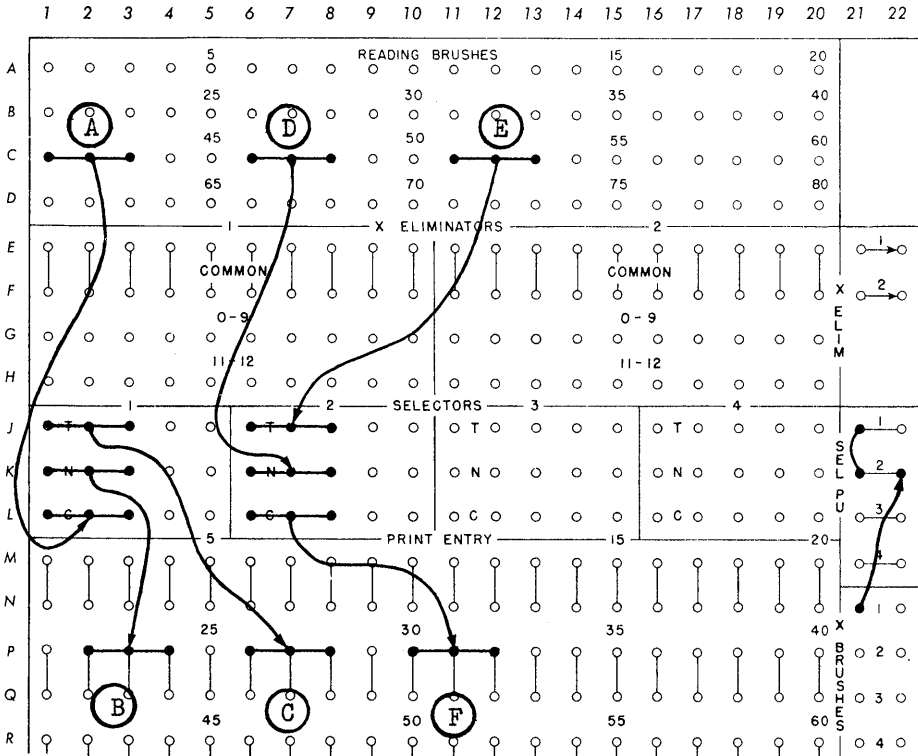
49.27

Figure 5-13.—Class and field selection.

4. INTERPRET EMITTER. This device e-mits an impulse for each character which can be punched in the card. This makes it possible to print emitted characters in addition to characters punched in the card.

5. PROOF. Data that is printed on the card is checked by this device to make sure that the proper characters are printed. Print suppression, repeat print operations, and type wheel alignments can also be checked. If an error is indicated, card feeding stops.

6. CARD COUNTER. All cards can be counted when this device is installed, except those for which the proof device has signaled an error.

7. PRINT ENTRY 2. Printing is performed by 60 typewheels. Either of two control panel entries (print entry 1 and print entry 2) can be selected by a manually operated switch, located on the front of the machine. This makes it possible to interpret two types of cards in different ways while using the same control panel.

8. PRESENSING. This device consists of a set of control X hubs, which can be used to control selectors for selecting alphabetic data in the same manner as the type 548. It can also be used to control the repeat print device to allow printing from a master card onto the following detail cards.

OPERATING FEATURES

The MAIN LINE SWITCH supplies power to the machine. The RUNNING INDICATOR lights up to indicate that the machine is ready for
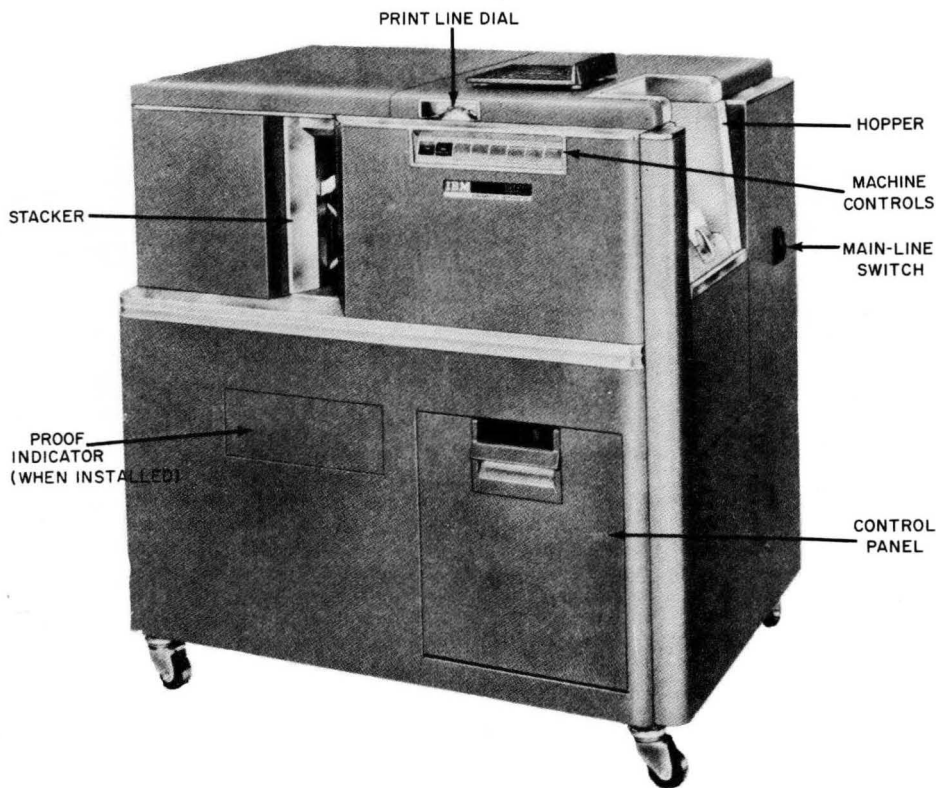

Figure 5-14.—IBM type 557 interpreter.

R49.20.2X

Figure 5-15.—Interpreted card.

R49.258X

operation, and goes OFF when the machine is in use. The START key is depressed to start card feeding. It must be depressed and held until three cards have been fed in order for continuous card feeding to be effective. When the STOP key is depressed, card feeding stops, but those cards already in the machine will be fed automatically into the stacker.

Printing Position Dial

The printing position dial, as shown in figure 5-16, can be manually set to cause printing on one of 25 printing lines. These lines are located from the 12 to the 9 edge of the card as illustrated in figure 5-15. When the dial is set on position 1, printing occurs above the 12 punching position. When set on position 2, printing occurs at the 12 position. When set on position 3, printing occurs between the 12 and 11 positions. Each

succeeding position causes printing to occur lower on the card, with line 25 printing below the 9 position.

R49.20.2X
Figure 5-16.—Machine controls.

Print Entry Switch, Lights

The print entry switch manually controls the selection of one of two different printing setups wired on one control panel. The two lights operate in conjunction with the switch and indicate which print entry is operating (fig. 5-16).

Proof Indicator

Incorrect printing of valid characters or failure to print all characters is detected by the proof device, when installed. When an error is detected, an indicator is extended to show the error. Depressing the error reset cover resets the unit and turns off the stop light.

Hopper

The capacity of the card hopper is approximately 800 cards. The cards must be placed in the hopper FACE DOWN, with the 12 edge toward the throat of the hopper. Therefore, you must work from the front of a file of cards toward the back in order to keep the cards in their original sequence.

Notice the difference between card feeding in the type 557 and other interpreters. This is the only interpreter which requires that cards be fed face down, and from the front of the file.

Stacker

The capacity of the stacker is approximately 900 cards. When the stacker becomes filled, a stacker stop switch causes the machine to stop. After removing the interpreted cards, the operation can be resumed by depressing the start key. Cards stack in their original sequence.

Print Unit

The printing mechanism consists of 60 typewheels. Each typewheel, as shown in figure 5-17, can print numerical, alphabetical, and special character information. Printing of special characters that have more than one numerical punch, such as the dollar symbol, requires a special character printing device.

Ribbon

On each print cycle the ribbon feeds from one spool to the other approximately one - fourth inch. A metal eyelet near the end of the ribbon
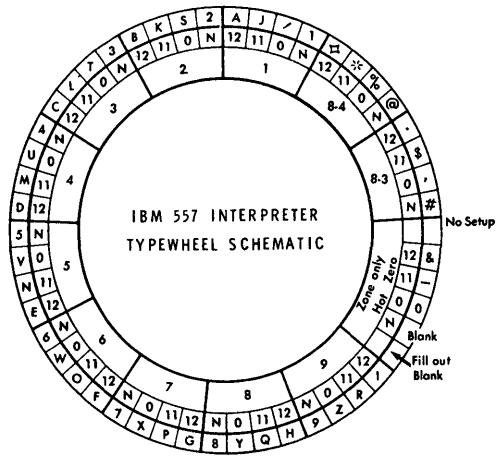
R49.30X

Figure 5-17.—Type 557 typewheel schematic.

reverses it automatically when it strikes the reversing lever. When a new ribbon is installed it should be threaded around the guide rollers as shown in figure 5-18.

PRINCIPLES OF CONTROL PANEL WIRING

Operations which may be performed are directed by control panel wiring. All standard hubs are located in the left section of the double-section panel, while the right section is composed entirely of hubs for special devices. Shaded areas on the control panel in figure 5-19 indicate special features.

Normal Printing

There are 80 pairs of interpret reading hubs on the control panel, representing the 80 columns of the card. For normal printing, they are wired to the 60 print entry 1 hubs representing the 60 typewheels. The interpret reading hubs may be wired to any of the print entry 1 hubs to cause data to be printed in any desired sequence across the card.

Zero Print Control

Wiring from interpret reading to print entry causes the typewheels to be positioned so that
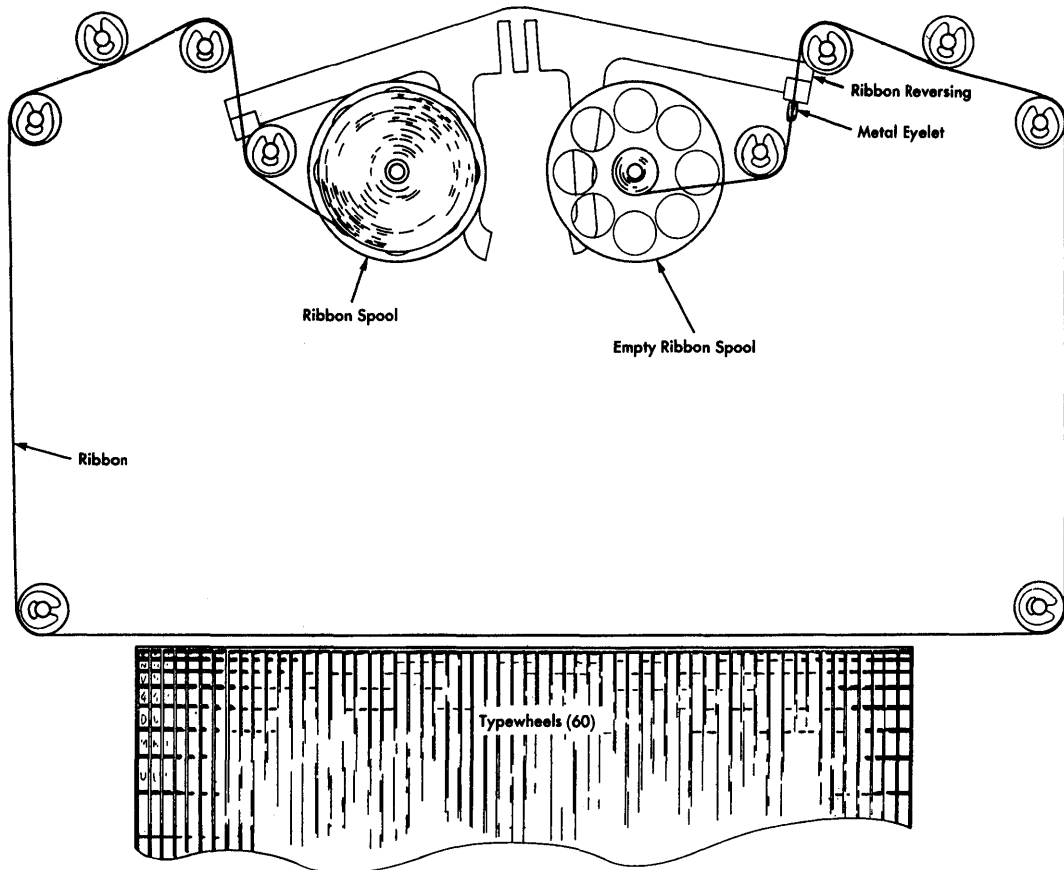
112

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Figure 5-18.—Type 557 ribbon feed schematic.

the punches which have been read from a card can be printed. Before a typewheel can actually print, an impulse must reach the print fuse and energize a print magnet. When the print magnet for a typewheel has been energized, a hammer will fire and press the card against the character on the typewheel to cause printing.

Impulses originating from a significant digit have a path to the fuse and will automatically energize a print magnet. However, zeros and single 11 or 12 punches do not normally have a path to the fuse, so they will not print unless additional wiring has been added. This additional wiring is provided for in the zero print control feature. By referring to figure 5-19 you will notice a pair of zero print control hubs for each printing position. The hubs in the lower row, numbered from 1 to 60, are diagonally connected internally to the hubs in the upper row as illustrated by the dotted lines in figure 5-20. The first hub in the upper row, directly above the lower hub of the first zero print control position, represents the upper hub of zero print control position 60.

When a significant digit reaches a print magnet, an internal machine impulse becomes available at the upper zero print control hub of that particular typewheel. This impulse can be used
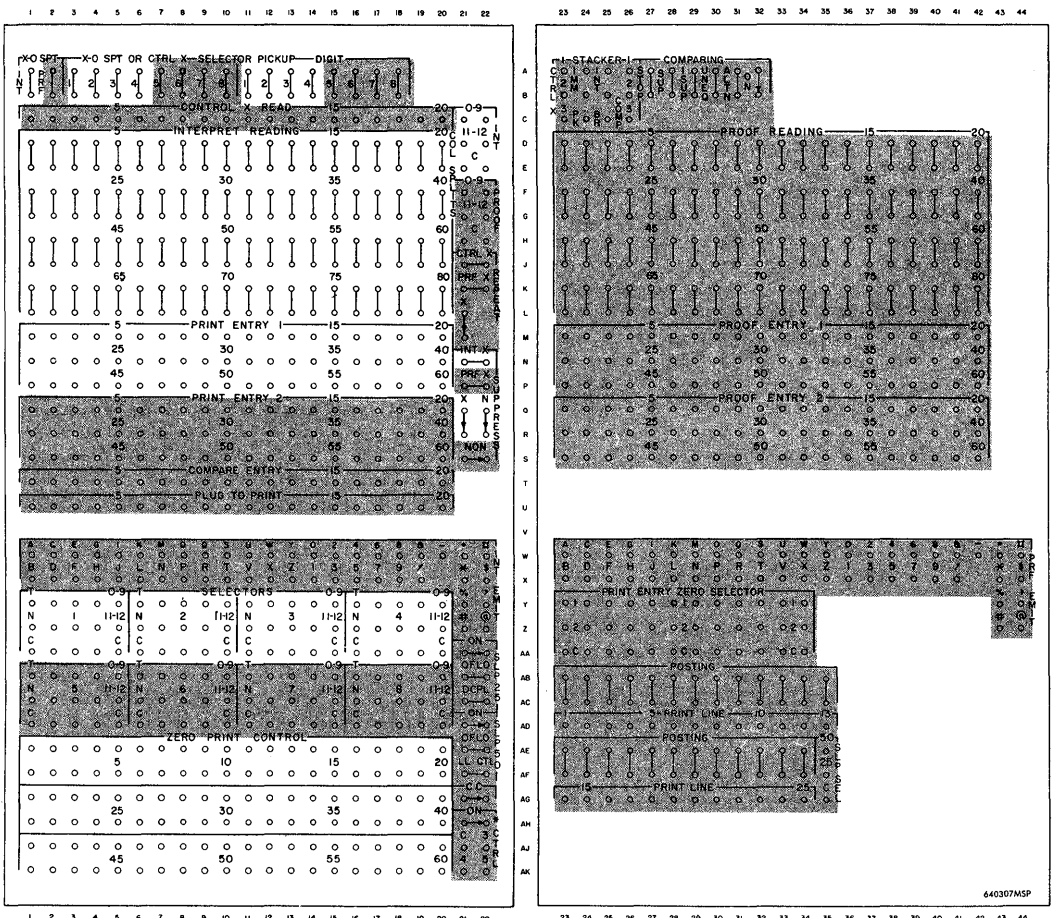
113

Figure 5-19.—Type 557 control panel.

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to energize the print magnet of the typewheel to the right, if that typewheel is to print a zero. This is accomplished by jackplugging the upper zero print control hub of the position containing the significant digit to the lower hub of the position to the right. The internal machine impulse is then allowed to reach the fuse and energizes the print magnet of the position that is to print a zero. Additional zeros to the right can be printed by jackplugging more zero print control hubs.

If all zero print control hubs for a field are jackplugged then all zeros to the right of a significant digit will print. But suppose you wish to print zeros to the left of the last significant digit. Since the low order position of the field will have a path to the fuse, either by being a significant digit or because a significant digit to the left has supplied an internal machine impulse, this impulse can be wired from the upper zero print control hub of the low order position around to the lower hub of the high order position, thus energizing the print magnets for the high order zeros. When zeros are controlled to print to the right or left of a significant digit, ten consecutive zeros can be carried or controlled to print.

Special characters which are actuated by only an 11 or 12 punch do not normally have a path to the fuse. For this reason, they must be controlled to print in the same manner as zeros.

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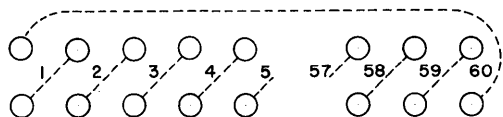
42.32

Figure 5-20.—Zero print control hubs.

In order to print a field which contains all zeros, such as a zero balance, the lower hub of the high order printing position must be wired from interpret reading.

Column Splits

If a numerical column, punched with a significant digit and a control X, is wired directly to a print entry, an alphabetic character will be printed. This can be prevented by wiring that particular column through a column split. The column split device operates on the same principle as the X eliminator in the type 548. Any impulse zero through 9 in a column wired to common is available from the hub marked 0-9, while 11 and 12 impulses are available from the 11-12 hub. By wiring the column containing the control X to common and from the 0-9 hub to a typewheel, the numerical punch in that column will be printed without the interference of the control punch.

Print Suppression

Selective printing of an entire card can be performed under the control of an X or NX condition. This permits you to interpret all cards of one type without separating the file or printing on the other cards in file. Either an 11 or 12 punch can be used for control.

The column containing the control punch is wired from interpret reading directly to the interpret X hub. No column split is required, since the pickup hub does not accept 9 through 0 impulses. If you wish to suppress printing of X cards, the X switch must be wired ON. If you wish to suppress printing of NX cards, the NX switch must be wired ON. The X switch must always be wired for all operations except when suppressing printing of NX cards.

Wiring

Figure 5-21 illustrates the wiring necessary for normal printing, zero print control, X elimination, and print suppression.

1. Columns 1-4, an alphabetic field, are wired to typewheels 4-7.

2. Columns 6-10, a numerical field, are wired to print in typewheels 9-13, with zeros controlled to print to the left of the high order significant digit.

3. Columns 11-14, a numerical field, are wired to typewheels 15-18 without printing zeros to the left of the high order significant digit.

4. Columns 15-18, an amount field, are printed in typewheels 22-25 with zero balances printed as all zeros, and with the credit X eliminated.

5. An X punch in column 80 impulses the print suppression pickup hub. The NX switch is wired ON to suppress printing of all NX cards. The X switch must be wired ON at all other times, whether or not printing is being suppressed.

Selection

Selectors may be used for two purposes; selection and splitting columns. When used as a selector, they operate on the same principle as those in the type 548. When used as a column split, they function in the same manner as an X eliminator. Since the standard 557 does not contain X brushes, all control punches must be read from interpret reading. Because of this, alphabetic selection can be performed only if presensing (Control X Read) is installed.

Four 5-position selectors are standard. Each selector has two separate pickups, which are X-0 Split or Control X, and Digit Pickup. These two pickup hubs should NEVER be connected to each other. Each pickup should be activated by a specific impulse for a specific function. When either pickup is impulsed, the selector transfers immediately and remains transferred for the duration of that card cycle.

The X-0 Split or Control X pickup can be wired from the X-0 Split hubs to cause a selector to operate as a column split. The interpret X-0 Split hub times the selector for use with the interpret reading brushes. The normal side of the selector becomes the exit for any 11-12 impulses that enter the common hubs, and the transferred side becomes the exit for any 0-9 impulses that enter the common hubs.

The Digit Pickup hubs are normally wired from interpret reading. Since these hubs accept any impulse 12 through 9, a column split should be used to select only the 11-12 control punch to be used.

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Figure 5-21.—Normal printing, zero print control, S elimination, and print suppress.
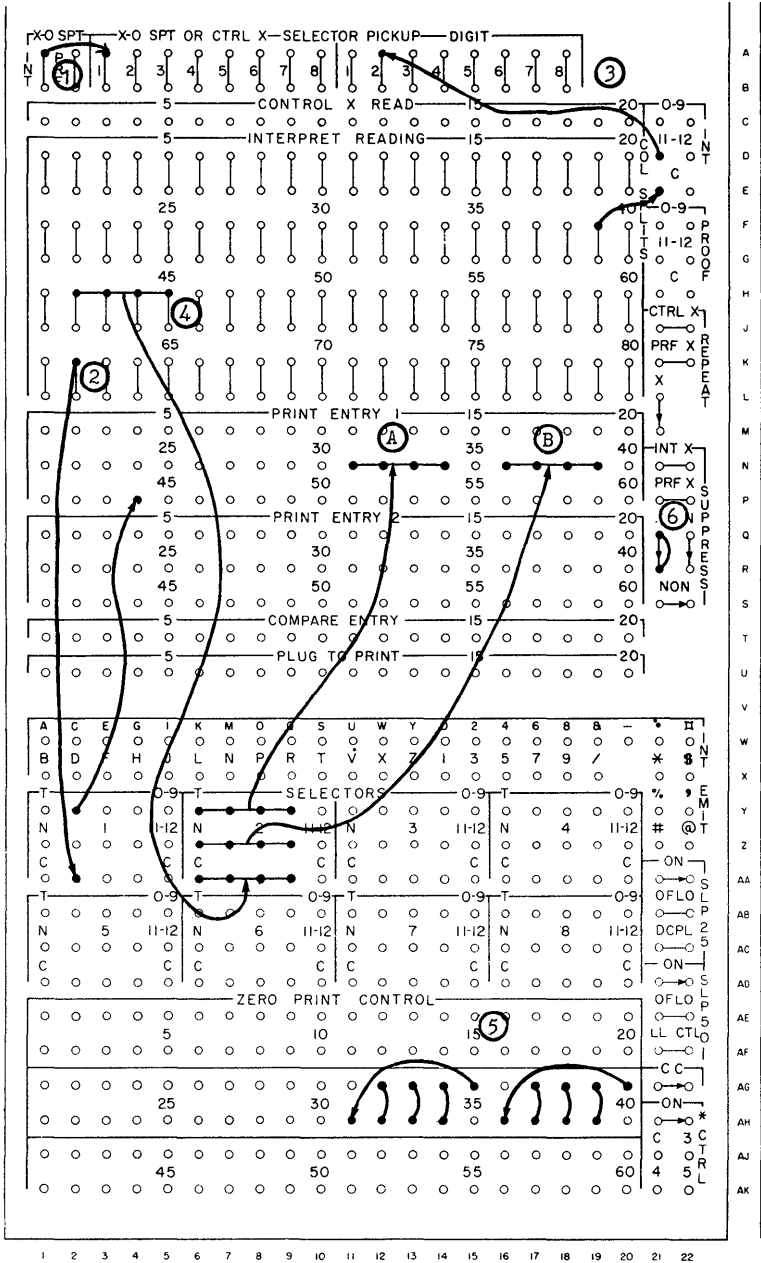
49.33

116

Figure 5-22 —Numeric class selection and X elimination.

49.34

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The wiring diagram in figure 5-22 shows the wiring for numerical class selection, and for X elimination using a selector, as a column split.

1. Selector 1 is picked up from the X-0 Split hub, which causes the selector to operate as a column split. The X-0 Split hub emits an impulse just after the 11 position in a card has passed interpret reading, and before the zero position is reached. This allows the 11-12 impulses to become available out of the normal side of the selector, and the zero through 9 impulses out of the transferred side.

2. Column 62 is wired through the transferred side of selector 1, to print only the numerical punch in that column.

3. Selector 2 is picked up from an X in column 39, which is wired through a column split to eliminate digit punches in that column.

4. Columns 42-45 are wired through selector 2 so that printing occurs at location A for X cards and at location B for NX cards.

5. All zeros are controlled to print.

6. The suppress X switch is wired ON to allow interpreting of all cards. If it were not wired, no cards would be interpreted.

CHAPTER 6

AUTOMATIC PUNCHES

One characteristic of record keeping is repetition. Records made on the same day must be dated identically. Records prepared at the same source contain identical location information. Likewise, information used at one place may be needed at another, requiring duplication of the same basic records. In some cases, partial changes to the original records must be made on a continuing basis, in order to keep the records up-to-date. At times, entire files must be partially changed or duplicated.

When records are maintained in punched card form, these repetitious operations can be performed automatically by automatic punches. The operations which may be performed on these machines are described as follows:

1. REPRODUCING. All or any part of the data contained in one set of cards can be punched into another set. Accuracy of punching can be verified at the same time by the comparing feature. For example, if you have a file of personnel status cards in which rate abbreviation and rate code must be changed, you can reproduce the original cards, leaving out rate abbreviation and rate code. Then you can reproduce the new rate abbreviation and code from a set of matching change cards into the reproduced personnel status cards. The reproduced cards then become the up-to-date personnel status card file.

2. GANGPUNCHING. Information contained in a master card can be transferred to each succeeding detail card which requires the same information. This application reduces the coding and keypunching required of source documents in those cases where one item of data relates to another. For example, it would not be necessary to code and keypunch rate code from the personnel diary, since a master rate code deck, containing rate code for each rate, can be used to gangpunch the code into the appropriate change cards.

3. SUMMARY PUNCHING. When the automatic punch and accounting machines are connected for a common application, totals which have been accumulated in the accounting machine from detail cards can be punched into a total card. The total, or summary cards, can then be used to prepare a variety of reports without having to tabulate the detail cards again. Summary cards may also be used as balance forward cards in order to keep a running account of totals accumulated during an accounting period or from one accounting period to another.

4. MARK SENSING. This is the process whereby information recorded on a card by pencil marks is automatically converted to punched holes. Consider supply operations where the supply of stock on hand is recorded in punched cards. When issues of stock are made, the quantity of issue can be marked on issue cards and can be converted to punched holes by automatic punches. The mark sensed cards can then be used to bring the balance of stock on hand up to date.

5. DOUBLE PUNCH AND BLANK COLUMN DETECTION. Double punches or blank columns can be detected by a special device. This feature may be used to ensure that certain fields in a card are punched in all positions and that each column in the field contains only one punch.

6. EMITTING. The gangpunch emitter is a special device which supplies punching impulses identical to the punches which may be placed in a card. Repetitive punching without the use of a master card can be accomplished by wiring the hubs of the gangpunch emitter directly to punch. Emitting can be performed in conjunction with any other operation. By emitting data common to all cards, the need for keypunching or duplicating this data during the keypunch operation is eliminated.

7. END PRINTING. The IBM type 519 document originating machine is equipped with a

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printing unit which can be controlled to print up to eight digits across the end of a card during a single operation. These digits may be printed on the cards in which they are punched, or on a duplicate set of cards. A typical application is the printing of employee number on time cards. Since these digits print in large characters, they are readily visible for employees to select the correct card from the time card rack when clocking in or out.

All operations, with the exception of summary punching, occur at the rate of 100 cards per minute. Summary punching requires 1.2 seconds per card.

This chapter discusses the two most widely used automatic punches; the IBM type 514 reproducing punch and the IBM type 519 document originating machine. While both machines are similar in appearance, operation, and functions, their control panels differ considerably in design and method of wiring. For this reason, each machine will be discussed separately.

REPRODUCING PUNCH, TYPE 514

The type 514 reproducing punch, pictured in figure 6-1, contains two feed units; the reading unit and the punching unit. Cards may be fed from either or both units depending upon the job being performed. Each unit holds approximately 800 cards. For normal operations, cards are placed in the hoppers face down, with the 12 edge toward the throat. Once card feeding is started, it continues automatically until a hopper becomes empty, a card fails to feed, an error is signalled by the comparing unit, or a stacker becomes filled.

OPERATING FEATURES

The MAIN LINE SWITCH, located on the right end, provides power to the machine and must be ON for all machine operations. Other switches, keys, and lights that control card feeding and machine operation are located on the front as illustrated in figure 6-1. The START KEY must be depressed to start card feeding, and the STOP KEY must be depressed to stop card feeding. The DOUBLE PUNCH AND BLANK COLUMN LIGHT goes on and the machine stops whenever a double punch or blank column has been detected. The RESET KEY must be depressed to reset the double punch and blank column detection circuits and to put out the DP&BC light. The COMPARE LIGHT signals an

error in card comparison, and causes the machine to stop. The comparing position in error is indicated by a COMPARING INDICATOR. The compare light may be turned off by pushing the restoring lever on the comparing indicator unit.

Reading Unit

Refer to the schematic diagram in figure 6-2. Notice that as cards feed through the reading unit, they first pass the five read X brushes. These brushes can be set to read any desired columns of the card in order to control the reading of other data from the card. These brushes must be set at least two columns apart.

The following station contains 80 reproducing brushes, which read the 80 columns of the card. These brushes may be wired to the punch magnets to reproduce data into a card passing through the punching unit, or they may be wired to the comparing unit to compare cards that have been gangpunched in the punching unit.

After cards pass the reproducing brushes, they are read by 80 comparing brushes. These brushes may be wired to the comparing unit to compare the card reproduced on the preceding cycle, or to check the accuracy of a gangpunching operation.

Punching Unit

A schematic diagram of the punching unit also is included in figure 6-2. Cards feeding through the punching unit first pass the six punch X brushes. These brushes can be set to read any columns of the card in order to control the reading of other data. These brushes must be set at least two columns apart.

If the mark sensing device is installed, the mark sensing brushes, located between the punch X brushes and the punch magnets, read the marks on a card and must be wired through an amplifying unit to the punch magnets to cause the marks to be converted to punches represented by the marks.

The next station contains the punching mechanism, consisting of 80 punch magnets and supporting dies. Each punch magnet may be actuated at either or all of the 12 punching positions in a column as a card moves past this station. During a reproducing operation the reading and punching units are synchronized so that as a card in the reading unit is being read by the reproducing brushes, the identical punching position of the card in the punching unit is passing under the punch magnets. Thus, if a 4 is
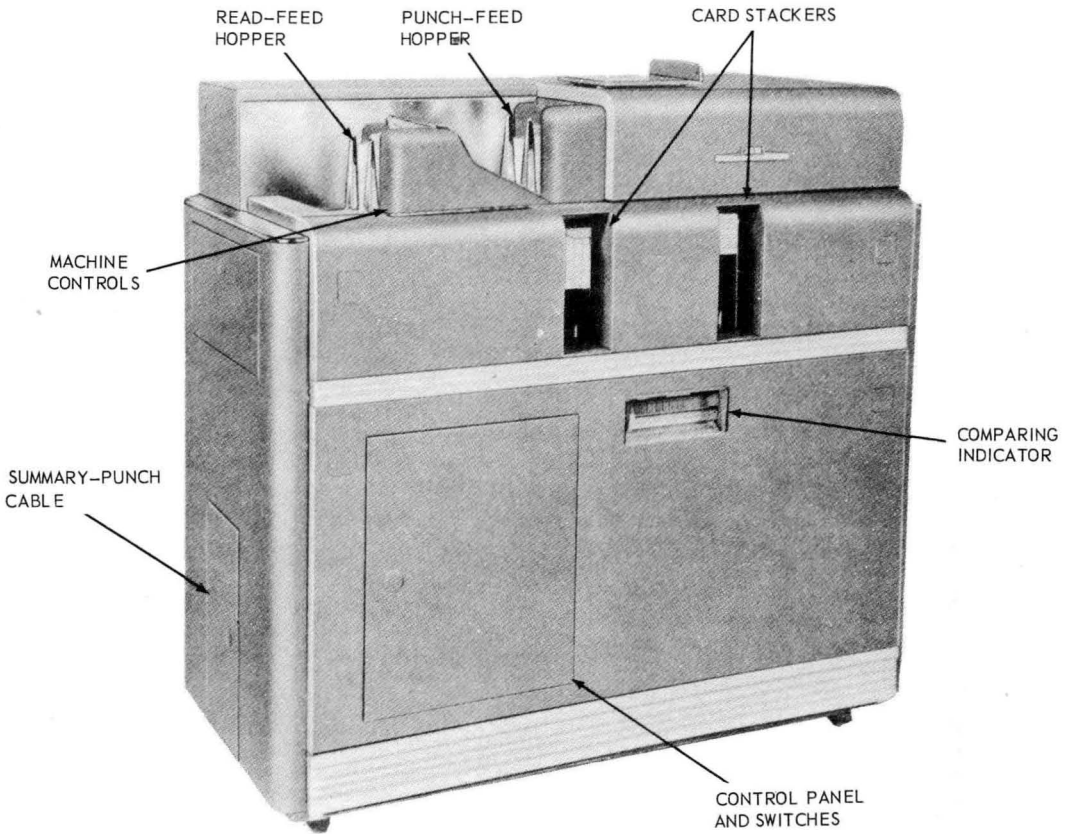
READ–FEED HOPPER

PUNCH–FEED HOPPER

CARD STACKERS

MACHINE CONTROLS

COMPARING INDICATOR

SUMMARY–PUNCH CABLE

CONTROL PANEL AND SWITCHES

R49.35X

Figure 6-1.—IBM type 514 reproducing punch.

read in the reading unit, a 4 can be punched in the punching unit. All columns which are to be punched with the same digit are punched at the same time.

After a card passes the punching station it is read by 80 punch brushes. These brushes may be wired to the comparing unit to compare the card reproduced on the preceding cycle with the original card, or they may be wired to the punch magnets to cause punching during a gang-punching operation.

Comparing Unit

The comparing feature provides for comparing the punching in two cards to see if punching is identical. Comparison may be made between one card in the reading unit and another in the punching unit, or between two cards in the reading unit. When the punching in the two cards being compared is different, the compare light goes on and the machine stops. The comparing indicator, shown in figure 6-3, points out the comparing position containing the error. In order to reset the comparing indicator and turn out the compare light, the restoring lever on the comparing indicator unit must be reset.

Comparison of two cards is performed through the use of comparing magnets. Each comparing position consists of two magnets, with an armature placed between them. An impulse wired to a comparing magnet from a
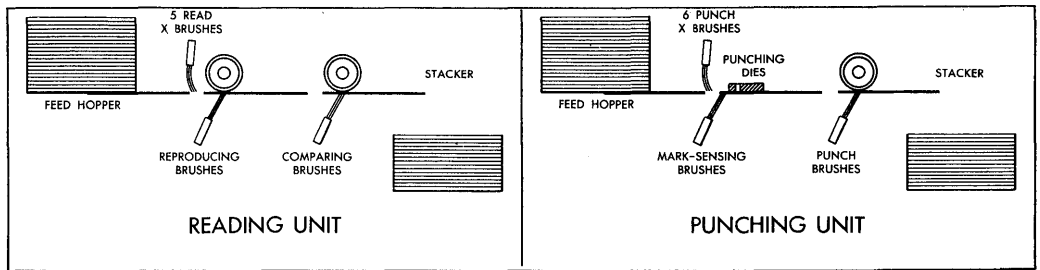
Figure 6-2.—Card feed schematic diagram.

brush causes the magnet to become energized. If neither magnet is energized, the armature remains in a central position between the magnets. An electrical current passing through the armature cannot go any farther as long as the armature is in this position. If both magnets are energized at the same time, the armature still remains in the central position, since both magnets .exert the same amount of pull. In either situation the armature is said to be normal. If one of the magnets becomes energized while the other remains inactive, the armature is then attracted to the energized magnet, causing the armature to transfer. The electrical current then flows from the armature through a contact point to signal the machine that an error has been detected.

The manner in which a comparing position signals an error is illustrated in figure 6-4.

In chart A, neither magnet has received an impulse, thus indicating that the card columns wired to both magnets are blank.

In chart B, both magnets are energized. In this case, the punching in both cards is the same, or equal.

In charts C and D, one magnet has been energized while the other remains inactive. This is a result of one card containing a punch that the other card did not have, causing an unequal condition. Current from the armature is then allowed to pass through the contact points to signal a difference in comparison between the two cards.

Functional Switches

Machine setups are controlled by the following functional switches, located inside the control panel compartment:

Reproducing Switch.—This switch synchronizes the reading and punching unit, so that they work together when reproducing information from one deck of cards onto another. When this switch is OFF each unit may be used independently to perform separate operations.

Sel Repd and GP Compare Switch.—This switch allows continuous feeding in the reading unit. It should be ON only when performing selective reproducing or a gangpunching and comparing operation. When this switch is turned OFF and the PX circuit is effective, feeding in the reading unit is suspended for the following card cycle, while a card is allowed to feed into the punching unit.

Detail-Master Switch.—The detail-master switch controls the handling of X and NX cards. This switch should be set to master when the master card has the controlling punch for gangpunching or when reproducing from the NX cards is desired. The switch should be set to detail when the detail cards have the controlling punch or when reproducing from the X cards is desired.

Mark Sensing Switch.—The mark sensing switch must be ON for any mark sensing operation.

Master Card Punching Switch.—In a combination reproducing and gangpunching operation in which mark sensed master cards are used, the master card punching switch, when ON, permits punching of mark sensed information into the master card. This switch should be OFF for all other operations.

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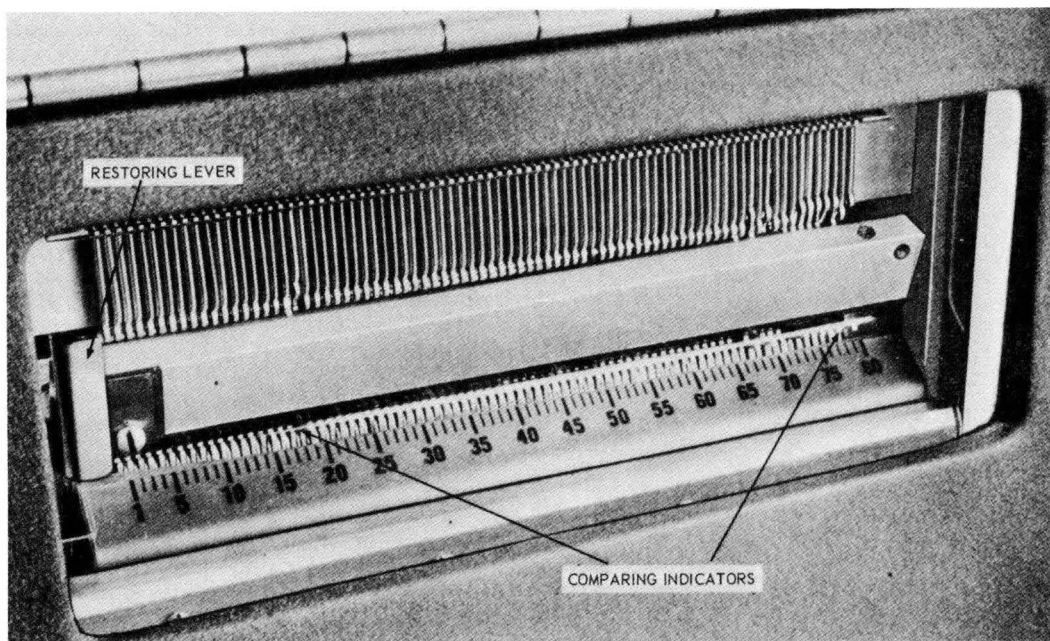
Figure 6-3.—Comparing indicator unit.

Blank Column Detection Switch.—A switch is provided for each position of double punch and blank column detection. When a switch is turned on and the corresponding position is wired on the control panel, the detection of either a blank column or a double punch will stop card feeding. Only double punches will be detected if the blank column switches are turned off.

PRINCIPLES OF CONTROL
PANEL WIRING

The automatic operation of reproducing punches is made possible through control panel wiring and proper switch settings. Typical applications are discussed below, along with illustrations of wiring diagrams and switches. As the explanation for each application progresses reference to figure 6-2 will assist you in understanding the wiring principles involved.

Straight Reproducing
And Comparing

Cards from which information is to be reproduced (source cards) are placed in the reading unit, and those to receive the information (reproduced cards) are placed in the punching unit. The reproducing switch is turned on. Figure 6-5 shows a sample of how the control panel is wired for normal reproducing and comparing of all cards.

1. As a source card passes the reproducing brushes, all columns are read by the brushes, and impulses representing digits punched are available at the reproducing brush hubs on the control panel. These impulses, when wired to the punch magnet hubs, cause punching to occur in the card passing the punching station in the punching unit.

2. Both cards then feed simultaneously past the next station in their respective unit. At this
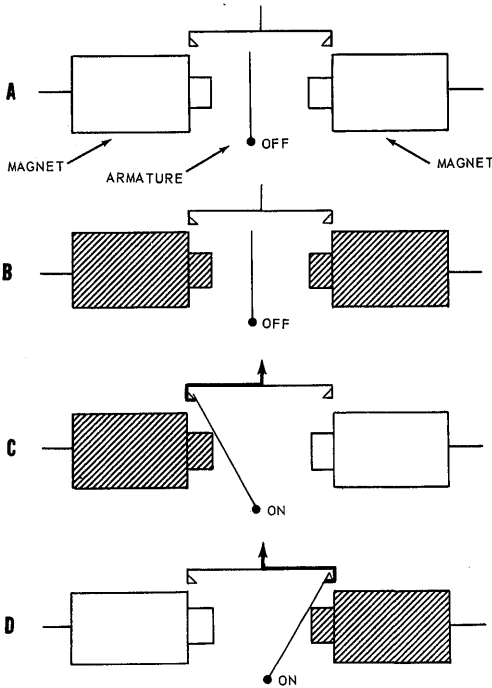
R49.38X

Figure 6-4.—Comparing position schematic.

point, the source card is read by the comparing brushes, and impulses representing digits punched are directed to the comparing magnets by wiring the comparing brush hubs of the field being reproduced to one side of the comparing unit. At the same time, the reproduced card will be read by the punch brushes, and impulses representing digits punched are directed to the corresponding magnets by wiring the punch brush hubs of the reproduced field to the other side of the comparing unit. Thus, if the two impulses received by a particular comparing position are the same, reproducing has been performed satisfactorily. If the impulses differ, or if only one magnet in a comparing position has received an impulse, an error is indicated. The machine stops and the comparing position in which the error is located is identified by the comparing indicator.

Any comparing position can be used to verify punching in any given column, but the positions corresponding to the columns in the reproduced card are generally used. This provides for ease in wiring, as well as simplifying the process of finding the error column.

Selective Reproducing
And Comparing

Selective reproducing is the process whereby only one type of card, X or NX, will be reproduced. The reproducing switch and the selective reproducing GP and compare switch must be turned on. There will be a blank card in the reproduced deck for each source card which is not reproduced. Wiring for this operation is shown in figure 6-6.

1. The wiring for punching and comparing is the same as for straight reproducing.

2. In order to identify the X cards, a read X brush is set to read the column containing the X punch, and the corresponding read X brush hub on the control panel is wired to the PX hub. The PX circuit then sets up the conditions under which reproducing and comparing can be performed, in conjunction with the detail-master switch, as follows:

a. When the detail-master switch is set to MASTER, punching is suspended when X punched cards pass the reproducing brushes. All NX cards will be reproduced. Comparing is suspended when the X punched cards pass the comparing brushes. NX cards will be compared.

b. When the detail-master switch is set to DETAIL, punching is suspended when NX cards pass the reproducing brushes, and all X punched cards will be reproduced. Comparing is suspended when NX cards pass the comparing brushes, and all X punched cards will be compared.

X Elimination of Transfer

Column splits operate on the same principle as those in the type 557 interpreter. They allow the reading of a column to be divided between the zero and 11 punching positions in order to separate the reading of control punches from digit punches, or to combine these punches from different columns into one column. Figure 6-7 shows three uses for column splits.

1. If an 11 or 12 control punch is not to be reproduced, the reproducing brush hub for the column containing the control punch is wired to common of a column split. The 0-9 hub is then wired to the desired punch magnet. The control
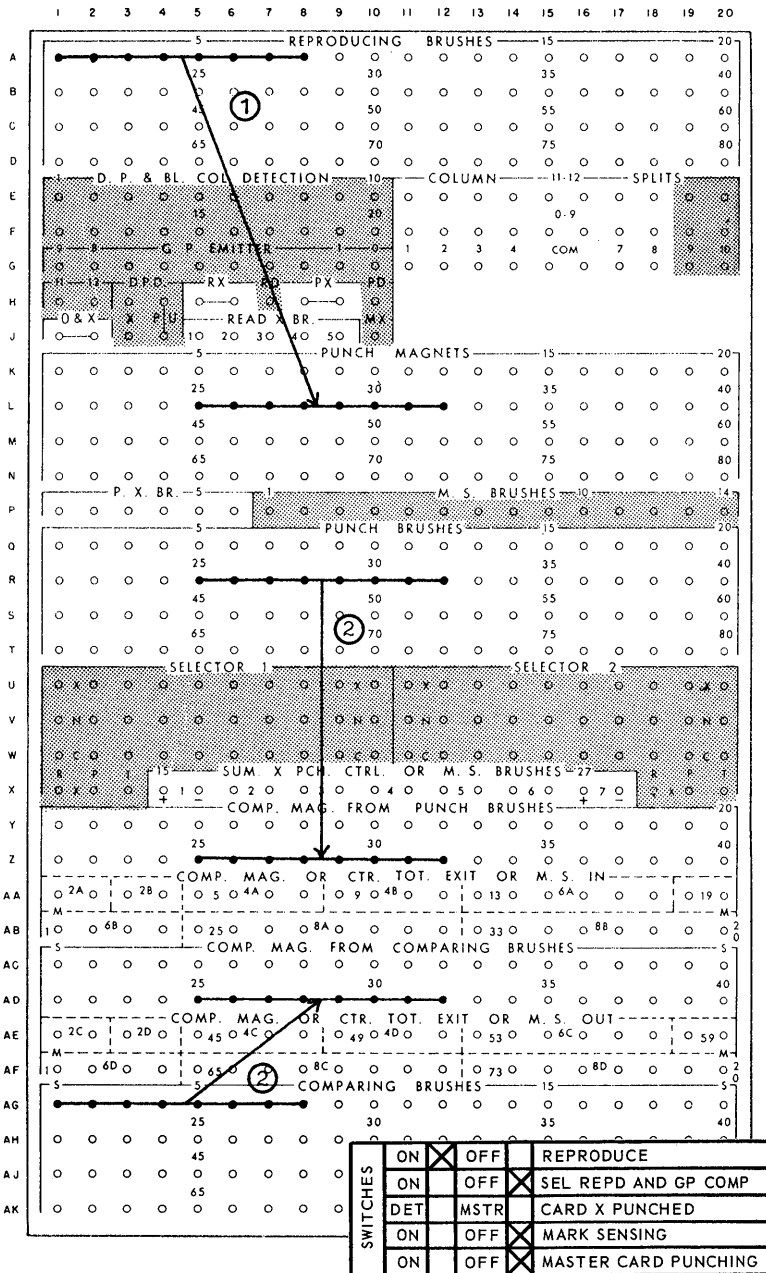
124

Figure 6-5.—Straight reproducing and comparing.

49.39

49.40
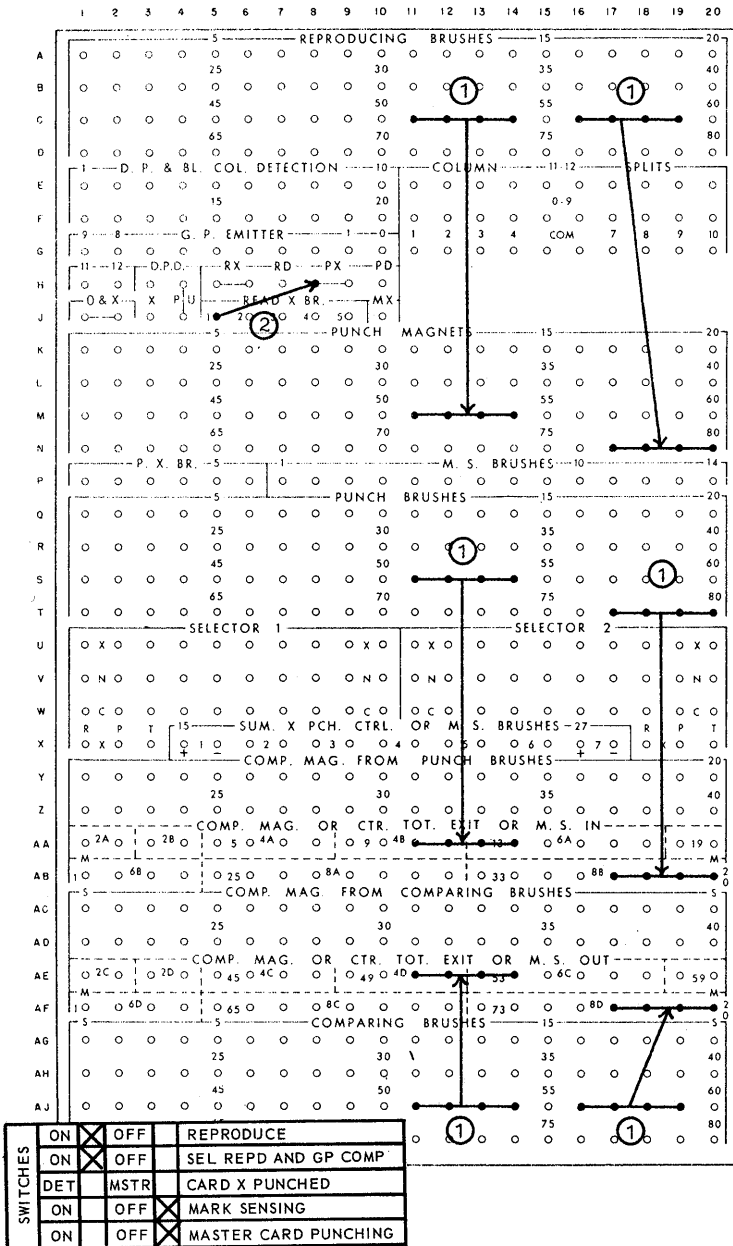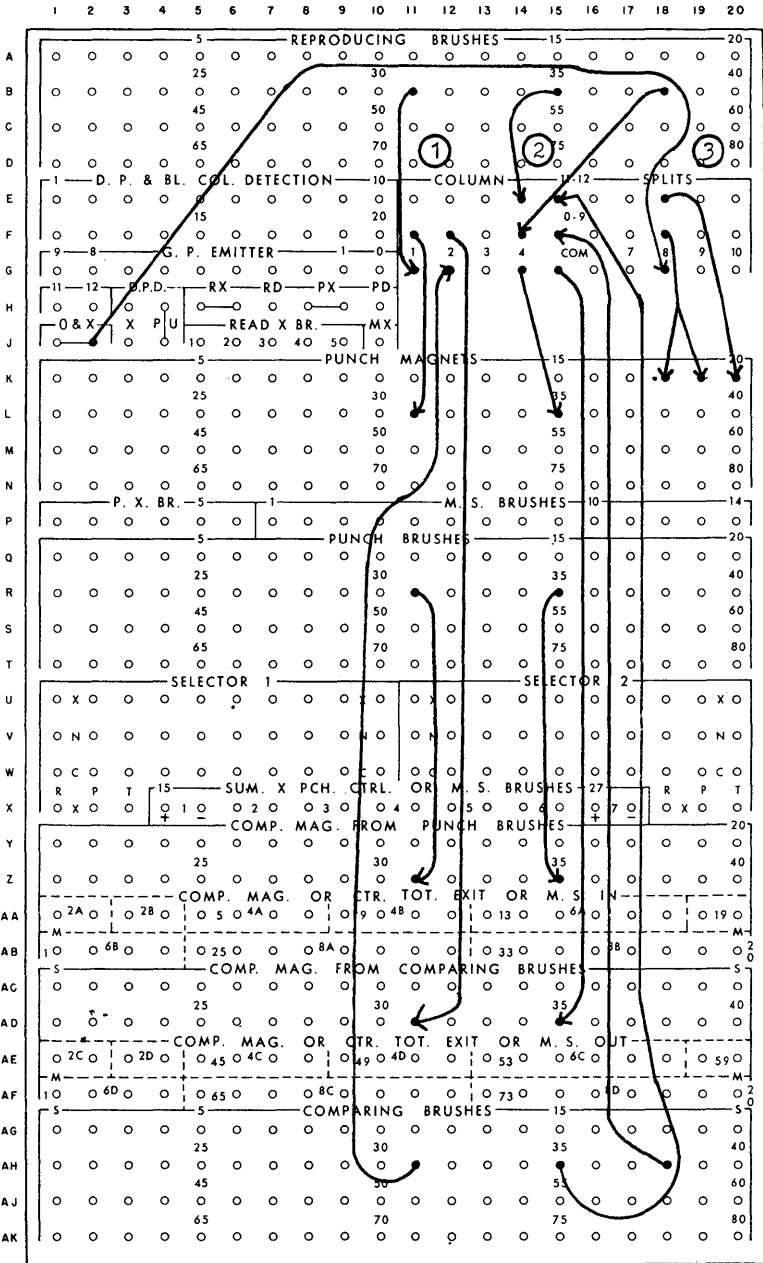
Figure 6-6.—Selective reproducing and comparing.

Figure 6-7.—Using the column splits.

49.41

punch may be wired from the 11-12 hub to any other punch magnet, if desired. The comparing brush must be wired through a column split in the same manner in order to avoid a false error light during comparison.

2. The column split may also be used for combining punches. The reproducing brush hub representing the control punch is wired to the 11-12 hub, and the digit punch from another column is wired to the 0-9 hub. The common hub is then wired to a punch magnet, where the two punches from different columns are punched into one column. The comparing brushes for both columns of the source card must be wired through a column split to the comparing unit to avoid false comparison.

3. In some instances you may wish to punch an X in all cards passing through the punching unit, or add zeros to increase the size of a field. This can be accomplished by wiring the 0 and X hubs through a column split to the punch magnets. These hubs emit both a zero and an X impulse each card cycle. In order to punch all cards with an X, a zero and X hub is wired to common of a column split and from the 11-12 hub to a punch magnet. Zero impulses are available from the 0-9 hub of the same column split, and may be wired to a punch magnet to punch a single zero, or split wired to several punch magnets for punching two or more zeros.

Gangpunching and Comparing

Gangpunching is the automatic copying of punched data from a master card into one or more detail cards. The information to be gangpunched is read from the master card by the punch brushes and punched into the first detail card. This information is then passed from the first detail card, when it reaches the punch brushes, to the second detail card, and from the second to the third, and so on until the next master card is reached.

Gangpunching from a single master card does not require the use of a control punch to identify the master or detail cards. Verification of punching should be performed by visually comparing the master card with the last detail card punched as each handful of cards is removed from the stacker.

Where information to be gangpunched changes from one group of cards to the next, interspersed gangpunching may be employed. This could be in the form of straight or offset gangpunching. A different master card is placed in front of each group of detail cards. Gangpunching and comparing are then controlled by the presence of a control punch in either the master or the detail cards. Each feed unit is allowed to operate independently of the other for gangpunching operations by turning the reproducing switch OFF.

The selective reproducing and gangpunch compare switch must be turned ON in order for the gangpunching operation to be compared.

Straight Intersperse Gangpunching and Comparing

Cards to be gangpunched are placed in the punching unit. After a handful has been punched, they may be compared for accuracy of gangpunching by placing them in the reading unit. Figure 6-8 illustrates the wiring for interspersed master card gangpunching and comparing.

1. Information to be gangpunched is wired from the punch brushes to the punch magnets. This permits each card to pass the punched information to the following card. The punch brushes must be wired to the corresponding punch magnets, column for column.

2. A punch X brush is set to read the column containing the control X, and the corresponding PX brush hub on the control panel is wired to the PX hub. This causes either X punched cards or NX punched cards to be gangpunched, depending upon the setting of the detail-master switch. If master cards contain the control X, the detail-master switch must be set to MASTER. If detail cards are punched with the control X, the detail-master switch must be set to DETAIL. Punching is then controlled by the detail-master switch as follows:

a. When set to MASTER, punching is suspended when X punched master cards are passing under the punch magnets. This prevents a master card from being punched with information contained in the last detail card of the preceding group. All NX detail cards are gangpunched.

b. When set to DETAIL, punching is suspended when NX master cards are passing under the punch magnets. This prevents a master card from being punched from the preceding detail card. All X punched detail cards are gangpunched.

3. In order to compare the gangpunched cards, the comparing brushes are wired to one side of the comparing unit and the reproducing
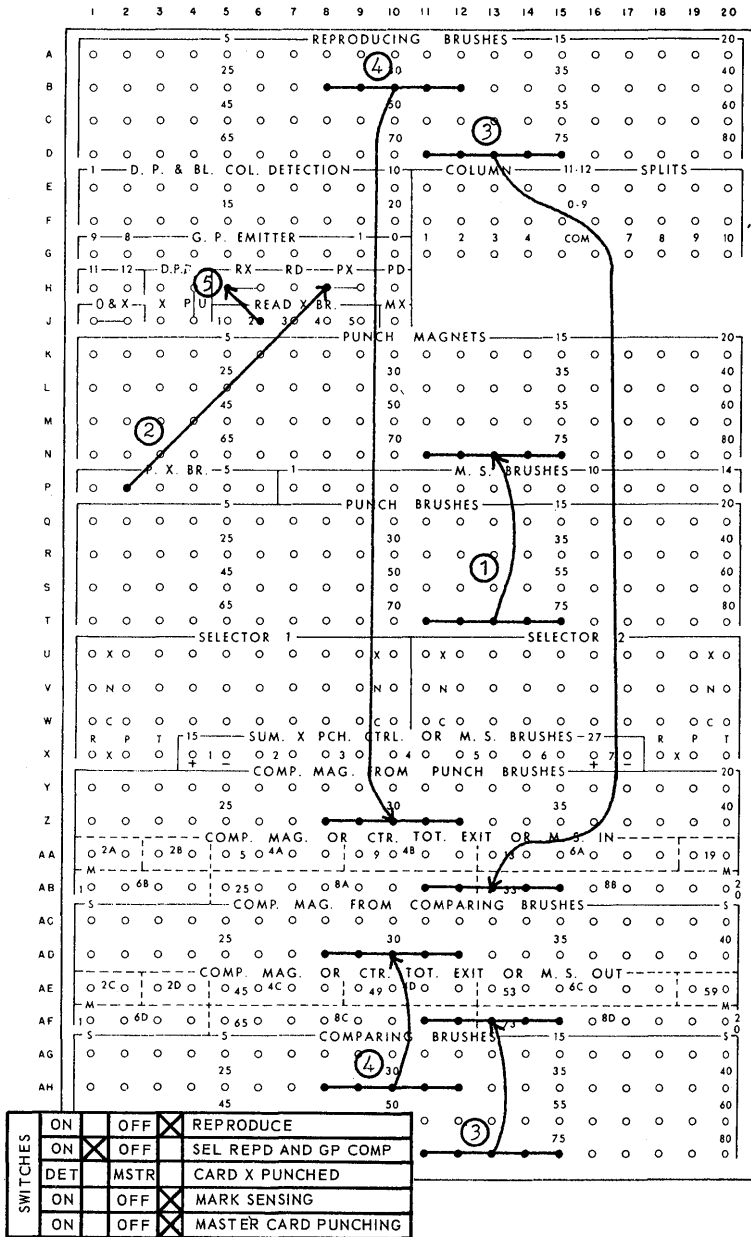
49.42

Figure 6-8.—Interspersed master card gangpunching and comparing.

brushes to the other side. The wiring allows information punched in one card to be compared with the information in the following card. If the punching differs, the machine stops and the comparing indicator points out the comparing position in which the error was detected. Any comparing positions can be used, but the positions which correspond to the columns being punched should be used to provide for ease in locating an error.

4. The control field is wired for comparing to ensure that the appropriate detail cards follow their respective master card. If a master card is missing, or if a detail card has been misfiled or punched with the wrong control data, an error will be signalled.

5. A read X brush is set to read the column containing the control X, and the corresponding read X brush hub is wired to the RX hub. This causes comparing to be performed under the control of the detail-master switch, as follows:

a. If the Control X is punched in the master cards and the detail-master switch is set to MASTER, comparing is suspended when the X punched master cards are passing the reproducing brushes. This prevents a master card from being compared with the last detail card of the preceding group. All NX detail cards are compared.

b. If the control X is punched in the detail cards and the detail-master switch is set to DETAIL, comparing is suspended when the NX master cards are passing the reproducing brushes. This prevents a master card from being compared with the preceding detail card. All X punched detail cards are compared.

Offset Intersperse Gangpunching

In order to differentiate between straight and offset intersperse gangpunching, the origin of impulses must be selected either from punch brushes 25-29 or 35-39 (see fig. 6-9).

Since the punch brushes (for gangpunching) and comparing brushes (for comparing) cannot be deactivated, a device must be available into which impulses from both sets of columns (25-29 and 35-39) are entered, but with the option of selecting either one. This is accomplished by controlling the device with an X punch in either the detail or master card. Required wiring for offset gangpunching and comparing is described in figure 6-9.

1. If the card containing the X is the master card, punch brushes 25-29 are wired to the transferred hubs of selector #1, and the normal hubs

of selector #1 are wired from punch brushes 35-39 for the column to be punched in the detail cards. The column to be punched in the detail cards is wired from the common hubs of selector #1 to punch magnets 35-39.

2. To prevent the master card from being punched from the last detail card of the preceding group, a punch X brush is placed on the proper column to pick up the master X punches. The outlet hub that corresponds to that particular punch X brush is wired to the PX hub.

3. The PD is wired to the P pickup hub of the selector to control the selector when the X punched master is at the punch brushes.

Offset Intersperse Gangpunch Comparing

In order to compare offset intersperse gangpunching, another class selector must be employed (fig. 6-9).

4. The comparing brushes 25-29 for the master card are wired to the transferred hubs of selector #2, and the normal hubs of selector #2 are wired from the comparing brushes corresponding to the columns punched in the detail cards. The common hubs of selector #2 are wired to the comparing magnets to compare with the field punched in the detail cards, as read by the reproducing brushes.

5. To prevent the master card from being compared with the last detail card of the preceding group, a read X brush is placed on the proper column to pick up the master X punches, and the outlet hub that corresponds to that particular read X brush is wired to the RX hub.

6. The RD hub is wired to the R pickup of the selector to control the selector when the X punched master is at the comparing brushes.

If the detail cards have the X control, then the wiring to the transferred and normal hubs of the selector would be reversed.

Summary Punching

For summary punching operations, the reproducing punch must be connected to the accounting machine by a summary punch cable. Cards to be punched are placed in the punching unit. One depression of the start key causes a card to feed past the punch magnets. From then on, feeding is controlled by the accounting machine. When a change occurs in the control for which summary totals are to be punched, the accounting machine stops and the reproducing punch operates for one card cycle. After this
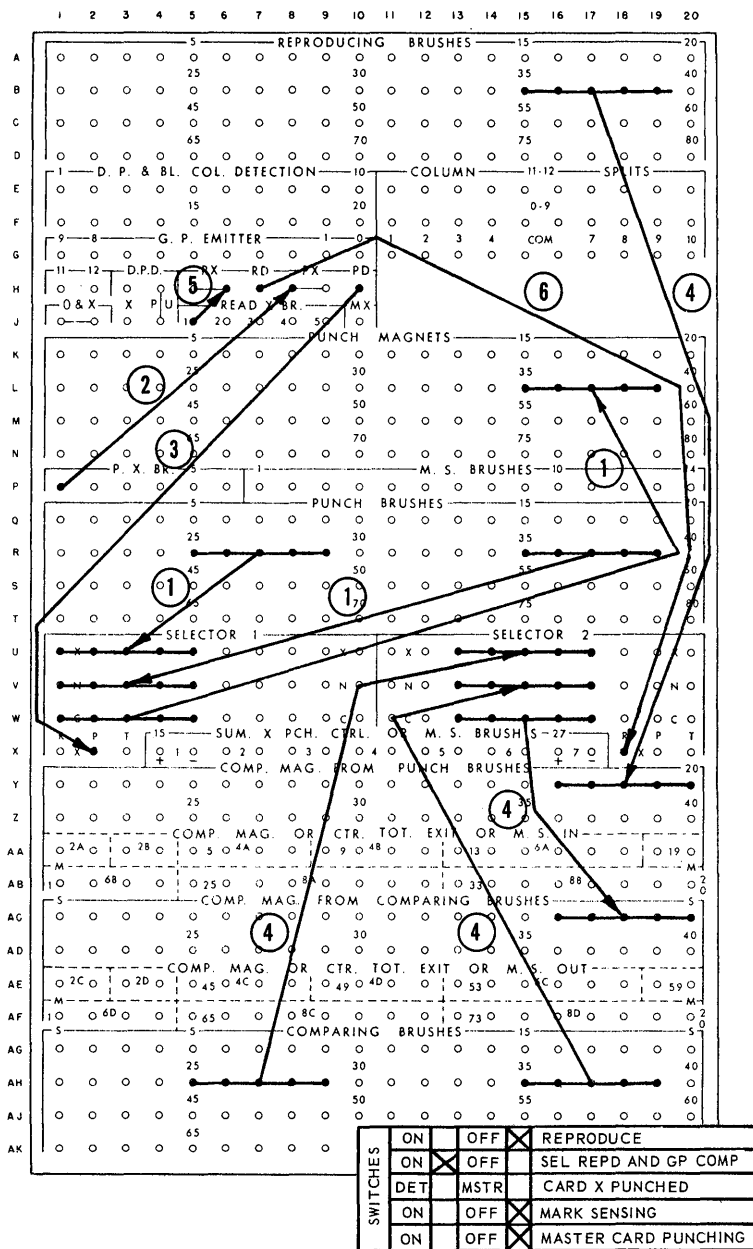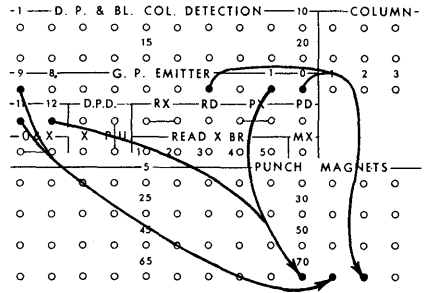
Figure 6-9.—Offset intersperse gangpunch and comparing.

49.259

summary card is punched, the accounting machine continues feeding cards to accumulate totals for the next control group.

When the reproducing punch is connected to the accounting machine for summary punching, the control panel hubs representing entries to both sides of comparing unit positions 41 through 80 become exits for totals which have been accumulated in counters in the accounting machine. These totals can be punched by wiring the appropriate counter total hubs to the punch magnets. Any group of counter total exit hubs may be wired to any punch magnet hubs.

When summary punching, the first card fed from the punching unit is not punched. Thus, it can be a master gangpunch card if summary cards are to be gangpunched.

Emitting

The gangpunch emitter is a special device which may be installed to supply punching impulses identical to those obtained from punches in the card. By reference to figure 6-8, G 1-10 and H 1-2, you will notice a hub for each punching position in a card. Each hub in turn emits an impulse whenever the corresponding punching position of the card is passing under the punch magnets. When wired to the punch magnets as seen in figure 6-10, they cause the particular digits wired to be punched. Since these hubs do not emit when the first card is under the punch magnets, a blank card should be placed in front of the deck. Emitting can be performed in conjunction with other machine operations without affecting the particular operation involved.

Double Punch and Blank Column Detection

The double punch and blank column detection device, although standard on a machine equipped for mark sensing, can be installed on other machines as a special feature. The entrance hubs to this device are located just above the gangpunch emitter hubs. When these hubs are wired from the punch brushes, double punches in any of the columns wired cause the machine to stop. The field which is wired for double punch detection can also be checked for blank columns by turning the corresponding blank column switches ON.

R49.348X

Figure 6-10.—Punching ART using the gangpunch emitter.

Mark Sensing

The mark sensing device is a special feature which may be installed in reproducing punches. The number of positions that may be installed are 27 in the punching unit and 26 in the reading unit. This feature is used to automatically convert pencil marks on a card to punched holes. To make these marks electrically conductive, pencils with special leads containing a high graphite content must be used for marking.

Each mark sense position covers three card columns. Marks placed in these positions are read as they pass the mark sense brushes, located in the punching unit between the punch X brushes and punch magnets, or the mark sense brushes located in the reading unit, between the read X brushes and the reproducing brushes. Because marks are not sufficiently conductive to permit direct operation of the punch magnets, an amplifying unit must be used. When the mark sensing switch is ON, the last 20 comparing positions on the control panel become mark sensing IN and OUT hubs. The mark sensing brushes corresponding to the positions marked are wired to the mark sensing IN hubs, which represent the entrance to the amplifying unit, and the mark sensing OUT hubs are wired to the punch magnets.

The only difference between the mark sensing brushes in the reading unit and those in the punching unit is that, when the brushes in the reading unit are used, the information is punched into cards other than those that are marked. The wiring is the same.

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Verification of mark sensing is performed by wiring the punch brushes representing the columns punched to the double punch and blank column detection hubs.

Figure 6-11 shows a mark sense card used for a military payroll. The data processing installation punches the card with name, service number, and pay group, and forwards it to the disbursing office. The disbursing office marks the amount to be paid and returns the card to data processing. The card is then processed through the automatic punch, where the pencil marks are read by the mark sensing device and converted to punched holes.

The wiring required for mark sense punching is illustrated in figure 6-12.

1. The mark sense brushes representing the columns marked are wired to mark sensing IN.

2. The mark sensing OUT hubs are wired to the punch magnets.

3. The card is checked for double punches or blank columns by wiring the punch brushes representing the punched amount field to the double punch and blank column detection hubs.

The corresponding blank column switches must be turned on in order for blank columns to be checked.

OPERATING SUGGESTIONS

The following suggestions are listed as an aid in obtaining the most efficient operation of reproducing punches.

1. Before beginning any punching operation, the accuracy of control panel wiring and machine setup should be checked. Test cards should be punched to ensure that every part of the operation will be tested thoroughly.

To test a gangpunch operation, the test card must contain information in every column to be gangpunched. The test card should then be placed in front of a few blank cards and fed through the punch unit. The results can be checked visually to see if gangpunching is performed correctly. At least two master cards with a few blank cards behind each should be used to test an interspersed gangpunching operation. All test cards should be processed through both the punching and reading units in order to check the accuracy of punching and verification.
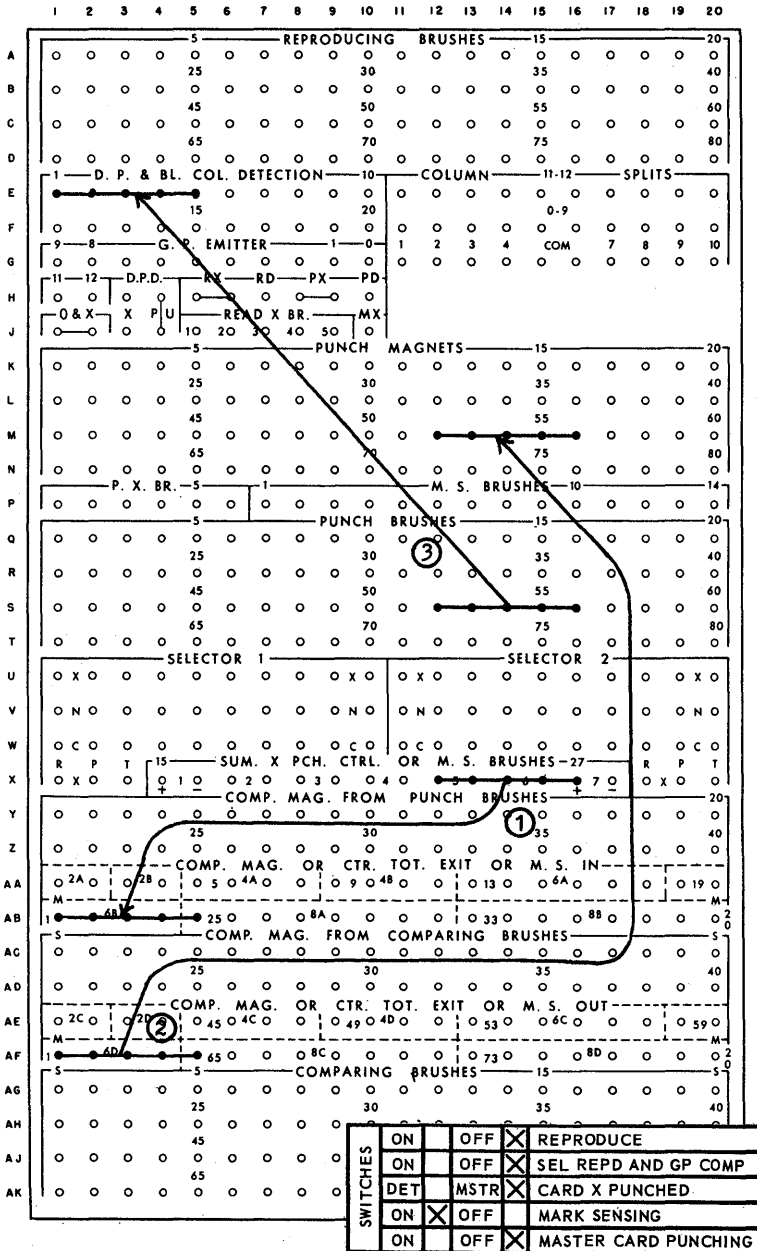

49.43

Figure 6-11.—Sample mark sense cards.

Figure 6-12.—Mark sense punching.

49.44

To test a reproducing operation, the test card should have all 80 columns punched. Reproduce this card and compare it with the new card to see if punching has been performed in the correct columns.

2. When the stackers must be emptied, stop the machine and remove cards from both stackers before resuming the operation. Failure to stop the machine may result in a card jam.

3. Always check the switch settings before starting any operation. If read X or punch X brushes are to be used, check to make sure they are set to read the correct columns.

4. If cards still remain in the punch feed unit when the reproducing operation is finished unload the punch feed hopper. Depress the start key and hold it down for three feed cycles in order to allow all cards remaining in both units to feed into the stackers.

5. The alignment of punching should be checked with a card gage at the start of each job, and periodically during the job.

6. In many instances a card jam will require removal of the brushes. Your supervisor will demonstrate the proper procedure for removing and replacing brushes, and removing the damaged cards. After your supervisor has finished the demonstration, practice this operation several times. The operation must be carefully performed, and can be learned only through personal instruction, repeated practice and experience.

7. Always leave a control panel in the machine, even when the machine is not in use. This will guard against damage to the prongs in the machine.

8. When setting up for a summary punch operation, the main line switches on both the accounting machine and the reproducing punch should be turned off before you connect the summary punch cable to avoid the possibility of your receiving an electrical shock.

9. If the comparing unit signals an error while verifying a gangpunch operation, empty the reading unit stacker and reset the comparing unit. Operate the machine for two feed cycles. Compare the error card, which will be the second card that moves into the reading unit stacker, with the card immediately preceding it.

10. Whenever the comparing indicator signals an error during a reproducing operation, mentally note the error column or columns and reset the comparing unit. Operate the machine for one card feed cycle, and remove cards from both stackers. The top cards removed from the stackers will not agree.

DOCUMENT ORIGINATING MACHINE, TYPE 519

The type 519 document originating machine, similar in appearance to the type 514 reproducing punch, is designed to perform all functions previously described for the type 514. In addition, a print unit provides for printing as many as eight digits across the end of a card as it passes through the punch unit. If the information is printed from punches in the same card, it is referred to as INTERPRETING. If printed from a card in the read unit, it is called TRANSCRIBING.

Notice in figure 6-13 that the paths of cards through the reading and punching units are the same as for the type 514. The only difference is in the terminology associated with some of the brushes, an additional read X brush, and addition of the print unit.

PRINCIPLES OF CONTROL PANEL WIRING

All operations of the type 519 machine are directed by control panel wiring. Machine controls are located on the left side of the control panel, while the remainder of the panel is used for position wiring.

Reproducing

The reading and punching units work together when performing a reproducing operation. In order to synchronize these two units, the reproducing switch (REP) located in the top left corner of the control panel must be wired ON. This switch may be disregarded or wired OFF for all other operations.

There are three separate entries to the punch magnets; punch normal, punch direct, and punch transfer. The punch normal hubs are active except when the punch direct switch or punch transfer pickup is impulsed. The punch direct hubs are active unless punching is suspended by the punch direct switch. The punch

135
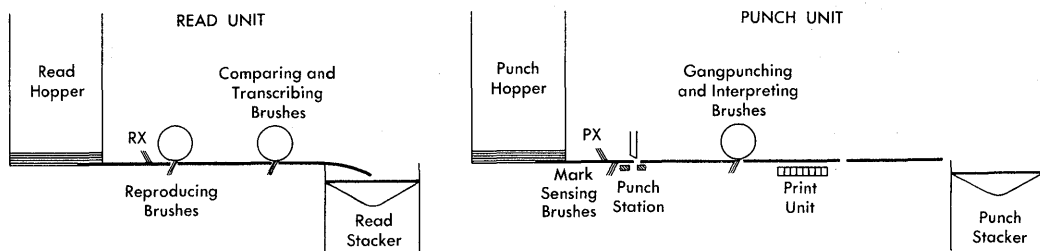
R49.45X

Figure 6-13.—Card feed schematic diagram.

transfer hubs are not active until the punch transfer (PTFR) pickup hub is impulsed. When the punch direct pickup hub is impulsed, all punching can be suspended for a particular type of card. When the punch transfer pickup hub is impulsed, the entries to the punch magnets operate like a selector, as illustrated in figure 6-14. The particular punch entry used depends upon the job being performed, as you will see in the following examples.

Figure 6-15 illustrates the wiring necessary for normal reproducing and comparing of all cards.

1. The reproducing switch is wired ON in order to cause both feed units to operate together.

2. The reproducing brushes are wired to punch direct. All cards will be reproduced, since no control punch is used to impulse the punch direct pickup hub. Punch normal could be used just as well.

3. The comparing brushes read the source card and send the readings to one side of the comparing unit.

4. The gangpunching brushes read the reproduced card, and send the readings to the other side of the comparing unit. When an error in punching is detected by the comparing unit, the machine stops, the comparing light comes on, and the comparing indicator points out the comparing position containing the error. The comparing unit can be restored by lifting the lever at the left of the unit.

Punching can be controlled so that only one type of card, X or NX, will be reproduced. Figure 6-16 illustrates the punch transfer method for selective reproducing and comparing.

1. The reproducing switch is wired ON.

2. In order to identify the X cards, a read X brush is set to read the column containing the X punch, and the corresponding RX brush hub on the control panel is wired to the punch transfer pickup hub.

3. The reproducing brushes are wired to punch transfer. When an X punched card is read, the punch transfer hubs are activated, thus allowing X punched cards to be reproduced. If NX cards were to be reproduced, the reproducing brushes would be wired to punch normal in place of punch transfer. The punch direct hubs cannot be used in this operation, since they would provide a constant path to the punch magnets.

4. Comparing takes place on the following card cycle. The RX brush is wired through the common punch transfer pickup hub to the read delay entry hub. This causes an impulse to become available from the read delay exit hub one cycle later, just before the X card reaches the comparing brushes. The read delay exit impulse is then wired to the comparing switch pickup hub to control comparing of X or NX cards. If the X hubs in the comparing switch are jackplugged, comparing is effective for X cards only. If the pickup alone is wired, or if the pickup is wired and the N hubs are jackplugged, comparing would be effective for NX cards only.
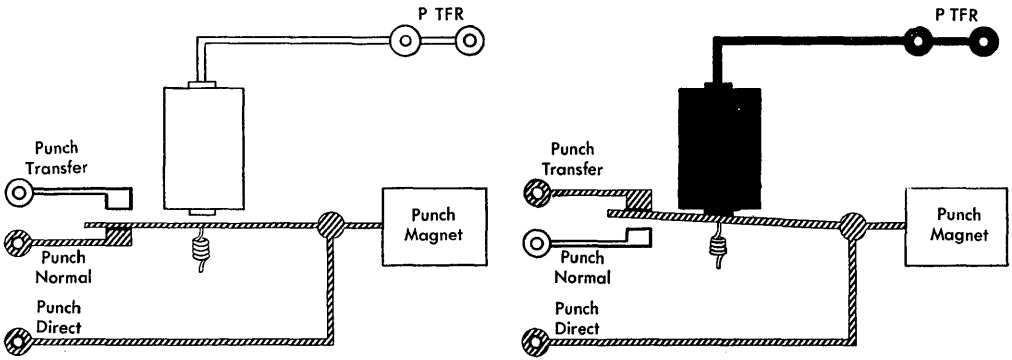
R49.46X

Figure 6-14.—Operation of the punch transfer feature.

49.47
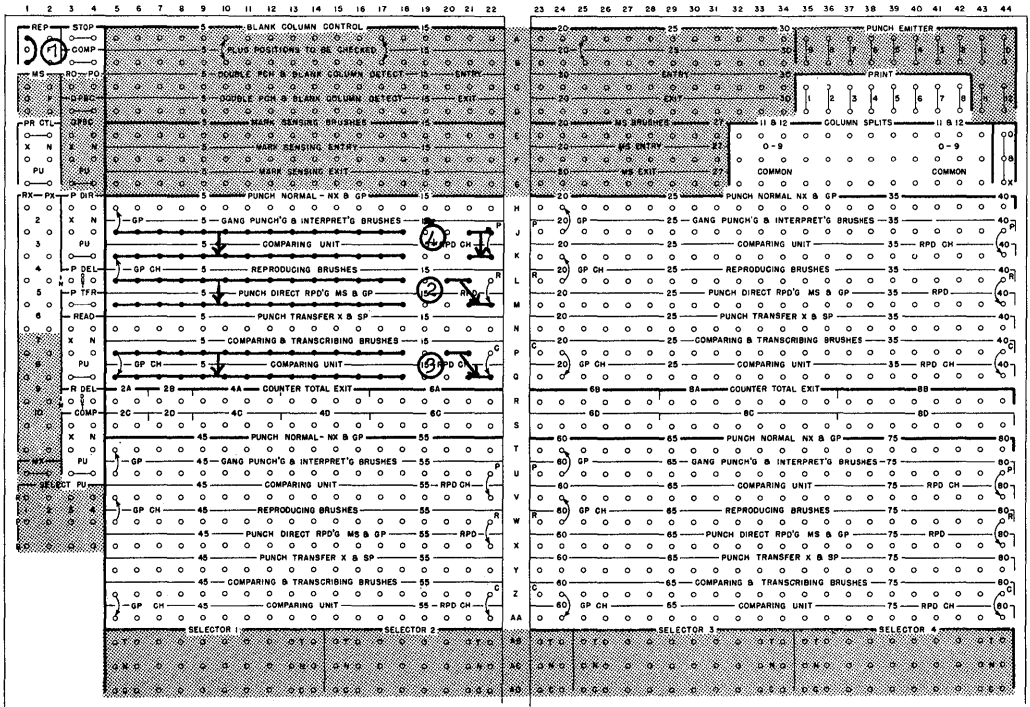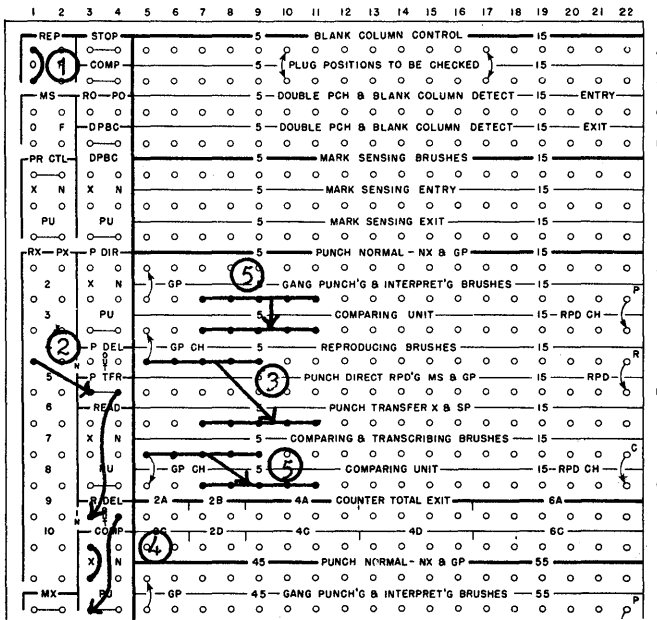
Figure 6-15.—Normal reproducing and comparing.

49.48

Figure 6-16.—Selective reproducing and comparing.

5. The comparing unit is wired the same as for normal reproducing.

Another method of selective reproducing would be to wire the reproducing brushes to punch direct, and wire the RX hub to the punch direct pickup hub. Then, if X cards were to be reproduced, the X hubs would be jackplugged, and punching would be suspended for NX cards. If NX cards were to be reproduced, the N hubs would be jackplugged and punching would be suspended for X cards. Comparing would be controlled in the same manner as shown in figure 6-15.

Gangpunching

Gangpunching from a single master card may be performed by wiring the gangpunching brushes to either punch normal or punch direct, since either entry provides a path to the punch magnets if no punch entry pickup has been impulsed. Interspersed gangpunching can be accomplished by either of two methods; punch direct or punch transfer.

The punch direct method causes suspension of all punching when the X or NX cards are under the punch magnets, depending upon whether the X control punch is in the master or detail cards. The gangpunched field cannot be wired to end print or to double punch and blank column detection when this method is used.

The punch transfer method uses an internal selector system for gangpunching. The punch normal hubs are considered to be the normal side of the selector, and the punch transfer hubs the transferred side. Thus, when the punch transfer pickup hub receives an impulse, the punch transfer hubs become active, and provide a path to the punch magnets. At all other times, entrance to the punch magnets is provided through punch normal. This method must be used when the gangpunched field is also wired to some other entry, such as end print or double punch and blank column detection.

Comparing is performed in the same manner for both methods. When an X punched card is recognized, comparing is either effective or
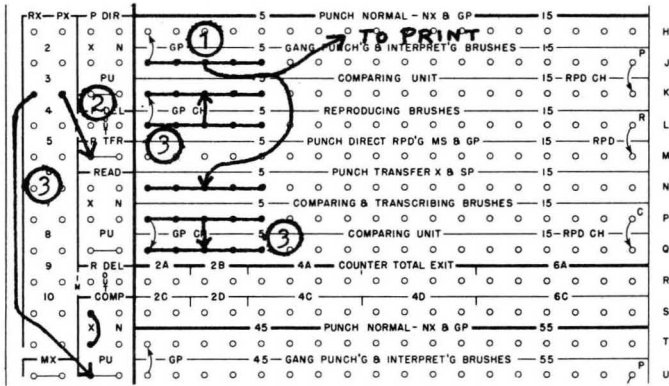
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suspended, depending upon the type of card which contains the control X.

In figure 6-17 the punch direct method of interspersed gangpunching is used to punch X detail cards.

1. The gangpunching brushes are wired to punch direct. Punch normal could be used just as well.

2. A PX brush is set to read the control X punched in the detail cards, and the corresponding PX brush hub is wired to the punch direct pickup hub.

3. Because the X detail cards are to be punched, the punch direct X hubs are jack-plugged. This causes punching to be suspended whenever NX master cards are under the punch magnets. If the master cards contain the control X punch, the punch direct N hubs would be jack-plugged or left unwired to cause punching to be suspended for X master cards.

4. Comparing is performed by wiring the reproducing brushes to one side of the comparing unit and the comparing brushes to the other side.

5. An RX brush is set to read the control X punched in the detail cards, and the corresponding RX brush hub is wired to the comparing switch pickup hub.

6. Since comparing is to be suspended whenever NX master cards are under the reproducing brushes, the comparing switch X hub is jack-plugged. If the master cards contain the control X, the comparing switch N hubs would be jack-plugged or left unwired.

The wiring for interspersed gangpunching using the punch transfer method is illustrated in figure 6-18. X punched detail cards are to be punched and all cards are to be end printed.

1. The gangpunching brushes are wired to both punch transfer and the print hubs. If master cards were to contain the control X, punch normal would be wired in place of punch transfer.

2. The PX hub is wired to the punch transfer pickup hub. This causes the field which is to be gangpunched to reach the punch magnets through the punch transfer hubs when X punched detail cards are sensed by the PX brush.

49.49

Figure 6-17.—Interspersed gangpunching, punch direct.

49.50

Figure 6-18.—Interspersed gangpunching, punch transfer.

3. Comparing is controlled in the same manner as previously described for the punch direct method.

End Printing

The end print unit shown in figure 6-19 consists of eight print wheels, each capable of printing all digits 0-9, and a blank position. Thus, a maximum of eight digits can be printed across the column-1 end of a card passing through the punch unit. Figure 6-20 illustrates an end printed card. Information can be printed on either of two lines from punches in the same card (interpreting), from an emitter, or from a card in the read unit (transcribing). Printing on two lines of the card requires two passes of the card through the machine.

Three notches in the rail on which the unit slides (fig. 6-19) determines the line selected. Latching the printing unit in the middle notch causes printing on the first line; the notch farthest from the operator causes printing on the second line, and the notch nearest the operator disengages the unit. The print unit should be disengaged when not in use, to prevent unnecessary wear on the moving parts.

The print unit can be wired to print every card or can be controlled to print only X-cards or only NX-cards during reproducing, gangpunching, or combined operations. The wiring shown in figure 6-21 combines the operation of reproducing, gangpunching from a single master card, and selective end printing.

DEPT.   NUMBER

34-09872

WEEK ENDING

6 23

MONTH   DAY   YEAR

DISTRIBUTION

ACCOUNT NUMBERS

	TOTAL					
ST.	HRS.					
	ST.					
OVERTIME	HRS.					
	OT					
	OA					
	TOTAL					
GR	TOTAL					

	MORNING		AFTERNOON		LOST OR OVERTIME		TOTAL
	IN	OUT	IN	OUT	IN	OUT	
MON. DAY							
TUE.							
WED.							
THU.							
FRI.							
SAT.							
SUN.							

THE ABOVE KEY ENTRIES AND TIME STAMPS ARE APPROVED

DEPT. HEAD

TOTAL

R49.347X

Figure 6-20.—End printed card.

1. The reproducing switch is wired ON since both units must work together when reproducing.

2. Columns 1 through 19 are wired for normal reproducing and comparing.

3. Columns 21 through 24 are wired for reproducing, comparing, and end printing from the card in the reading unit.

4. Columns 34 through 37, are wired for gangpunching and end printing from the cards in the punching unit.

5. An RX brush is set to read the control X in the source cards, and the corresponding RX hub is wired to the print control pickup hub.

6. The print control X hubs are jackplugged, thus causing the print unit to operate only when X punched cards are sensed in the reading unit. If the N hubs were jackplugged in place of the X hubs, printing would occur only when NX cards were fed in the reading unit. If the pickup hubs are wired and neither the X nor N hubs are jackplugged, no cards will be printed. If all cards were to be printed, the pickup hubs would be left unwired and the N hubs jackplugged. Leaving the N hubs unplugged would result in failure of the print unit to operate.

Summary Punching

When the summary punch cable is connected to the accounting machine, totals accumulated in counters of the accounting machine can be punched into summary cards. The punch transfer hubs are made receptive automatically when a summary punch cycle occurs. These are the only entrance hubs to the punch magnets that can be used for summary punching.

When the type 519 is connected for summary punching to any accounting machine other than the type 407, the counter total exit hubs in the 519 are internally connected to the corresponding counters in the accounting machine. This requires wiring the counter total exit hubs representing the counters used for accumulation to the appropriate punch transfer hubs. Punching can be performed in any columns desired.

When the type 519 is used with the 407 accounting machine, the counter total exit hubs are internally connected to the 80 summary punch entry hubs in the 407. The punching positions are controlled by wiring the counter punch exits in the accounting machine to the proper summary punch entry hubs. The only wiring necessary on the 519 control panel is from the 80 counter total exit hubs to the 80 punch transfer entry hubs, column for column.
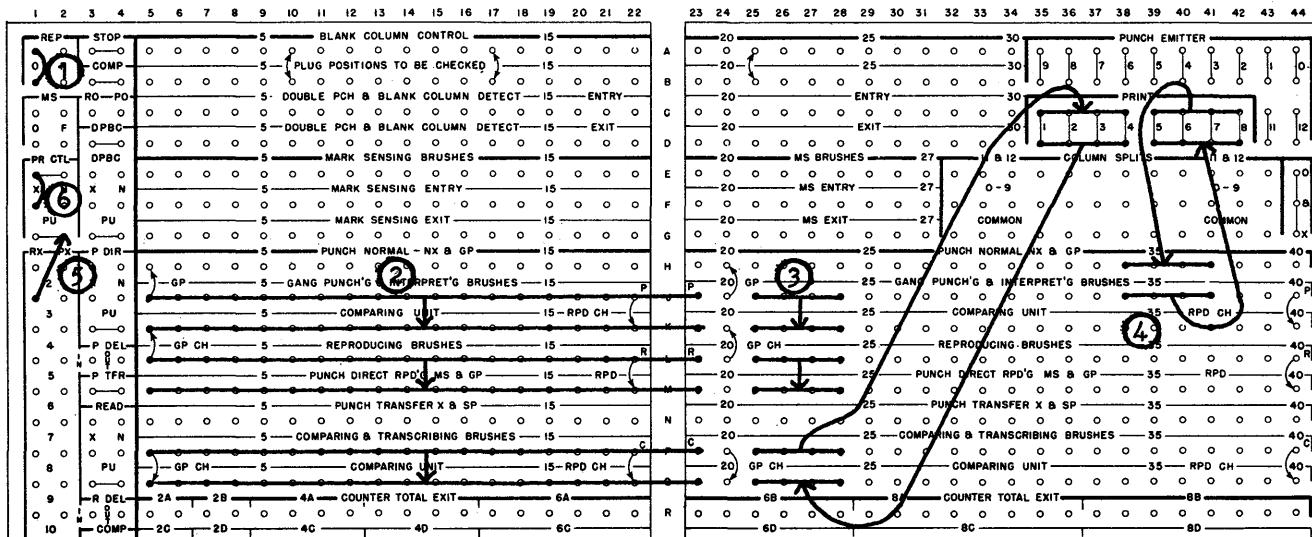
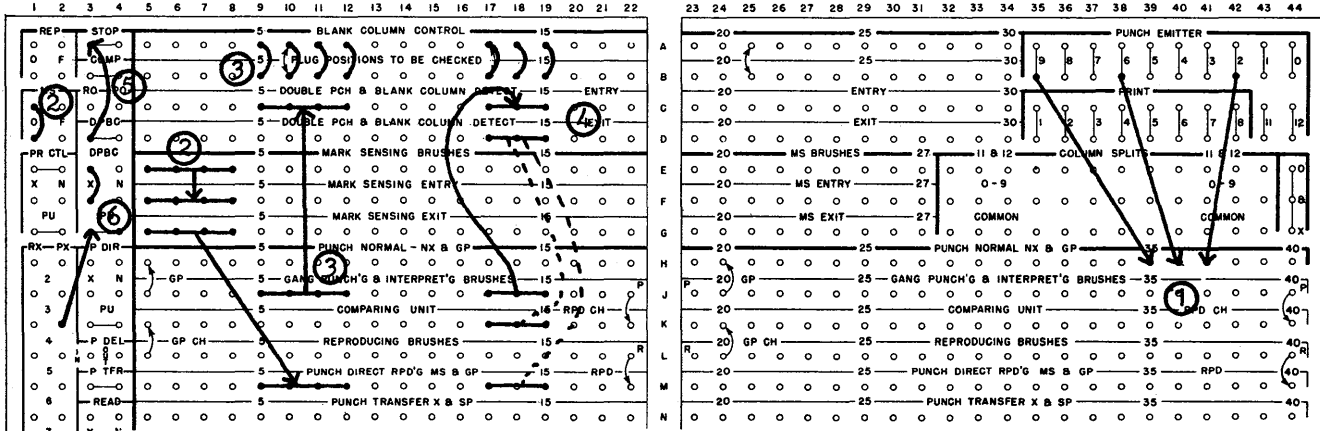Figure 6-21.—End printing.

49.51

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49.52

Figure 6-22.—Special devices.

Special Devices

The type 519 can be equipped with additional features to perform other operations not previously described. Figure 6-22 presents the basic wiring principles involved in wiring for emitting, mark sensing, and double punch and blank column detection.

1. The emitter is wired to punch normal for punching information common to all cards.

2. Mark sensing can be accomplished by wiring the mark sensing brushes to mark sensing entry, and from mark sensing exit to punch direct. The mark sensing switch must be wired ON.

3. The accuracy of mark sense punching can be verified by wiring the gangpunching brushes representing the columns mark sense punched to the double punch and blank column detect entry hubs. The corresponding blank column control hubs must be jackplugged if blank columns are to be checked.

4. Double punch and blank column detection can be performed as a separate operation during reproducing, gangpunching, or summary punching. Tor any of these operations, the gangpunching brushes can be wired to double punch and blank column detect entry, and the corresponding blank column control hubs jackplugged. If reproducing is being accomplished, the double punch and blank column detect exit hubs are wired to the comparing unit. If gangpunching is being performed, these exit hubs are wired to the punch magnets. When summary punching, or when checking double punches and blank columns as a separate operation, the double punch and blank column exit hubs are left unwired.

5. Whenever a double punch or blank column is detected, the DPBC hubs emit an impulse. Wiring this impulse to the STOP hub causes the machine to stop, and turns on the DPBC detection light. Depressing the reset key causes the light to go off and the detection circuits to be restored.

6. Double punch and blank column detection can be controlled so that only certain cards are checked. For example, if only X cards are to be checked, a PX or RX brush is wired to the DPBC pickup hub and the X hubs are jackplugged. If the X hubs were not wired, NX cards only would be checked.

OPERATING SUGGESTIONS

The first nine suggestions listed under the type 514 reproducing punch apply equally to the type 519. Suggestion number 10 must be modified to allow for the extra printing station in the punch unit of the type 519. The machine must be operated for two feed cycles after the comparing unit has been reset before removing cards from the stackers. The top card from the punch stacker and the next-to-stop card from the read stacker will not agree.

CHAPTER 7

COLLATORS

We know that one of the basic requirements for preparing any type of report from punched cards is to have the cards in some kind of sequence. We also know that the original card arrangement is performed on the sorter. Now suppose you wish to combine two files of cards already in sequence to prepare a report. One method would be to place both files together and sort them again as one file. This method would work, provided you had the time to do it, and further provided that all cards in both files are to be used in the report. But suppose you wish to use only those cards from one file that contain the same control numbers as the cards in the other file. Now you have a problem that the sorter cannot solve. What you need is a machine that will merge the two files of cards without disturbing their original sequence, and at the same time, will select the cards you do not wish to use. The collator is designed to do just this sort of job, along with various other functions as explained later.

The principal job of the collator is to feed and compare two files of cards simultaneously in order to match them or combine them into one file. At the same time, cards in each file that do not have a matching card in the other file can be selected automatically. Two hoppers and feed units are provided for feeding two files of cards, along with four or five pockets, depending upon the type, for stacking the cards. All operations are performed as directed by control panel wiring.

Operations which can be performed on the collator fall into five general categories as follows:

1. CHECKING SEQUENCE. After a file of cards has been sorted into the desired sequence, it can be checked on the collator to see if the cards are in proper order. The collator performs this job by comparing each card with the one ahead of it. If any cards are found to be out of sequence, the machine can be directed by control panel wiring to stop and turn on the error light, or select the cards that are out of sequence.

2. MERGING. This is the operation in which two files of cards already in sequence are combined into one file. Feeding from each feed unit is controlled by comparing the cards from one feed with the cards from the other, so that the combined file will be in proper sequence.

3. MERGING WITH SELECTION. The operation of merging two files into one can be controlled so that if either file contains cards that do not match cards in the other, these cards can be selected. Then, at the end of a merging operation, you may have three groups of cards; one group of merged cards and two groups of selected cards.

4. MATCHING. Suppose that instead of merging two files of cards, you want only to see if the cards in one file match those in the other. Cards in either file that do not match the other can be selected, as well as stacking the cards that do match in two groups. When the operation is completed, you may have four groups of cards; two groups of matched and two groups of unmatched.

5. CARD SELECTION. Particular types of cards can be selected from a file without disturbing the sequence of the others. The type selected may be an X or NX card, the first card of a group, the last card of a group, a single-card group, a zero balance card, a card with a particular number, or cards with numbers between two control numbers. Single cards or groups of cards out of sequence can be selected also. The type of card or cards selected depends upon the operation being performed, and control panel wiring. Collators can be classified in two general

groups; numerical and alphabetic. Numerical collators, such as the IBM types 77, 85, and 88, can process numerical data only, unless a special alphabetic collating device is installed; whereas alphabetic collators, such as the IBM types 87, and 188, can process either numerical or alphabetic data. The types 77, 85, and 87 collators are designed along the same lines, both in operation and control panel wiring. Therefore, an understanding of the collating principles involved for the type 85 as presented

in this chapter should enable you to adapt your knowledge to the types 77 and 87 if you should be required to operate either of those machines. Since the types 88 and 188 collators differ considerably from the previous generations, they will be discussed separately.

COLLATOR, TYPE 85

The type 85 collator (fig. 7-1), is designed to perform all the functions previously mentioned.

MACHINE CONTROLS

SECONDARY FEED HOPPER

PRIMARY FEED HOPPER

MAIN–LINE SWITCH

STACKERS

CONTROL PANEL
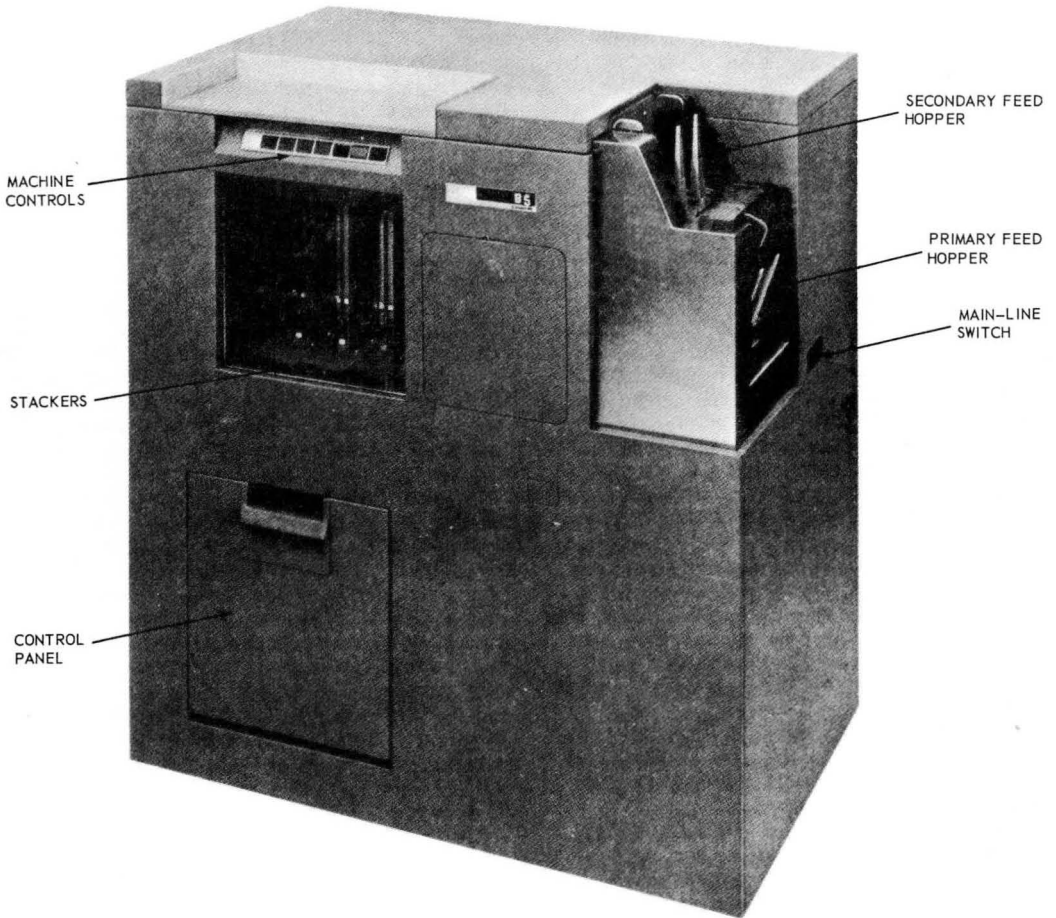
R49.53.1X

Figure 7-1.—IBM type 85 collator.

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In addition, it has the capacity for checking blank columns in cards fed from either hopper. Blank column detection can be performed separately or can be combined with any of the other operations.

OPERATING FEATURES

The MAIN LINE SWITCH, located on the right side of the machine, controls the power supply, and must be ON for all machine operations. The operating keys and lights, located above the stackers, are illustrated in figure 7-2.

Depression of the START KEY starts card feeding, while the STOP KEY is used to stop card feeding. When the last card has been fed from either hopper, the machine stops. The RUNOUT KEY must then be held down until the cards from the depleted hopper, remaining in the machine, have been moved into the stackers. Whenever the machine stops because of an error or blank column detection, the RESET KEY must be depressed before the operation can be resumed.

The READY LIGHT signals that the machine is ready to be operated. This light goes off when cards are passing through the machine, or when the main line switch is turned off. The ERROR LIGHT comes on when an error condition is recognized by the machine through control panel wiring, such as a card out of sequence. The BCD 1 LIGHT comes on whenever a blank column is detected in a field wired to blank column detection entry 1. The BCD 2 LIGHT comes on if the blank column is detected in a field wired to blank column detection entry 2.

Card Feed Units

The two feed units in the collator are called the PRIMARY FEED and the SECONDARY FEED. Cards placed in the primary feed are referred to as primary cards, and those placed in the secondary feed are called secondary cards. Cards are placed in the hoppers face down, with the 9 edge toward the throat. Either feed unit can feed cards at the rate of 240 cards per minute. When using both feeds, the number of cards fed per minute will range between 240 and 480, depending upon control panel wiring, and the job being performed.

As cards feed from the primary feed hopper, they pass the sequence reading station and then the primary reading station. Each station consists of 80 reading brushes, which completely reads the cards one row at a time. Cards fed from the secondary feed hopper pass the secondary reading station, consisting of 80 reading brushes.

Pockets

After cards are read by the brushes, they are directed to one of four pockets, or stackers, by control panel wiring. From right to left, these pockets are known as pocket 1, pocket 2, pocket 3, and pocket 4. Cards fed from either hopper will always stack in pocket 2 unless directed to one of the other pockets by control panel wiring. Primary cards can be selected into pocket 1, and secondary cards can be selected into pockets 3 and 4. Under no circumstances can primary cards be selected into pockets 3 and 4, nor secondary cards into pocket 1.
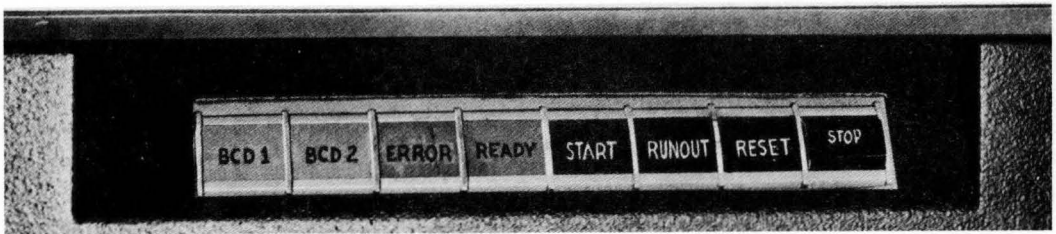

R49.53.1X

Figure 7-2.—Machine Controls.

PRINCIPLES OF OPERATION

Most collating operations require that two numbers be compared. For example, when checking sequence, the number in one card must be compared with the number in the preceding card to see if the cards are in the proper order. When merging, the number in a card in one feed unit must be compared with a number in a card in the other feed unit to see which card is to be fed first. When one card is compared with another, one of three possible conditions may exist; it may be lower, equal to, or higher than the other card. Card feeding and selection can be controlled by proper control panel wiring when either of these conditions occurs.

All collators are designed so that the master cards feed first during a merging operation. For this reason the master file is placed in the primary feed hopper unless it is specifically desired to put all detail cards ahead of the master cards. If this is the case then the detail file is placed in the primary.

Schematic Diagram

Refer to figure 7-3. This gives you a look inside the machine, to see how card feeding and brush reading occur. Notice that the primary cards pass two sets of brushes, while the secondary cards pass only one set. The readings from the two sets of brushes in the primary feed unit can be compared with each other, or with readings from the secondary brushes. Since the secondary feed unit contains only one set of brushes, readings from the secondary brushes can normally be used only for comparing with readings from primary brushes.

Comparing is performed in either or both of two comparing units; the sequence unit and the selector unit. Each unit has two sides or entrances, and consists of 16 comparing positions. The sequence unit is normally used for checking sequence by comparing the readings from the two sets of brushes in the primary feed unit, while the selector unit is used for merging or matching by comparing a card in the secondary feed unit with one in the primary feed unit. However, both comparing units operate in the same manner, and may be used interchangeably if desired.

Control Panel Hubs

Figure 7-4 represents the entire control panel. The hubs on the left side of the panel are used for position wiring, while the hubs on the right side are used for control. A basic understanding of the standard hubs will help you to understand the principles involved in wiring the control panel for a particular application. Refer to figure 7-4 and locate the particular hubs as they are described.
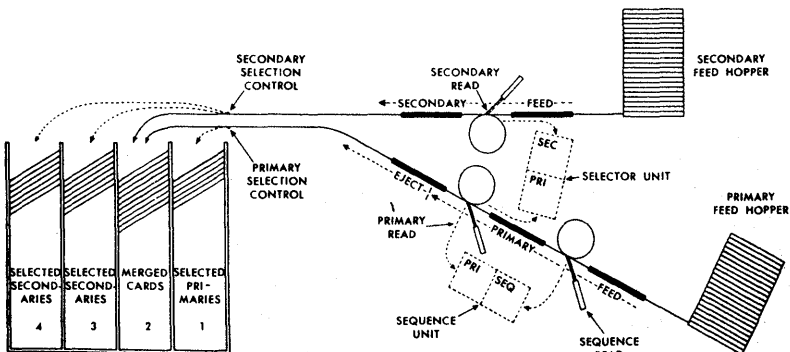

R49.55X

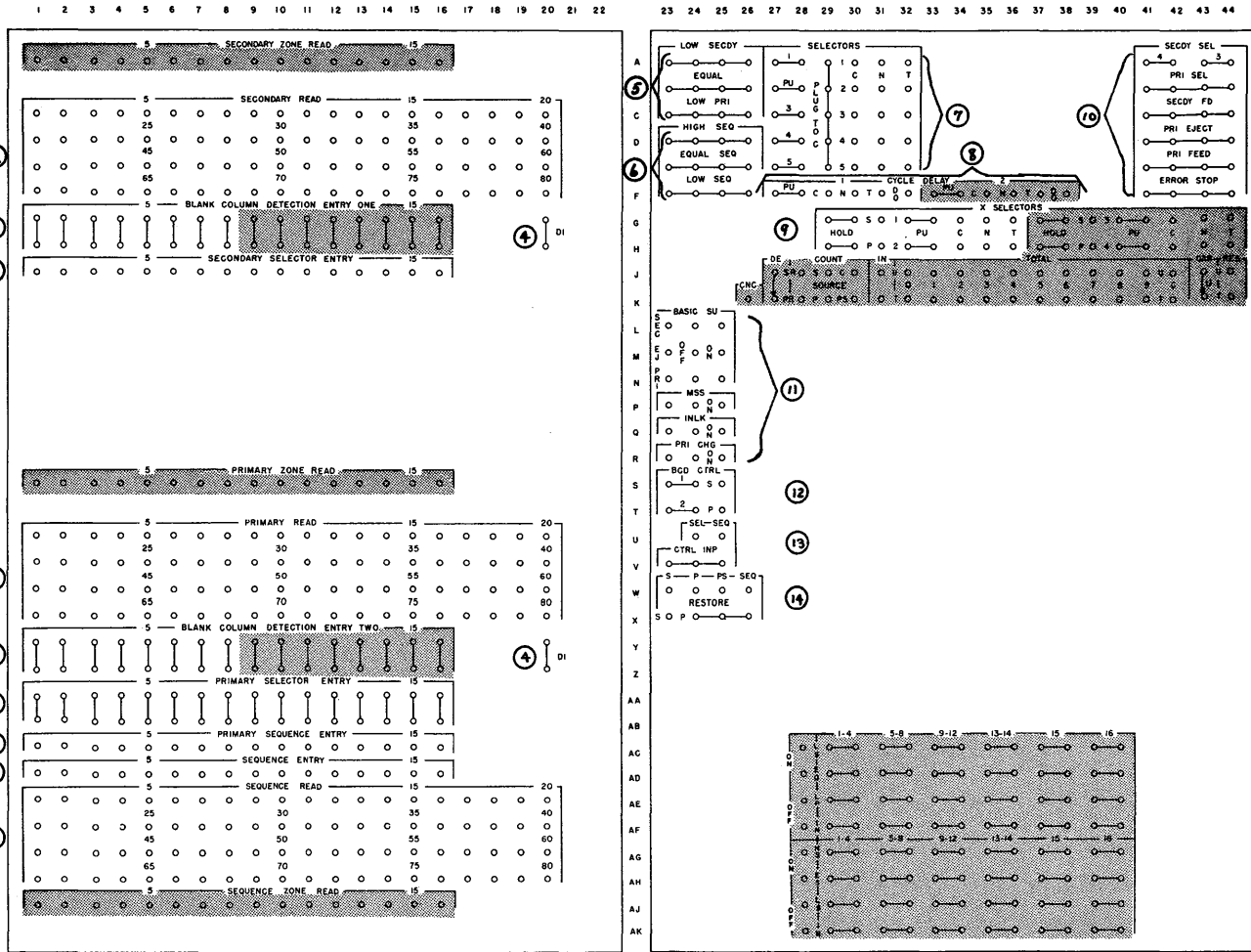Figure 7-3.—Card Feed Schematic Diagram.

Figure 7-4.—Type 85 control panel.

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R49.56X

1. READ. These three sets of hubs represent outlets from the corresponding set of reading brushes.

2. COMPARING ENTRIES. These hubs provide entrance to the comparing units, and are normally wired from the read hubs. The selector unit compares two numbers by wiring one number to secondary selector entry and the other number to the corresponding positions of primary selector entry. The sequence unit compares two numbers by wiring one number to primary sequence entry and the other number to the corresponding positions of sequence entry.

3. BLANK COLUMN DETECTION. Flexibility is provided in the blank column detection units to allow for checking up to eight blank columns from each feed during the same operation, or up to 16 columns when checking cards from one feed only. Operation of these units is controlled by the way the BCD control hubs are wired.

4. DIRECT IMPULSE. The DI hubs emit an impulse each machine cycle, which corresponds essentially to a 2-punch in a card. A direct impulse must be wired to unused blank column detection entry hubs when checking for blank columns in order to deactivate these unused hubs and prevent false blank column indication.

5. SELECTOR UNIT CONTROL EXITS. These hubs emit impulses whenever a high, low, or equal condition exists in the selector unit. If the secondary reading is lower than the primary, LOW SECONDARY emits an impulse. If the primary reading is lower than the secondary, LOW PRIMARY emits an impulse. If both readings are the same, EQUAL emits an impulse. They are normally wired to the functional entry hubs or to selector pickup hubs to control card feeding and selection.

6. SEQUENCE UNIT CONTROL EXITS. These hubs emit impulses resulting from a high, low, or equal comparison in the sequence unit. If the sequence reading is higher than the primary reading, HIGH SEQUENCE emits an impulse. If the sequence reading is lower than the primary reading, LOW SEQUENCE emits an impulse. If both readings are the same, EQUAL SEQUENCE emits an impulse. The high sequence and equal sequence exits are normally wired to the functional entry hubs or to selector pickup hubs to control card feeding and selection. Low sequence exit is usually wired to ERROR STOP to cause card feeding to stop and the error light to turn on when a step-down in sequence is detected.

7. SELECTORS. Card feeding and selection can be controlled by proper wiring of the selectors. The pickup hubs are normally wired from the control exit hubs. They cannot be wired from a reading station. Five common PLUG TO C hubs, located immediately to the right of the selector pickup hubs, emit an impulse each card feed cycle. They are normally wired to functional entry hubs, either directly or through the normal or transferred sides of the selectors to the functional entry hubs, to cause card feeding or selection as required. A selector will transfer immediately when the pickup hub receives an impulse, and will return to normal at the end of the controlling impulse.

8. CYCLE DELAY. This unit operates in a manner similar to the selectors, but with two notable exceptions. First, the cycle delay unit does not transfer until the cycle following that on which the pickup impulse is received. Second, once the cycle delay unit is transferred, it remains transferred until an impulse is received by the DROPOUT (DO) hub. When DO is impulsed, the unit returns to normal for the following card cycle, unless another pickup impulse is received.

9. X SELECTORS. Feeding and selection of X or NX cards can be controlled through the use of X selectors. Either selector may be controlled to operate with either the primary or secondary feed by wiring the selector HOLD hub from either P (primary) or S (secondary). The P hub emits an impulse when cards are fed from the primary feed, and the S hub emits an impulse whenever secondary cards are fed. The pickup hubs may be wired from primary read when X or NX primary cards are to be selected, or from secondary read when the selection of X or NX secondary cards is desired. A plug to C, wired through the selectors to the functional entry hubs, causes feeding or selection of the desired type of cards.

10. FUNCTIONAL ENTRIES. These hubs accept impulses to control feeding and selection of cards. They are usually wired from control exits or plug to C. Each hub, when impulsed, will cause the following to occur; SECONDARY SELECT 4 directs a secondary card to pocket 4, while SECONDARY SELECT 3 directs a secondary card to feed or select into pocket 3. If both 4 and 3 are impulsed at the same time, pocket 4 will take precedence over pocket 3. PRIMARY SELECT directs a primary card

o pocket 1. SECONDARY FEED causes a card to be fed from the secondary feed hopper. PRIMARY EJECT causes a card to move from the eject station in the primary feed unit without causing a primary feed cycle. PRIMARY FEED causes a primary card to be fed from the primary feed hopper. ERROR STOP causes card feeding to stop and the error light to turn on. It is normally wired from low sequence. A plug to C impulse must NEVER be wired to error stop, since this would result in a card jam without stopping card feeding.

11. BASIC SETUP SWITCHES. It is possible to control card feeding for most operations by using the basic setup switches in place of wiring the control exits and functional entries. However, you should first have a complete understanding of how functional wiring is accomplished in order to fully realize the relationship between these switches and functional wiring, and the role that each switch plays in performing a given operation. Therefore, a detailed discussion of the basic setup switches is reserved for later in this chapter.

12. BLANK COLUMN DETECTION CONTROL. These hubs control the use of the blank column detection units. Each unit may be controlled to operate with either the primary or secondary feed by wiring the control entry hub from P (primary) or S (secondary). Primary card feeding causes the P hub to emit an impulse, while the S hub emits an impulse during a secondary card feed cycle.

13. CONTROL INPUTS These hubs allow test impulses to enter the comparing units for the purpose of determining whether a low, equal, or high condition exists. The hubs labeled CTRL INP are exits which emit impulses every card feed cycle. They are normally wired to SEQ (sequence) and SEL (selector) to test comparisons in the sequence and selector units.

A control input hub wired to SEL allows an impulse to travel internally through the selector unit, where it tests the comparing positions wired. This impulse then becomes available from one of the selector control exits, depending upon the condition found in the selector unit.

A control input hub wired to SEQ allows an impulse to test the sequence unit in the same manner as the selector unit is tested. This impulse is then available from one of the sequence control exits, depending upon the condition found in the sequence unit.

The test impulse in each unit travels from left to right, so that the high order position of the control field is tested first, and continues toward the units position until an unequal condition is found, or in the case of an equal condition, until the last position in the unit is reached

In multi-field operations, (major, intermediate, minor) the major field should be wired to the leftmost position of the comparing entries, then the intermediate, then minor.

14. RESTORE. The sides of comparing units wired from brushes in the primary feed unit are usually cleared each primary card feed cycle to allow new readings to enter from the next primary card. Likewise, sides of comparing units wired from the secondary feed brushes are usually cleared each secondary card feed cycle to allow new readings to enter from the next secondary card. The single hub in the lower row labeled S emits an impulse every secondary card feed cycle, and is normally wired to the restore S hub directly above it to cause the secondary side of the selector unit to clear, or restore, each time a secondary card is fed. Each of the three common P hubs in the lower row emits an impulse each time a primary card is fed. These hubs usually are wired to the restore hubs directly above to cause both sides of the sequence unit (PS and SEQ) and the primary side of the selector unit (P) to restore on each primary card feed cycle.

PRINCIPLES OF CONTROL
PANEL WIRING

Position wiring for most collating operations is basically the same. For example, in an operation where sequence checking is involved, it is common practice to wire sequence read to sequence entry, and primary read to primary sequence entry. This sets up the sequence unit, as illustrated in figure 7-3, so that two cards feeding through the primary feed can be compared with each other. In operations such as merging or matching, secondary read is usually wired to secondary selector entry, and primary read is wired to primary selector entry. The selector unit, as illustrated in figure 7-3, then compares a card from secondary feed with a card from primary feed.

Sequence checking can be combined with merging or matching operations. When this is done, primary read must be wired to both

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comparing units. Split wiring is avoided by wiring primary read to primary selector entry, and from the common primary selector entry hubs to primary sequence entry.

Checking Sequence

Wiring the functional control hubs for checking sequence is a simple operation. In figure 7-5, a plug to C wired to primary feed causes continuous card feeding from the primary feed unit. Whenever a stepdown in sequence is detected, an impulse wired from low sequence to error stop causes the machine to stop and the error light to come on.

What has happened inside the machine? Examine the analysis charts in figure 7-6. In chart A, cards punched with 3 and 4 were found to be in sequence, and were stacked in pocket 2. The 5 card has just been read by the primary read brushes and the reading has been entered into the primary side of the sequence unit. The following card has just been read by the sequence read brushes, resulting in a 7 being placed in the sequence side of the sequence unit. Since 7 is higher than 5, a high sequence condition exists, indicating that the cards are in order.

In chart B, the 5 card has been stacked, and the following cards have moved up. In this case, the 7 card is followed by another 7 card, so an equal condition exists, indicating that the cards are still in order.

In chart C, the first 7 has stacked, the second 7 has moved up, and a 6 card has been read into the sequence side. Since 6 is lower than 7, a low sequence condition is indicated. The machine stops and the error light comes on when low sequence is wired to error stop.

Merging

Card files may consist of one card for each control number, or there may be several cards with the same control number. For example, a personnel status card file would contain only one card for each person. Therefore, we could say this file consists of single card groups. A file of personnel change cards may consist of one card for some personnel, and two or more cards for others. In this case, the file contains multiple card groups as well as single card groups.

During a merging operation, one of three conditions may exist. The secondary card may be lower than the primary card, they may equal, or the primary card may be lower than the secondary card. Feeding from either the primary or secondary feed is then controlled by the particular condition present in the selector unit. If a low secondary condition exists, a secondary feed cycle is desired. If a low primary condition is present, a primary card should be fed. In case of an equal condition, equal primary cards are normally filed in front of equal secondary cards.

The analysis charts in figure 7-7 show three different comparisons made in the selector unit.

In chart A, the primary card is lower than the secondary, thus requiring a primary feed.
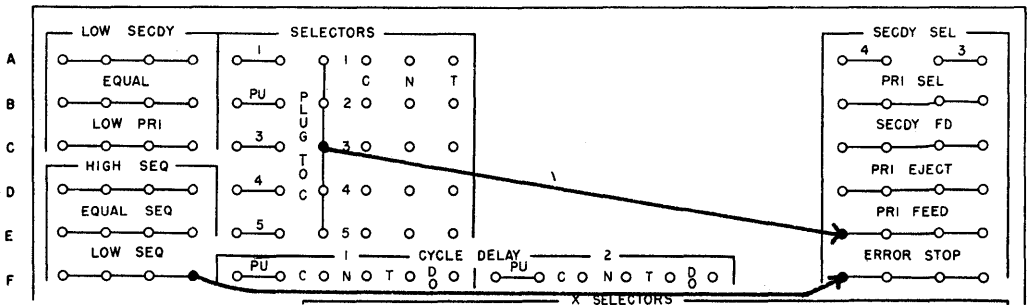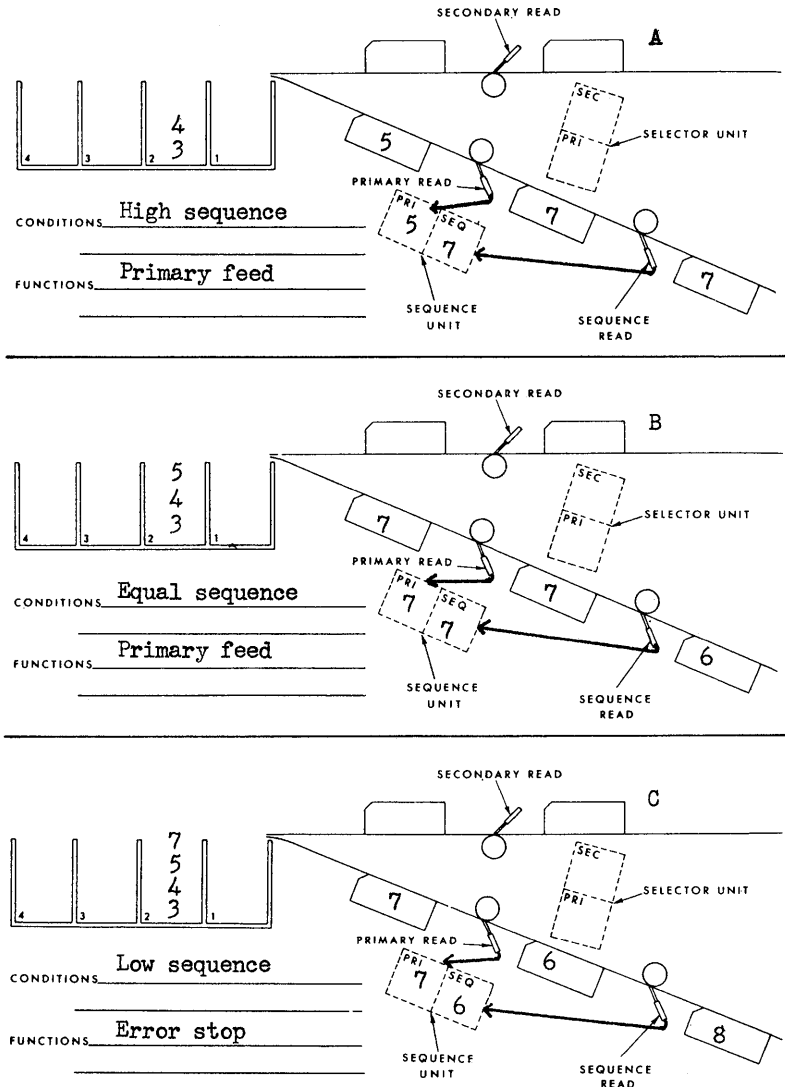

Figure 7-5.—Checking sequence.

49.57

Figure 7-6—Checking sequence.

49.58

In chart B, the situation is reversed so that the secondary card is lower than the primary. This calls for a secondary feed.

In chart C, the primary and secondary cards are equal. Because it is customary to file equal primaries ahead of equal secondaries, a primary feed cycle is desired.

There are several methods of wiring the functional control hubs to obtain the desired results indicated in figure 7-7. One method is illustrated in figure 7-8.
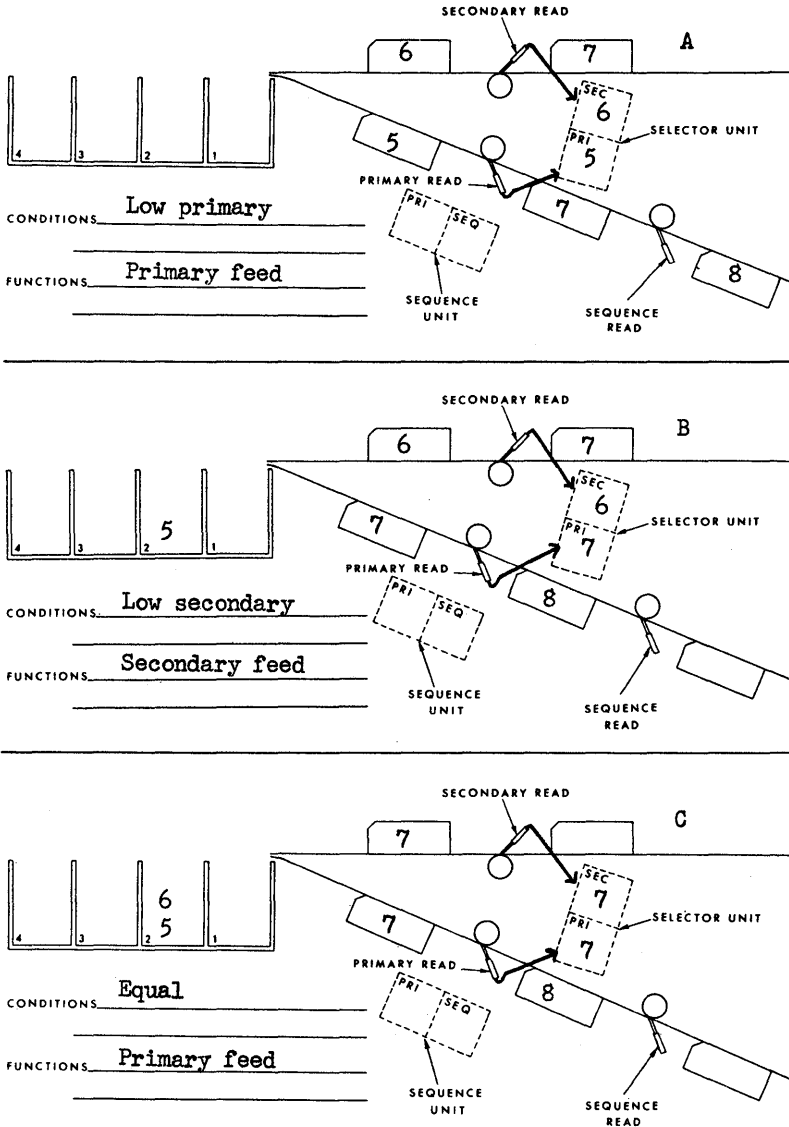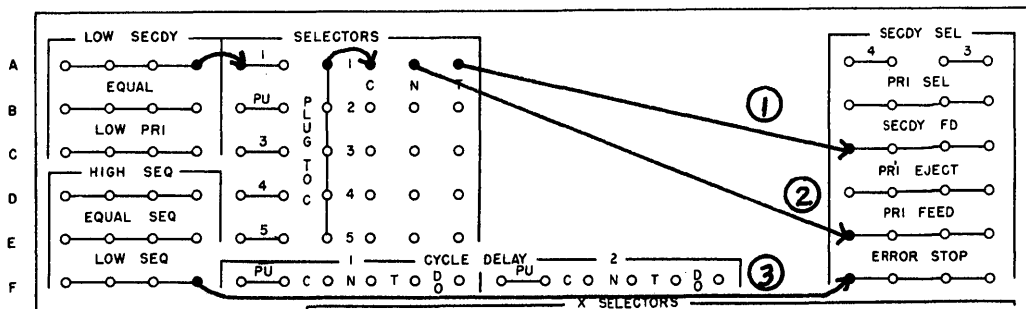

49.59

Figure 7-7.—Merging, feeding from one feed at a time.

49.60

Figure 7-8.—Merging, feeding from one feed at a time.

1. Low secondary is wired to the pickup hub of selector 1. A plug to C, wired through the transferred side of selector 1 to secondary feed causes a secondary card to feed when it is lower than the primary.

2. The normal side of selector 1 is wired to primary feed. This wiring causes a primary feed when the primary card is equal to or lower than the secondary card, since selector 1 is transferred only when a low secondary condition exists.

3. Primary cards can be sequence checked by adding a wire from low sequence to error stop.

The above wiring causes a card to be fed from only one feed unit at a time. However, the speed of a merging operation can be increased by causing both feed units to operate at the same time whenever possible. For example, whenever the primary and secondary cards are equal, one feed cycle can be eliminated by causing both feed units to operate at the same time. However, when multiple primary cards are involved, and all equal primaries are to be filed ahead of equal secondaries, then the secondary feed must be delayed until all but the last equal primary card has been fed.

The analysis charts in figure 7-9 show how the sequence unit is used in conjunction with the selector unit to control card feeding.

In charts A and B, card feeding is controlled by a low primary or low secondary condition in the selector unit, and the reading in the sequence unit is ignored.

In chart C, the primary and secondary cards are equal, and the primary card is followed by an equal primary. If all equal primaries are to be filed ahead of equal secondaries, a primary feed only is desired.

In chart D, the selector unit contains an equal reading, while the reading in the sequence unit is unequal. This indicates that the last multiple primary card has been reached, and feeding from both the primary and secondary feed units can be accomplished. If there are multiple secondary cards, the remaining equal secondaries will be treated as low secondaries.

Functional wiring for simultaneous merging is illustrated in figure 7-10.

1. Low secondary is wired to the pickup hub of selector 1, and a plug to C is wired through the normal side of the selector to primary feed. This causes a primary feed on an equal or low primary condition in the selector unit, since the selector transfers only on a low secondary condition.

2. Plug to C is wired through the transferred side of selector 1 to secondary feed. This causes a secondary feed on a low secondary condition in the selector unit.

3. Feeding of an equal secondary card is dependent upon the reading in the sequence unit. Therefore, two selectors must be used. Equal is wired to the pickup of selector 2, and high sequence is wired to the pickup of selector 3. Plug to C is wired through the transferred sides of selectors 2 and 3 to secondary feed. This causes a secondary card to feed on an equal condition in the selector
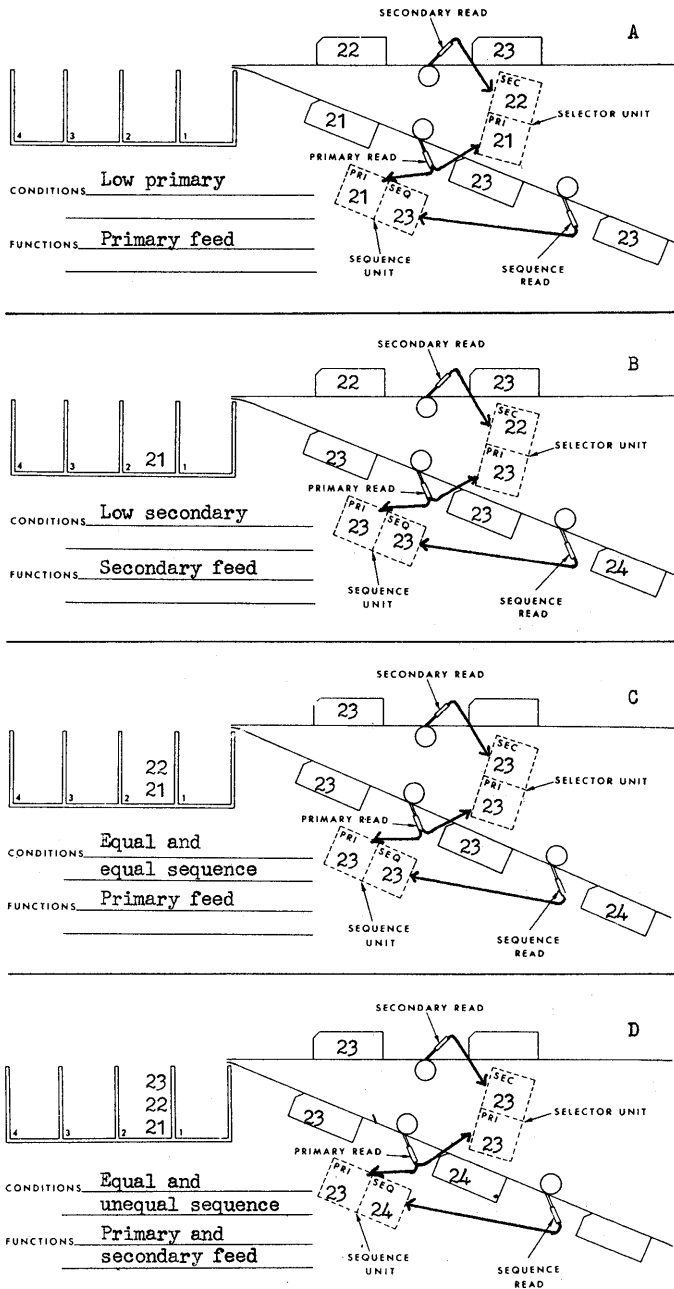
Figure 7-9.—Merging, feeding from both feeds simultaneously.

49.61

49.62

Figure 7-10.—Merging, feeding from both feeds simultaneously.

unit only if an unequal condition is present in the sequence unit.

4. Primary cards may be sequence checked by wiring low sequence to error stop.

Merging with Selection

It is possible to select certain cards from both files during a merging operation. For example, if master and detail cards are being merged, and it is desired to merge matching cards only, then detail cards that do not have matching master cards and master cards for which there are no detail cards can be selected.

Figure 7-11 presents analysis charts for merging with selection when the secondary feed consists of single card groups only.

In chart A, low primaries are fed and selected, while in chart B, low secondaries are fed and selected.

In chart C, an equal reading in the selector unit causes a primary feed, but since there is also an equal reading in the sequence unit, a secondary feed does not occur.

In chart D, an equal reading in the selector unit causes a primary feed. Since an unequal reading now exists in the sequence unit, simultaneous feeding from the secondary feed will occur.

Functional wiring for this type of selection is illustrated in figure 7-12. Card feeding is controlled the same as for straight merging. Additional wiring is added to control the selection of unmatched primary and secondary cards. Matching cards are automatically merged into pocket 2.

1. Low secondary is wired to secondary select 4. This causes unmatched secondary cards to fall into pocket 4.

2. Unmatched primary cards are directed to pocket 1 by wiring low primary to primary select.

Whenever the file in the secondary feed contains multiple card groups, the wiring for card feeding and selection must be altered so that all cards of a matched group in the secondary feed will be treated as equals. This is done by eliminating a primary FEED and causing only a primary EJECT when the last card of the matching primary group is detected. A primary eject causes the card that has just been ready by the primary brushes to move into the stacker without causing a primary feed cycle, and without clearing the primary sides of the sequence and selector units. This allows all matching secondary cards to be treated as equals with the last primary card of the matching group.

The analysis charts in figure 7-13 illustrate feeding and selection of cards when the secondary feed contains multiple card groups.

In chart A, primary feeding occurs whenever an equal reading is recognized in the selector unit, together with an equal reading in the sequence unit.

In chart B, the selector unit still contains an equal reading, but an unequal reading is now present in the sequence unit. As there may be multiple matching secondary cards, primary feeding must be delayed until all matching multiple secondary cards have been fed. A primary eject causes the last equal card from

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49.63

Figure 7-11.—Merging with selection, single secondaries.

49.64

Figure 7-12.—Merging with selection, single secondaries.

the primary feed to be filed ahead of all equal secondary cards without destroying the primary reading in the comparing units. Feeding of the first matching secondary card occurs simultaneously with the primary eject.

In chart C, the readings in both comparing units remain the same. A primary eject and secondary feed cycle will occur, but since there is no card at the eject station, no primary card is stacked.

In chart D, the condition now changes to low primary. This results in a primary feed and primary select, but since no card is at the eject station, primary selection does not occur.

Wiring for merging with selection when multiple card groups are present in the secondary feed is shown in figure 7-14.

1. Secondary feeding and selection occur on a low secondary reading in the selector unit.

2. Primary feeding and selection occur on a low primary reading in the selector unit.

3. Primary feeding occurs on an equal reading in the selector unit, together with an equal reading in the sequence unit.

4. A primary eject occurs on an equal reading in the selector unit. This wiring causes the last card of an equal primary group to be stacked without feeding another primary card.

5. Secondary feeding occurs on an equal reading in the selector unit together with an unequal reading in the sequence unit.

6. This wiring checks the sequence of the primary cards.

The illustration shown in figure 7-14 can be used also to emphasize the use of selectors for avoiding BACK-CIRCUITS. Since electrical impulses can travel through a wire in either direction, back-circuits are sometimes caused when common hubs are wired directly from two or more sources, causing an improper machine action. Suppose that instead of using selector 1, a low secondary impulse were wired directly to secondary feed. This would cause a secondary feed cycle to occur on a low secondary condition, which is what we want. But what about the SELECTION of secondary cards? We want only to select low secondaries, which is accomplished by the impulse wired from low secondary to secondary select 4. If low secondary were wired directly to secondary feed, then the plug to C impulse represented by wire 5 would travel to secondary feed, back to low secondary, thence to secondary select 4, causing equal secondary cards to be selected when the sequence unit contained an unequal reading.

Matching

Matching involves stacking the matched cards from both files separately rather than combining them into one file. All other aspects of matching are the same as merging with selection. The wiring shown in figure 7-12 and 7-14 can be adapted for matching by adding a wire from equal to secondary select 3. Thus, matched secondary cards will fall into

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Figure 7-13.—Merging with selection, multiple secondaries.

49.66

Figure 7-14.—Merging with selection, multiple secondaries.

pocket 3 whenever an equal condition is recognized in the selector unit, and matched primary cards will be directed to pocket 2 automatically.

Run-Out Card Feeding

The collator automatically stops when either feed hopper runs out of cards. The runout key must be depressed and held to move the cards remaining in the machine to the pockets. When one hopper becomes empty during a merging or matching operation, the runout key must be held down until all cards from the empty feed have been stacked. Card feeding will be performed automatically until the remaining hopper becomes empty. The runout key must be depressed again, and held until all cards are stacked.

After the last card has been cleared from either feed, automatic 9's are set up in the corresponding side of the selector unit. Therefore, if merging with selection or matching is being performed, runout card feeding must be controlled in order for the remaining cards to be properly selected. For example, when the secondary feed is cleared, the secondary selector unit will contain automatic 9's. If the control field in the remaining primary cards is lower than all 9's, the primary cards will be selected correctly as low primaries. However, if the primary control field consists of all 9's, the primary cards will be treated as equals, and will not be selected. To avoid this condition, the INTERLOCK SWITCH (fig. 7-4, Q, 23-25) is wired ON. This causes an

equal condition, occurring on the runout, to be changed internally to both low primary and low secondary so that any unmatched cards punched with all 9's will be properly selected when run out of either feed.

The interlock switch must be wired ON for all operations involving matching or merging with selection. It may be wired OFF or left unwired at all other times.

Basic Setup Switches

Up to this point, card feeding for all collating operations has been controlled by functional wiring; that is, wiring the control exit hubs of the sequence and selector units and plug to C impulses to the appropriate functional entry hubs. Functional wiring for card feeding can be eliminated in most cases by using the basic setup switches. In figure 7-15, the basic conditions which cause card feeding are wired functionally as shown by the dotted lines, and the following numbered paragraphs explain how the basic setup switches are used to replace the functional wiring.

1. SEC (Secondary Feed). When this switch is wired ON, a secondary card is fed on a low secondary condition, thus replacing wire 1. This switch has no effect when wired OFF. Secondary feeding is further controlled by the primary change switch, as explained later.

2. EJ (Primary Eject). When wired ON, this switch causes a primary eject on an equal or low primary condition, thus replacing wire 2. When wired OFF, it has no effect.

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Figure 7-15.—Basic setup.

49.67

3. PRI (Primary Feed). The basic function of this switch, when wired ON, is to cause a primary feed on a low primary condition, thus replacing wire 3. It has no function when wired OFF. Primary feeding is further controlled by the setting of the multiple secondaries and selection switch, and the primary change switch, as explained later.

4. PRI CHG (Primary Change). This switch is used to condition the primary and secondary feed switches, depending on a control change in the primary cards.

When wired ON, primary feeding occurs on an equal reading in the selector unit together with an equal reading in the sequence unit, provided the multiple secondaries and selection switch is also wired ON, thus eliminating wire 4A.

When wired ON, secondary feeding will occur on an equal reading in the selector unit together with an unequal reading in the sequence unit, thus replacing wire 4B.

When wired OFF, primary feeding will occur on an equal reading in the selector unit regardless of the reading in the sequence unit.

5. MSS (Multiple Secondaries and Selection). This switch conditions the primary feed switch. When MSS is wired ON or not wired, primary feeding occurs on an equal reading in the selector unit together with an equal reading in the sequence unit, provided the primary change switch is wired ON. When the MSS is wired OFF, a primary feed occurs on an equal reading in the selector unit regardless of the reading in the sequence unit.

Card Selection

In the discussion on merging with selection, you saw how the selection of cards from either feed was dependent upon the cards in the opposite feed. It is possible also to select certain cards from either feed independently of the other. In this respect, card selection can be generally divided into two categories; selection of X or NX punched cards from either feed, and selection of certain cards from the primary feed depending upon the condition in the sequence unit.

X SELECTION.—All X or NX cards can be selected from both feeds as a separate operation, or during another operation. Suppose you were required to merge two files of

cards and select all cards containing a control X. This could be accomplished by the wiring illustrated in figure 7-16.

1. The basic setup switches are wired to control card feeding.

2. X Selector 2 is controlled to operate with the primary feed by wiring the P hub to the selector HOLD hub. The P hub emits an impulse each primary feed cycle, thus causing the selector to hold for the feeding of each primary card. X-80 primary cards are selected by wiring primary read 80 to the pickup hub of X selector 2. When an X punch is read, the selector transfers immediately and remains transferred for the duration of the pickup impulse. A plug to C is wired through the transferred side of the selector to primary select. All X-80 primary cards will stack in

Figure 7-16.—X selection.

49.68

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pocket 1, and NX-80 primary cards will stack into pocket 2.

3. X selector 1 is controlled to operate with the secondary feed by wiring the S hub to the selector HOLD hub. The S hub emits an impulse each secondary feed cycle, thus causing the selector to hold for the feeding of each secondary card. X-80 secondary cards are selected by wiring secondary read 80 to the pickup hub of X selector 1, and wiring a plug to C through the transferred side of the selector to secondary select 3. All X-80 secondary cards will stack in pocket 3.

4. Plug to C is wired through the normal side of X selector 1 to secondary select 4 so that all NX cards in the secondary feed will fall in pocket 4. If this wire were omitted, NX secondary cards would merge with NX primary cards in pocket 2.

The use of the S and P hubs is not restricted to the selector with which they seem to appear. They emit an impulse on the corresponding card feed cycle, and may be used to hold either or both selectors. For this reason, one selector may be used to select secondary cards which contain one control X, while the other is used to select secondary cards with another control X. By the same token, both selectors can be used to select two different X punched primary cards.

Sequence Selection.—Various types of cards, such as the last card of a group, the first card of a group, or single card groups, can be selected under certain conditions existing in the sequence unit. As you can see by the analysis chart in figure 7-17, the LAST card of a group is at the eject station when a control change occurs, and can be selected by wiring high sequence to primary select.

Now refer to the analysis chart in figure 7-18. Notice that the FIRST card of a group is one station away from the eject station when a high sequence condition is recognized. Therefore, selection of this card must be delayed for one card cycle in order for the proper card to be selected. This is done by using the cycle delay unit. Operation of the cycle delay unit differs from other selectors in the collator in two respects. First, when picked up, it does not transfer until the following cycle. Second, once transferred, it remains transferred until returned to normal by an impulse received by the DROPOUT (DO) hub. When the DO is impulsed, the cycle delay unit will be normal on the following card cycle, unless the pickup hub has again been impulsed.

The first card of a group can be selected by the wiring shown in figure 7-19.

1. A high sequence impulse is wired to the pickup hub of the cycle delay unit. The unit will be transferred one cycle later, when the high sequence card reaches the eject station.

2. A plug to C, wired through the transferred side of the cycle delay unit to primary select, causes the high sequence card to be selected into pocket 1.

CONDITIONS — End of control group (high sequence)

FUNCTIONS — Primary select on high sequence (last card of control group)

49.69
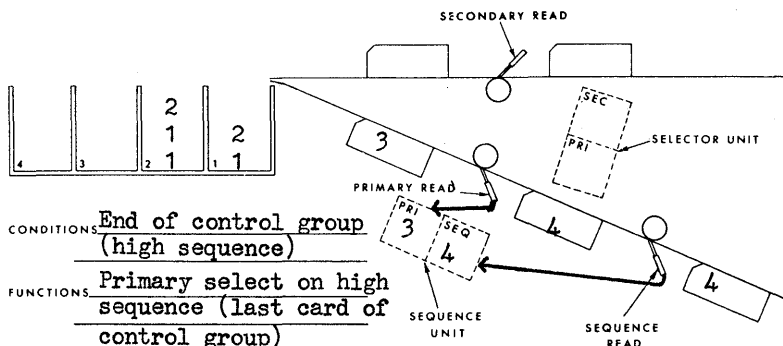
Figure 7-17.—Selecting the last card of a group.

CONDITIONS End of control group
(high sequence)

FUNCTIONS Primary select on high
sequence delayed
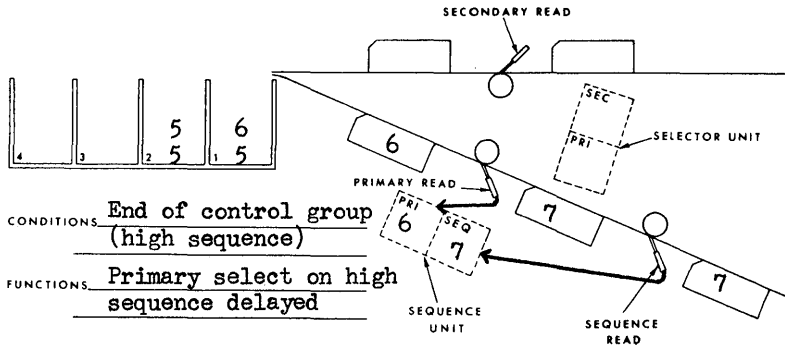
49.70

Figure 7-18.—Selecting the first card of a group.
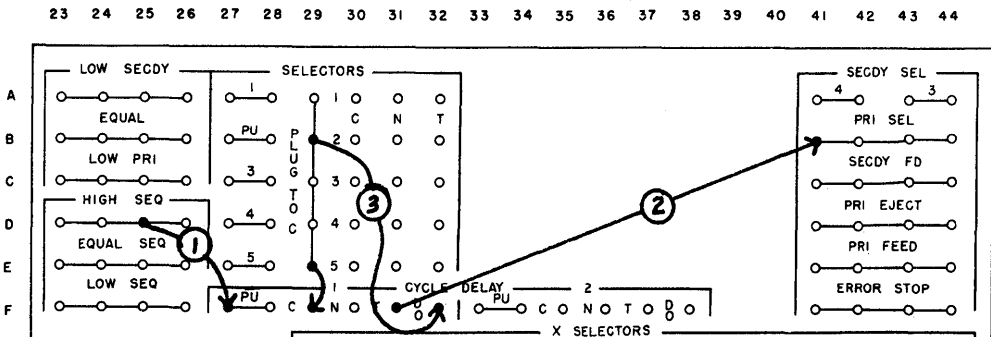
49.71

Figure 7-19.—Selecting the first card of a group.

3. The cycle delay unit is returned to normal on each card feed cycle by wiring a plug to C to DO.

Single card groups are recognized by a high sequence followed by a high sequence. As seen in analysis chart A in figure 7-20, card 4, which is the first card of a new control group, has caused a high sequence reading in the sequence unit. Is this a single card group? The machine must wait one card cycle to find out. In chart B, card 4 is followed by card 5, thereby causing two consecutive high sequence conditions. Card 4 is then recognized as a single card group, and can be

selected. If card 4 had been followed by another 4, then the requirement that a high sequence be followed by a high sequence would not be met, and selection would not occur.

Wiring for selection of single card groups is illustrated in figure 7-21.

1. When a high sequence condition in the sequence unit is recognized, a high sequence impulse wired to the pickup of the cycle delay unit causes the unit to be transferred for the following card cycle.

2. If a high sequence condition still exists on the following cycle, a second high sequence impulse, wired through the transferred side

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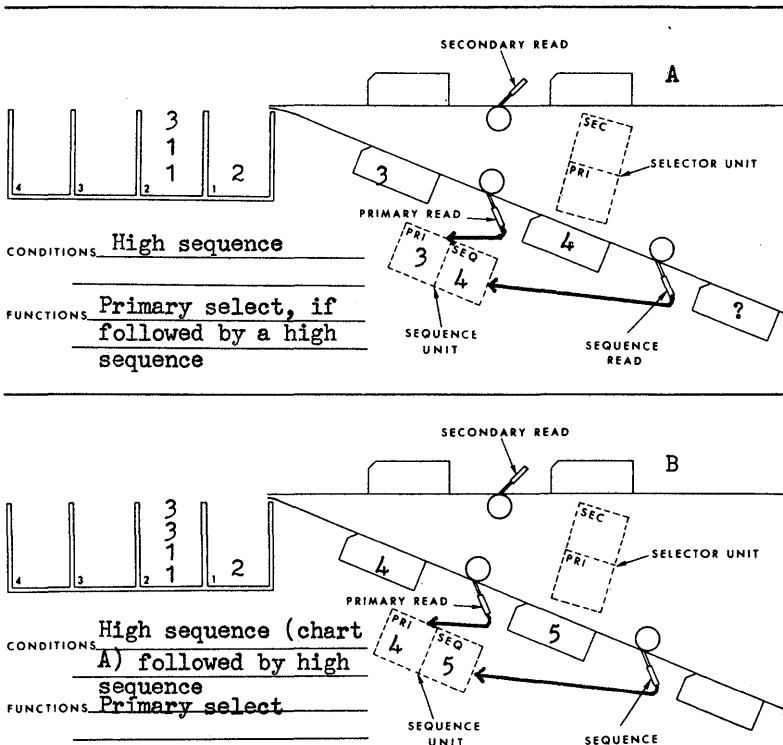
49.72

Figure 7-20.—Selecting single card groups.

of the cycle delay unit to primary select, causes a card to be selected. Multiple card groups will be stacked automatically in pocket 2.

3. Plug to C is wired to the dropout hub. This causes the cycle delay unit to be normal for the next card cycle, unless another high sequence condition has been recognized.

Blank Column Detection

Two blank column detection units provide for blank column checking as cards feed through the collator, either as a separate operation or in conjunction with other operations. A maximum of eight columns can be checked in each card when detection is required in both feeds, or 16 columns can be checked when detection is required in one feed only. Card feeding stops when a blank column is detected, and the blank column detection light (BCD1 or BCD2) corresponding to the unit in which the error is detected comes on. The reset key must be depressed in order to turn off the BCD light. Card feeding may then be resumed by depressing the start key. The next card stacked from the feed in which the error was detected will be the error card.

Each blank column detection unit can be used with either feed, or both units can be wired to operate with one feed. The S and P hubs, located to the right of the blank column detection pickup hubs, emit an impulse each secondary and primary feed cycle, respectively. The S hub can be wired to a BCD pickup hub to hold that unit between secondary feed cycles, or the P hub can be

166
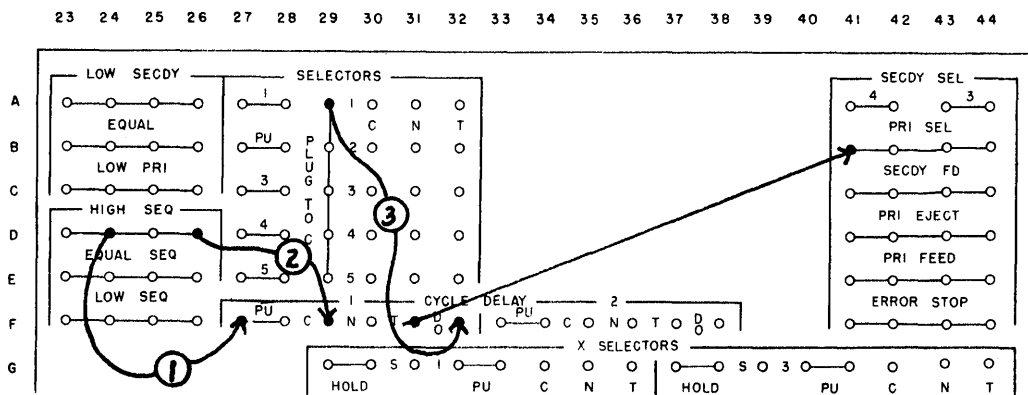
Figure 7-21.—Selecting single card groups.

wired to the BCD pickup hub to hold that unit between primary feed cycles.

In figure 7-22, columns 26-37 of the primary cards are checked for blank columns during a merging operation.

1. Primary and secondary cards are merged on columns 1-5.

2. Card feeding is controlled by the basic setup switches.

3. Control inputs test the sequence and selector units in order for card feeding to be controlled.

4. The secondary side of the selector unit is restored each secondary card feed cycle, while the primary side of the selector unit and both sides of the sequence unit are restored each primary card feed cycle, to allow new readings to enter the comparing units on the next secondary or primary feed cycle, as appropriate.

5. Primary cards are checked for sequence.

6. Columns 26 through 37 in the primary cards are to be checked for blank columns. Columns 26-33 are wired to BCD entry 1, and columns 34-37 are wired to BCD entry 2.

7. The pickup hubs of both BCD units are wired from P in order to hold both units between primary feed cycles.

8. A direct impulse (DI) is wired to the remaining positions in BCD entry 2 in order to prevent false indication of a blank column.

OPERATING SUGGESTIONS

A successful collating operating is dependent primarily upon proper control panel wiring and an understanding of the operation to be performed. While it is impossible to describe all the situations that you may encounter while collating, the following guidelines apply to all operations.

1. Always joggle cards into perfect alignment before placing them in the feed hoppers. Particular care must be observed when placing cards in the primary feed hopper, because this hopper is placed at an angle on the machine.

2. In any collating operation involving both feeds, no errors should exist in the numerical sequence of either file. Both files should be checked for sequence to avoid misfiled cards. The secondary file can be sequence checked as a separate operation, and the primary file can be checked during the merging or matching operation.

3. Any operation involving sequence checking should be tested at the beginning of the job. Insert several blank cards throughout the first 300 or 400 cards to be checked. The blank cards will break the continuity of any series of numbers, causing the machine to stop when the blank cards feed through. If the blank cards fail to stop card feeding, either

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49.74

Figure 7-22.—Merging and blank column detection.

the control panel has not been wired correctly or the machine is not operating properly.

4. Always depress the stop key to stop card feeding. Never turn off the main line switch while the machine is in operation.

5. In case of a card jam, depress the stop key immediately and tell your supervisor. Removal of a card jam can best be learned by personal instruction. All damaged cards must be repunched or duplicated and manually filed in their proper sequence.

COLLATOR, TYPE 87

The IBM type 87 collator is essentially like the 85 in design, features, and operation. The major difference lies in the fact that while the standard 85 can process numerical data only, the 87 can process numerical, alphabetic, and special character data.

The type of data which can be processed through the type 87 is arranged in ascending sequence (low to high) as follows:
1. Blank column
2. Special characters in the following order:

CODE	CHARACTER
12-3-8	
12-4-8	¤
12	&
11-3-8	$
11-4-8	*
11	-
0-1	/
0-3-8	,
0-4-8	%
3-8	#
4-8	@

3. Letters A through Z.
4. Digits 0 through 9.

The type 87 control panel is illustrated in figure 7-23. Shaded areas represent optional features. Wiring is the same as for the type 85, with the following exceptions:

1. The primary sequence side of the sequence unit is wired internally to the primary side of the selector unit. Thus, any reading which enters primary selector entry is automatically read into the primary sequence entry. There are 19 positions of comparing available in both the sequence and selector units.

2. The function of the primary change switch is performed through internal wiring.

The ZONE SWITCH, when wired ON, allows both comparing units to recognize zone punches as well as numerical punches, making it possible to compare alphabetic and special character data in addition to numerical data. When the zone switch is wired OFF, numerical punches only are recognized.

3. Conditions existing in the comparing units are tested by internal wiring, thus eliminating the control input hubs.

4. The PS hub is inactive. Primary selector magnets and primary sequence magnets are restored when the restore P hub is impulsed.

COLLATOR, TYPE 88

The IBM type 88 collator, pictured in figure 7-24, performs all operations previously described for the type 85. In addition, an editing feature allows for checking cards in both feeds for accuracy of numerical punching. Card feeding can be stopped whenever a double punch or blank column is detected in either feed. Each feed unit operates at 650 cards per minute. Up to 1300 cards per minute can be collated, depending upon the operation being performed.

OPERATING FEATURES

The switches and keys perform the same functions as described for the type 85 collator. The lights differ somewhat, as indicated in figure 7-25, and as explained below.

If a fuse burns out, card feeding will stop and the FUSE LIGHT will come on.

If a card jam has occurred in the rollers of the card transport area, the TRANSPORT LIGHT comes on. This light goes out after the card jam has been removed.

The DP&BC CHECK LIGHT goes on and card feeding stops if a double punch or blank column has been detected. An indicating lamp points out the position containing the double punch or blank column. If a blank column has been detected, the indicating lamp will glow continuously. A double punch causes only a flash on the lamp panel when the second punch in a column is detected. The reset key must be depressed to turn out the signal lights before card feeding can be resumed.

If a card fails to feed from either feed, a PRIMARY or SECONDARY CHECK LIGHT comes on. It also comes on, together with the DP&BC check light, when a double punch or

169
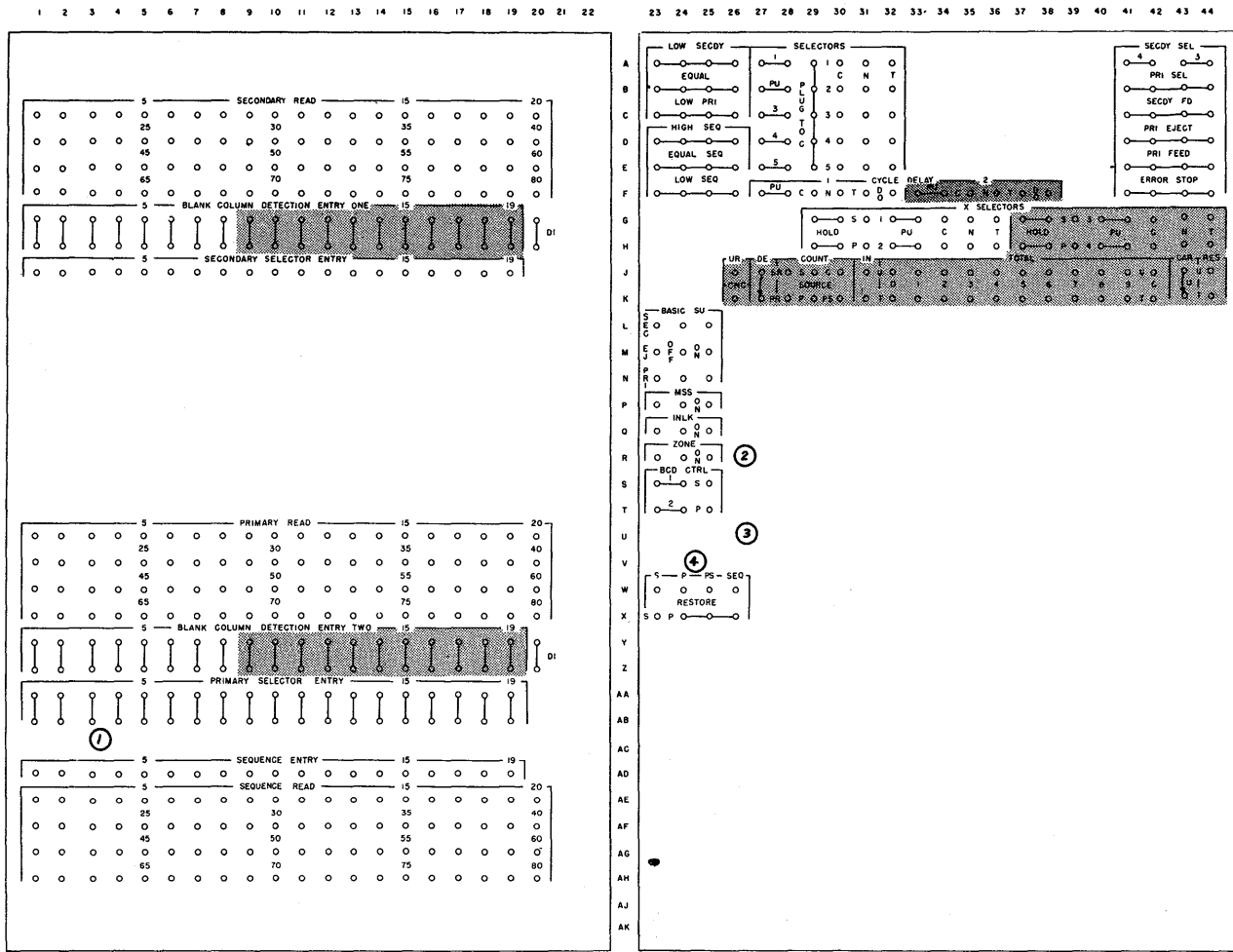
Figure 7-23.—Type 87 control panel.

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SECONDARY FEED
HOPPER

MACHINE
CONTROLS

FILE FEED

PRIMARY FEED
HOPPER

CONTROL
PANEL

STACKERS
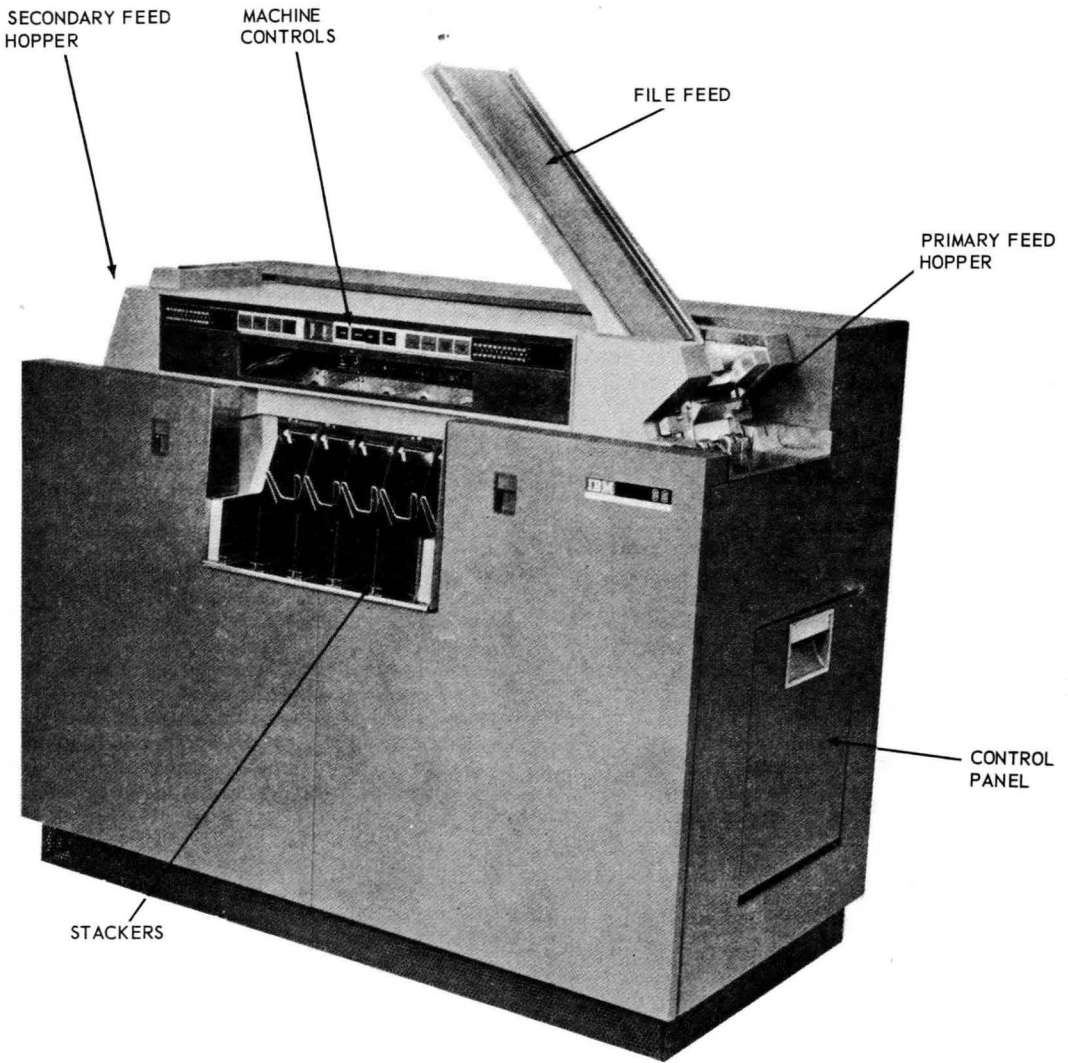
R49.53.2X

Figure 7-24.—IBM type 88 collator.

blank column has been detected. Depresing the reset key turns out the check lights and permits card feeding to be restarted.

The PRIMARY and SECONDARY CONTROL STOP LIGHTS indicate that card feeding has stopped as a result of an error condition, recognized by control panel wiring, in the corresponding feed unit. Depressing the reset key turns out the stop lights and allows card feeding to be restarted.
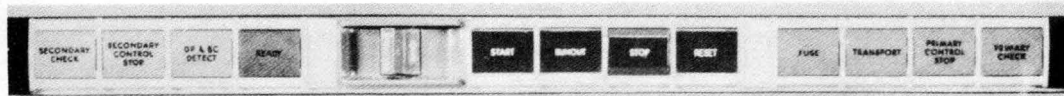
R49.53.2X

Figure 7-25.—Machine controls.

Card Feed Units

The primary feed unit is located at the right end of the machine, and the secondary feed unit is at the left end. Since cards feed from opposite directions, primary cards must be placed face down with the 9-edge first, while secondary cards must be placed face down with the 12-edge first. It may be easier for you to remember that cards are placed face down in both hoppers, with the 9-edge TO THE LEFT. The secondary feed hopper holds approximately 1200 cards, while the primary feed is equipped with a file feed which holds approximately 3600 cards.

Pockets

Five radial stackers, or pockets, are provided for receiving the cards. From right to left, they are numbered 1 through 5. Primary cards are ordinarily stacked in pocket 1 unless selected into pocket 2 or 3. Secondary cards stack in pocket 5 unless directed to pocket 4 or 3. Merged cards stack in pocket 3. Error cards are automatically stacked in pockets 1 and 5; thus selected cards should be directed to pockets 2 and 4 whenever possible. Each pocket holds approximately 1000 cards. The machine need not be stopped to remove cards from the pockets.

PRINCIPLES OF OPERATION

Most collating operations require that two numbers be compared. For example, in order to check the sequence of a file of cards, the number in one card must be compared with the number in the preceding card to ensure that the cards are in order. When merging, the number in a card from one feed must be compared with the number in a card from the other feed in order to determine which card is to be fed first. One of three conditions will exist when two numbers are compared; low, equal, or high.

Schematic Diagram

The schematic diagram in figure 7-26 shows the paths of cards from the hoppers to the pockets. Separate sequence units provide for checking the sequence of both primary and secondary cards. The comparing unit provides for comparing the cards from one feed with cards from the other feed. Cards are directed to the various pockets by control panel wiring.

Control Panel

Figure 7-27 shows the entire control panel for a full capacity machine, with the shaded areas representing optional features or devices. The control panel is divided into two main sections, with the right side corresponding essentially to the primary feed, and the left side to the secondary feed.

Basic Machine Control

Regardless of the operation being performed, there are four groups of control panel hubs which are essentially involved. These hubs can be located by reference to figure 7-27. Other hubs will be discussed when first used for a particular operation.

All Cycles.—Each of these hubs (T, 17-28) emits an impulse for each machine cycle except when a check or control stop light is on. ALL CYCLES impulses are usually wired to primary or secondary feed if matching or merging is not being performed, or to selector pickup hubs. They should not be wired to a pocket entry.

Secondary/Primary Feed.—Each feed unit has four common feed entry hubs. Secondary feeding occurs when the secondary feed hubs (T, 13-16) receive an impulse, and primary feeding occurs when the primary feed hubs (T, 29-32) are impulsed. These hubs are not active during card feed run-in, nor when the merge or match switch is wired. They should be wired from ALL CYCLES only.

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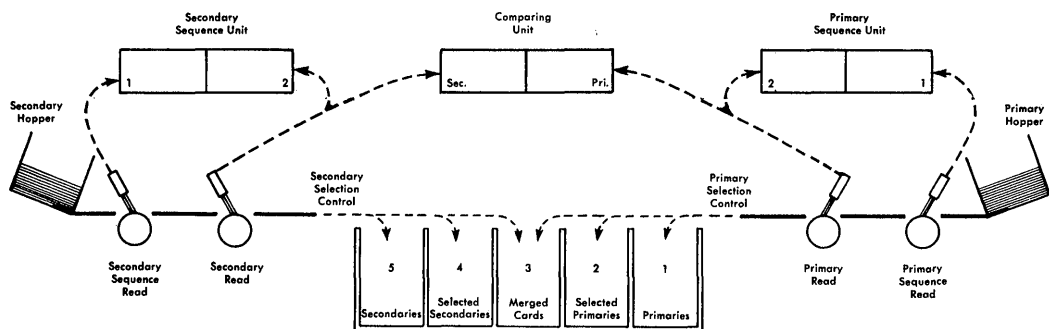
R49.78X

Figure 7-26.—Card feed schematic diagram.

Sequence On, Off.—The secondary sequence switch (L-N, 21) and the primary sequence switch (L-N, 43) must be wired for card feeding to occur from the respective feed unit. The center hub of either switch accepts an impulse from either the ON or OFF hub each machine cycle to permit card feeding. The OFF hub emits an impulse each machine cycle. The ON hub emits an impulse each machine cycle except when the corresponding sequence unit recognizes a low sequence condition. If the center hub does not receive an impulse, card feeding stops and the corresponding control stop light goes on. The appropriate sequence switch must be wired ON for any operations involving sequence checking, and wired OFF for all other operations. The sequence units operate when the sequence OFF hubs are wired, but the machine does not stop when a low sequence condition occurs.

Pocket Control.—Primary cards automatically fall into pocket 1 and secondary cards into pocket 5 unless otherwise directed to one of the other pockets by control panel wiring.

The primary pocket control hubs (Q-S, 38-40) can be wired to direct primary cards to either pocket 2 or pocket 3. The three common pocket control exit hubs emit an impulse each machine cycle, except when a check or control stop light is on. These exit hubs can be wired to pocket 2 or pocket 3, either directly or through selectors, to control the stacking of merged or selected primary cards. If both pocket 2 and pocket 3 receive an impulse at the same time the card will be directed to pocket 3. If neither pocket entry

receives an impulse, the card will fall into pocket 1. The pocket control exit hubs are inactive when the runout key is depressed if a check or control stop light is on.

The secondary pocket control hubs (Q-S, 5-7) can be wired to direct secondary cards to either pocket 4 or pocket 3. Either of the three common pocket control exit hubs can be wired to pocket 4 or pocket 3, either directly or through selectors, to control the stacking of merged or selected secondary cards. If both pockets 4 and 3 receive an impulse at the same time, the card will be directed to pocket 3. If neither pocket entry receives an impulse, the card will fall into pocket 5. The pocket control exit hubs emit an impulse each card cycle except when a check or control stop light is on.

PRINCIPLES OF CONTROL PANEL WIRING

Control panel wiring for typical operations which may be performed on the type 88 is discussed in the following paragraphs. Analysis charts will not be shown, since the sequence and comparing units compare the readings from cards in the same manner as the type 85.

Checking Sequence

Each sequence unit in a full capacity machine provides for checking the sequence of up to 22 columns of data. Each unit can be split into two groups of 11 positions each by wiring the sequence split switches (secondary, P, 21-22 and primary, P, 43-44). The secondary sequence unit

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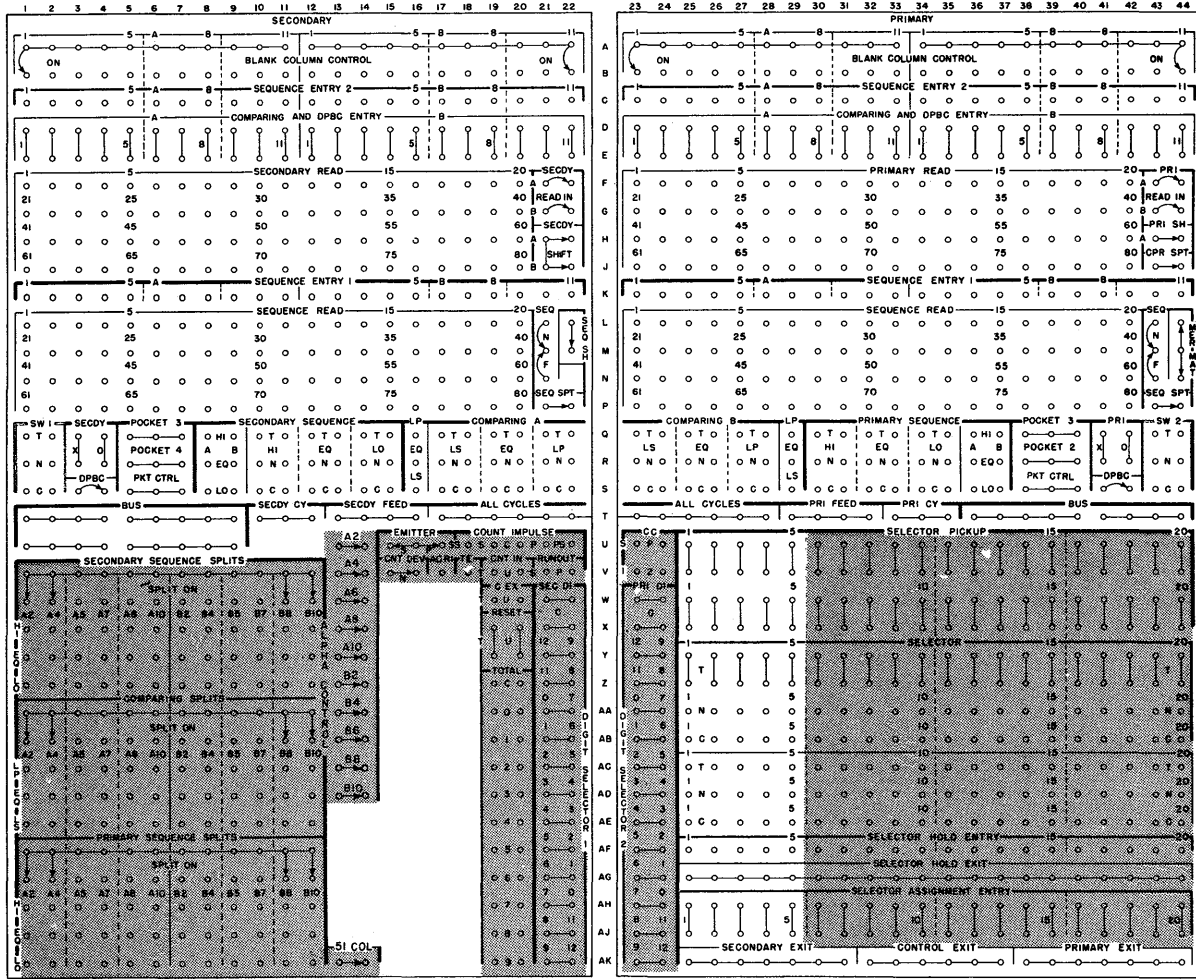
Figure 7-27.—Type 88 control panel.

R4979X

can further be controlled to operate with the primary feed by wiring the sequence shift switch (L-M, 22). However, to aid you in understanding how the sequence units operate, each unit will be treated herein as one group, and will be used with the respective feed.

In figure 7-28, two separate cost analysis files are to be sequence checked on job order number.

1. The control field in each file of cards is wired from SEQUENCE READ to SEQUENCE ENTRY 1, and from PRIMARY and SECONDARY READ to the corresponding positions of SEQUENCE ENTRY 2. As can be seen by reference to figure 7-26, the readings from the primary and secondary read brushes are compared with readings from the sequence read brushes, resulting in a high, equal, or low sequence condition in the sequence units.

2. An all cycles impulse is wired to secondary feed and to primary feed to cause both feed units to operate each card cycle.

3. The secondary and primary sequence switches are wired ON to stop the machine when a low sequence condition is detected in either sequence unit.

4. Secondary cards are directed to pocket 4, and primary cards to pocket 2. Pockets 1 and 5 are reserved for error runout.

Merging

In order to merge two files of cards, the comparing unit must be used to compare the control field in one file of cards with the control field in the other file. The comparing unit in the full capacity machine is capable of comparing a maximum of 22 columns of data. This unit can be divided into two separate groups of 11 positions each by wiring the COMPARING SPLIT SWITCH (J, 43-44). The entire secondary side of the comparing unit can be shifted to operate with the primary feed unit by wiring the SECONDARY SHIFT SWITCHES (H-J, 21-22) and the first eleven positions of the primary side can be shifted for use with the secondary feed unit by wiring the PRIMARY SHIFT SWITCH (H, 43-44). However, in the following illustration, the comparing unit is used as it would be for normal operations.

In addition to the comparing unit, both sequence units must be used for a merging operation. Card feeding is controlled by the MERGE SWITCH (L-M, 44). When this switch is ON, internal circuits are set up to control card feeding from either feed, thus avoiding considerable

control panel wiring. With the sequence and comparing units properly wired, and the merge switch wired ON, card feeding is controlled under one of five conditions as follows:

1. Primary feed on a low primary.

2. Secondary Feed on a low secondary.

3. Primary feed on an equal reading in the comparing unit together with an equal sequence reading in the primary sequence unit.

4. Primary and secondary feed on an equal reading in the comparing unit together with a high sequence reading in the primary sequence unit. The primary card will feed first.

5. Primary and secondary feed on an equal reading in the comparing unit, high sequence reading in the primary sequence unit, and an equal sequence reading in the secondary sequence unit. In this case, the equal secondary sequence condition interlocks the primary feed to prevent further feeding of primary cards until all equal secondaries have been fed.

Figure 7-29 illustrates the wiring necessary to merge two files of cards.

1. The primary and secondary control fields are wired to the comparing and sequence units.

2. The merge switch, when wired ON, automatically controls merging.

3. Primary and secondary sequence switches are wired ON, causing card feeding to stop when an error in sequence is detected in either sequence unit.

4. All cards are directed to pocket 3.

Merging With Selection

Cards from either feed that do not match a card in the other feed can be selected during a merging operation. Each condition that can exist in the comparing unit is represented by a selector (Q-S, 17-28). When the comparing unit is not split, comparing selectors A and B operate together and transfer for the comparison in the entire comparing unit. When the unit is split, selectors A and B operate with their respective section. One of the comparing selectors transfers each machine cycle, depending upon the condition in the comparing unit. For example, if an equal reading is present in the comparing unit, the EQUAL selector transfers, and any impulse entered into C (common) is available out of T (transferred). When a selector is not transferred, a connection exists between C and N (normal).

Wiring for merging with selection is illustrated in figure 7-30.
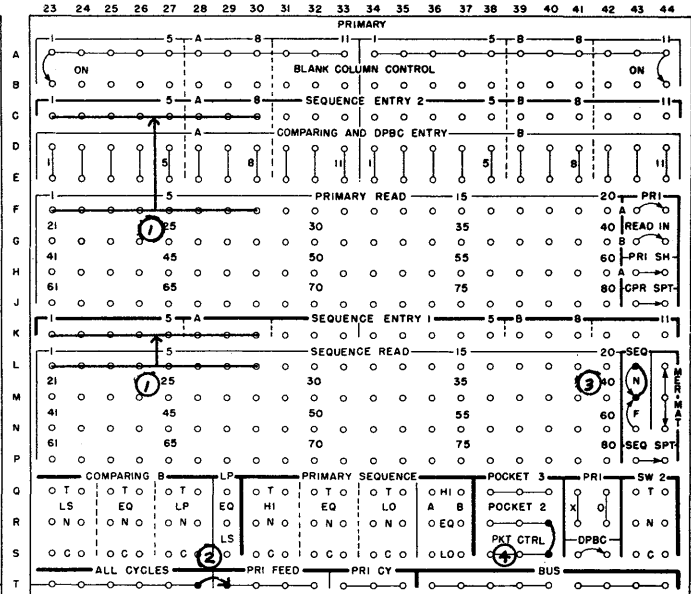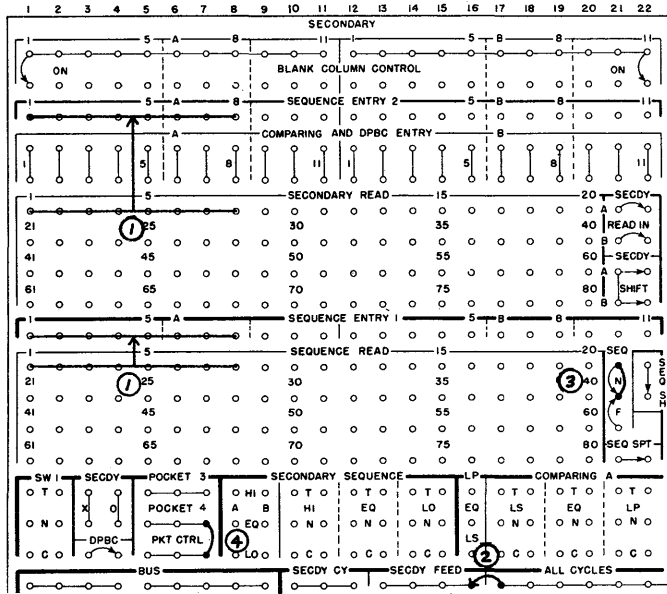
49.80

Figure 7-28.—Checking sequence.

Figure 7-29.—Merging.

49.81
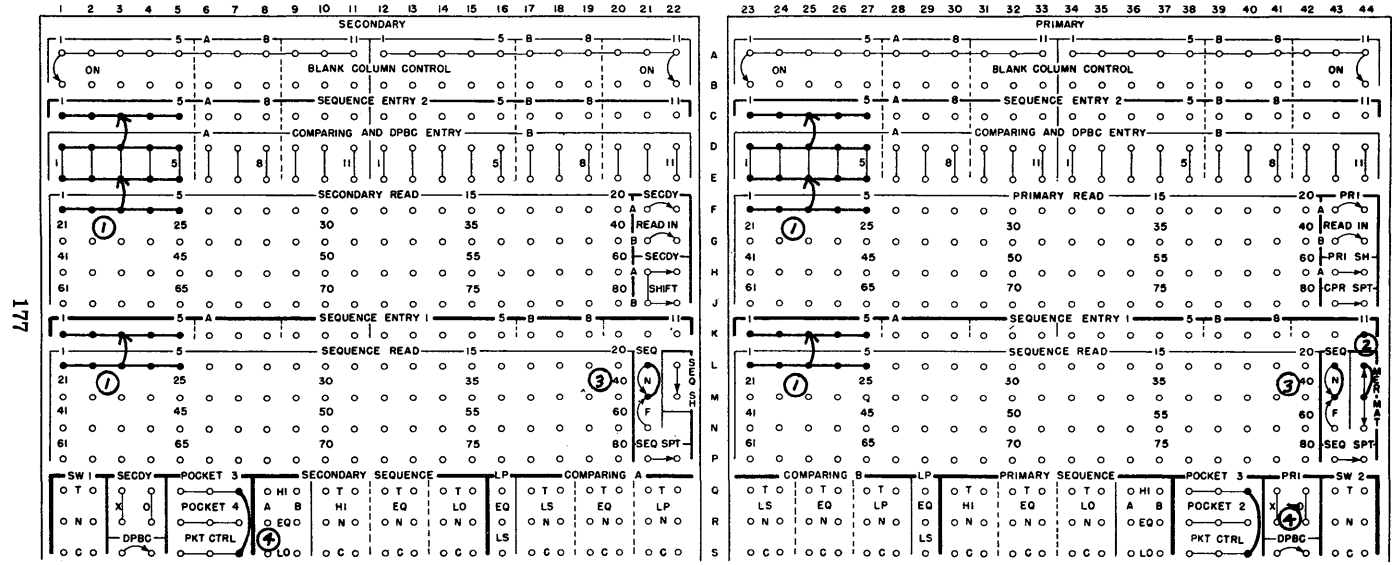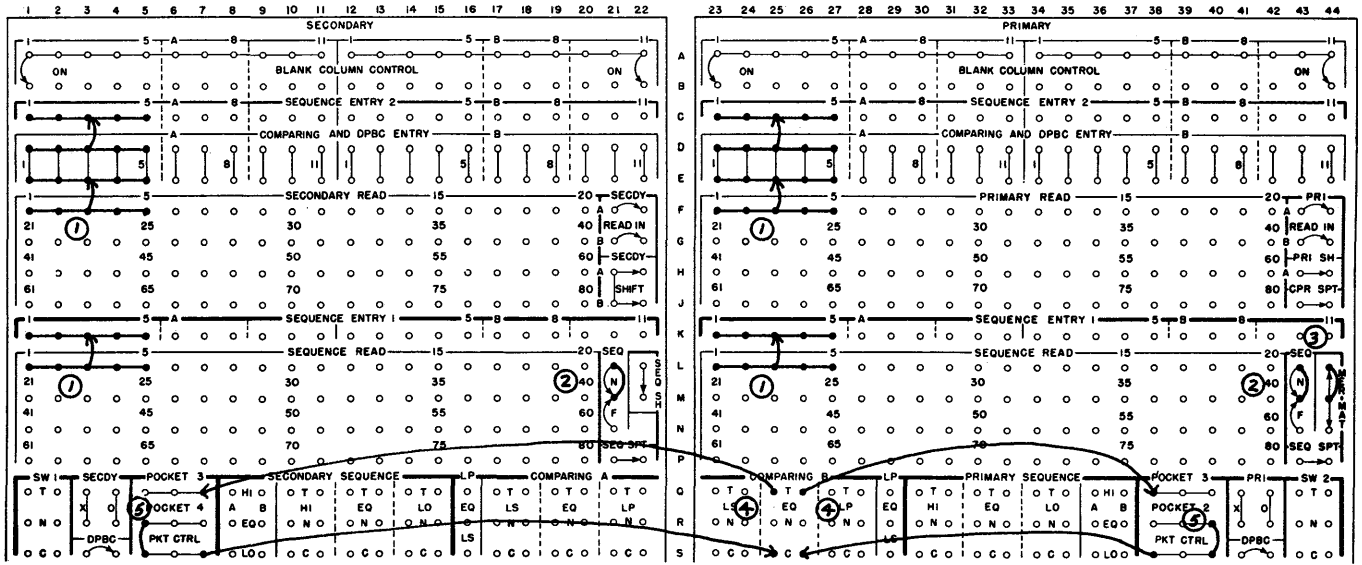
48.82

Figure 7-30.—Merging with selection.

1. The control fields are wired the same as for straight merging.

2. Primary and secondary sequence switches are wired ON.

3. The merge switch is wired ON to control card feeding.

4. Pocket control is wired through the transferred side of the equal comparing selector to pocket 3. This causes equal cards from both feeds to merge into pocket 3.

5. Pocket control is wired straight to pockets 2 and 4 to select low primaries and low secondaries. Since an impulse wired to pocket 3 takes precedence over an impulse wired to pockets 2 and 4, the only time cards will be stacked in pockets 2 and 4 is when the reading in the comparing unit is other than equal.

Matching

The comparing unit and both sequence units must be used for a matching operation. When the MATCH SWITCH (M-N, 44) is wired ON, card feeding is automatically controlled under one of five conditions as follows:

1. Primary feed on a low primary.

2. Secondary feed on a low secondary.

3. Primary and secondary feed on an equal reading in the comparing unit, high primary sequence reading in the primary sequence unit, and a high secondary sequence reading in the secondary sequence unit.

4. Primary and secondary feed on an equal reading in the comparing unit, high primary sequence, and equal secondary sequence. The equal secondary sequence condition interlocks the primary feed to allow continuous feeding of multiple secondaries until a high secondary sequence reading is reached.

5. Primary feed on an equal reading in the comparing unit, equal primary sequence and high secondary sequence. The equal secondary card is held and fed with the last equal primary card.

The wiring for matching is illustrated in figure 7-31.

1. The control fields are wired the same as for straight merging.

2. Primary and secondary sequence switches are wired ON.

3. The match switch is wired ON to control card feeding.

4. Matched primary cards are direct to pocket 2 and matched secondary cards to pocket 4 by wiring POCKET CONTROL through the transferred side of the equal comparing selector

to pockets 2 and 4. Unmatched primaries and secondaries are automatically directed to pockets 1 and 5 respectively.

Card Selection

Certain cards may be selected from a file under many varying conditions through the use of selectors. Control panel hubs which are used to control selectors are illustrated in figure 7-32.

1. Each selector has two sets of pickup hubs which must be impulsed at the same time in order for the selector to transfer. A single impulse wired to one pickup can be jackplugged to the other, or each pickup can be impulsed from a different source. When both upper and lower pickups are impulsed at the same time, a selector transfers immediately If neither pickup hub receives an impulse, or if only one is impulsed, the selector remains normal.

2. Each selector has two sets of common, normal, and transferred hubs. An internal connection exists between common and normal when a selector is not transferred, and between common and transferred when the selector is transferred. These connections are made only between hubs in each particular set. For example, an impulse entered into common of the lower set cannot be obtained from the normal or transferred hubs of the upper set, and vice versa.

3. Each selector has a set of common selector assignment entry hubs which are used to assign a selector to operate with the primary or secondary feed, or for control use. These entry hubs must be wired from primary, secondary, or control exit only.

4. A secondary exit impulse, emitted each secondary card feed cycle, can be wired to a selector assignment entry to allow a selector, picked up from any source, to remain transferred until the start of the next secondary card feed cycle.

5. A primary exit impulse, emitted each primary card feed cycle, can be wired to a selector assignment entry to allow a selector, picked up from any source, to remain transferred until the start of the next primary card feed cycle.

6. When a control exit impulse is wired to a selector assignment entry, the selector can be picked up on any machine cycle during control time (after card reading time) and will remain transferred through the reading of the next card (except the last digit). These hubs emit an impulse each machine cycle.
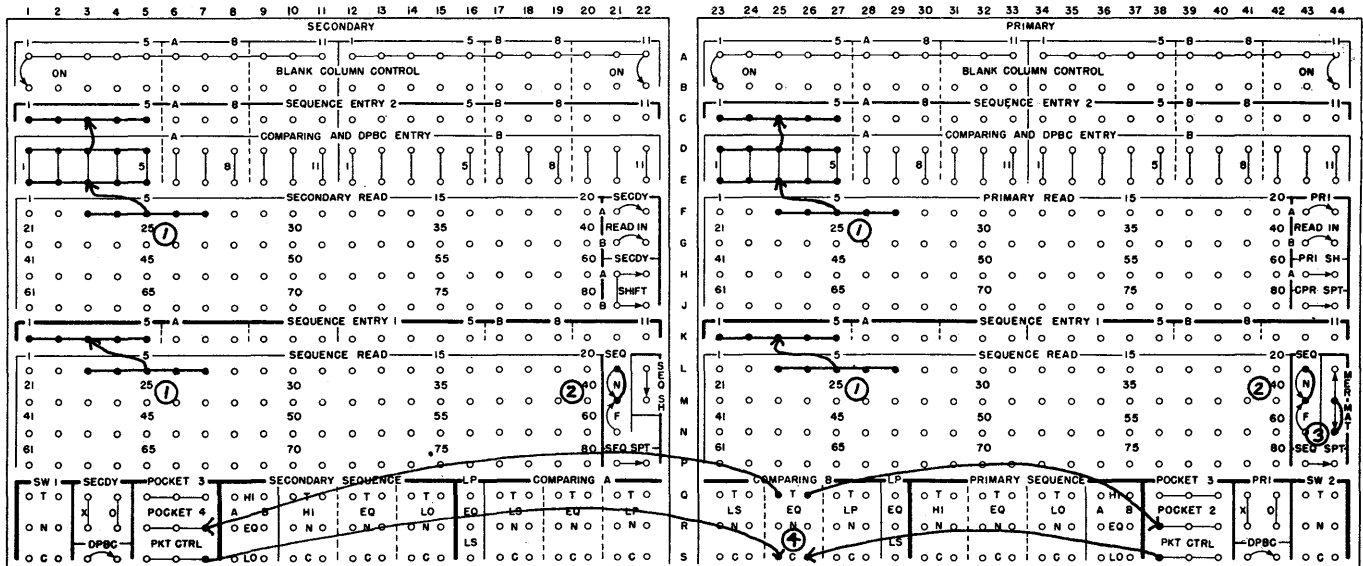
Figure 7-31.—Matching.

49.83
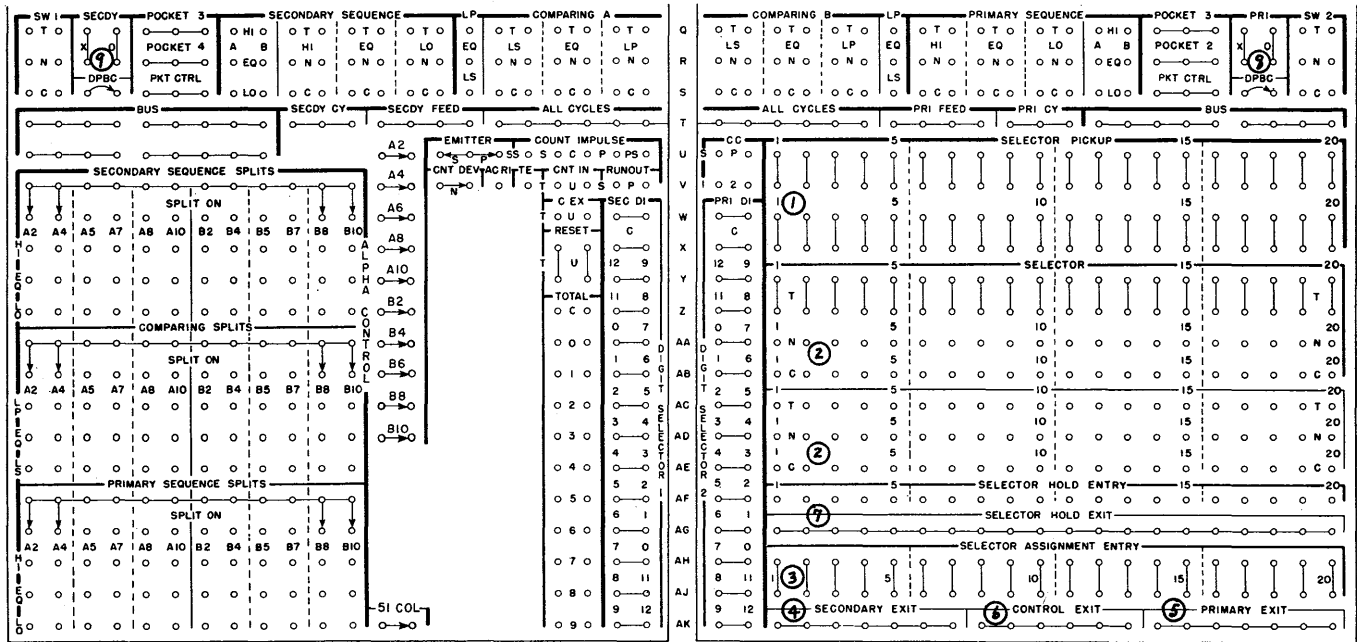
Figure 7-32.—Hubs used for card selection.

49.84

7. When a primary or secondary exit is wired to a selector assignment entry, the selector can be held transferred by wiring SELECTOR HOLD. Once the selector transfers, it will remain transferred until the hold circuit is broken. This is done by wiring the hold exit through another selector to HOLD ENTRY.

8. The PRIMARY X AND O hubs emit an impulse corresponding to the X and O punching positions each primary card feed cycle. They are normally wired to one of the selector pickup hubs to condition the selector to transfer when an X or O is read from a primary card.

9. An impulse is emitted by the SECONDARY X AND O hubs each secondary card feed cycle. These impulses are normally used to condition a selector to transfer when an X or O is read from a secondary card.

It is possible to perform many selection operations if you have a thorough understanding of how selectors work. While it is impossible to list all the methods of selection in this manual, the wiring shown in figure 7-33 may help you to adapt selectors for other types of card selection. In this illustration, secondary cards punched with an X are selected, and the first card of each primary control group is selected, during a merging operation.

1. Wiring for merging is performed in the usual manner, with the exception of pocket control.

2. X-punched secondary cards are selected by wiring secondary read 80 to one pickup of selector 1, and a secondary X impulse to the other pickup. Selector 1 will be transferred when an X-80 secondary card is read.

3. Selector 1 is held for a secondary card feed cycle.

4. A pocket control impulse is wired through the transferred side of selector 1 to pocket 4, and through the normal side to pocket 3. This causes all X-80 secondary cards to stack into pocket 4 and all NX-80 secondary cards to merge into pocket 3.

5. The first card of a primary control group is recognized by a high primary sequence condition. Since this card is not in stacking position, as seen by reference to figure 7-26, selection must be delayed until the following primary card feed cycle. A PRIMARY CYCLES impulse, emitted each primary card feed cycle, is wired through the transferred side of the high primary sequence selector to both pickups of selector 3. Since the primary cycles impulse cannot reach selector 3 pickup until the primary card feed

cycle following the cycle on which a high primary sequence condition was recognized, selector 3 will be transferred when the first card of a primary control group has reached the stacking position.

6. Selector 3 is held for a primary card feed cycle.

7. A pocket control impulse, wired through the transferred side of selector 3, directs the first card of a primary control group to pocket 2. The same pocket control impulse, wired through the normal side of selector 3, causes all other primary cards to merge in pocket 3.

Editing

Cards in each feed should always be checked for double punches or blank columns to assure accuracy of any given collating operation. This check can be performed separately, or in conjunction with other operations. For purposes of simplicity, wiring for double punch and blank column detection as a separate operation, using both feeds, is shown in figure 7-34.

1. Primary and secondary read are wired to COMPARING AND DPBC entry. These entry hubs provide entrance to the comparing unit for comparing, and for double punch and blank column detection. A double punch is recognized as two or more digits 0 through 9 punched in a single column. Control X or 12 punches are not detected as part of a double punch.

2. The blank column control hubs must be jackplugged, if blank columns in addition to double punches are to be detected.

3. The primary and secondary READ IN switches are wired. This wiring causes the readings in the selector unit to clear each card cycle in order to allow a new reading to enter. If the MERGE or MATCH switch is wired, the READ IN switches need not be wired, since read-in is then internally controlled.

4. The sequence switches are wired OFF to permit card feeding.

5 Cards feed continuously from both feeds by wiring ALL CYCLES to primary and secondary feed. Since pocket control is not wired, primary cards are directed automatically to pocket 1, and secondary cards to pocket 5.

6. The DPBC switches are wired ON to cause the machine to stop and the signal lights to turn on when a double punch or blank column is detected.
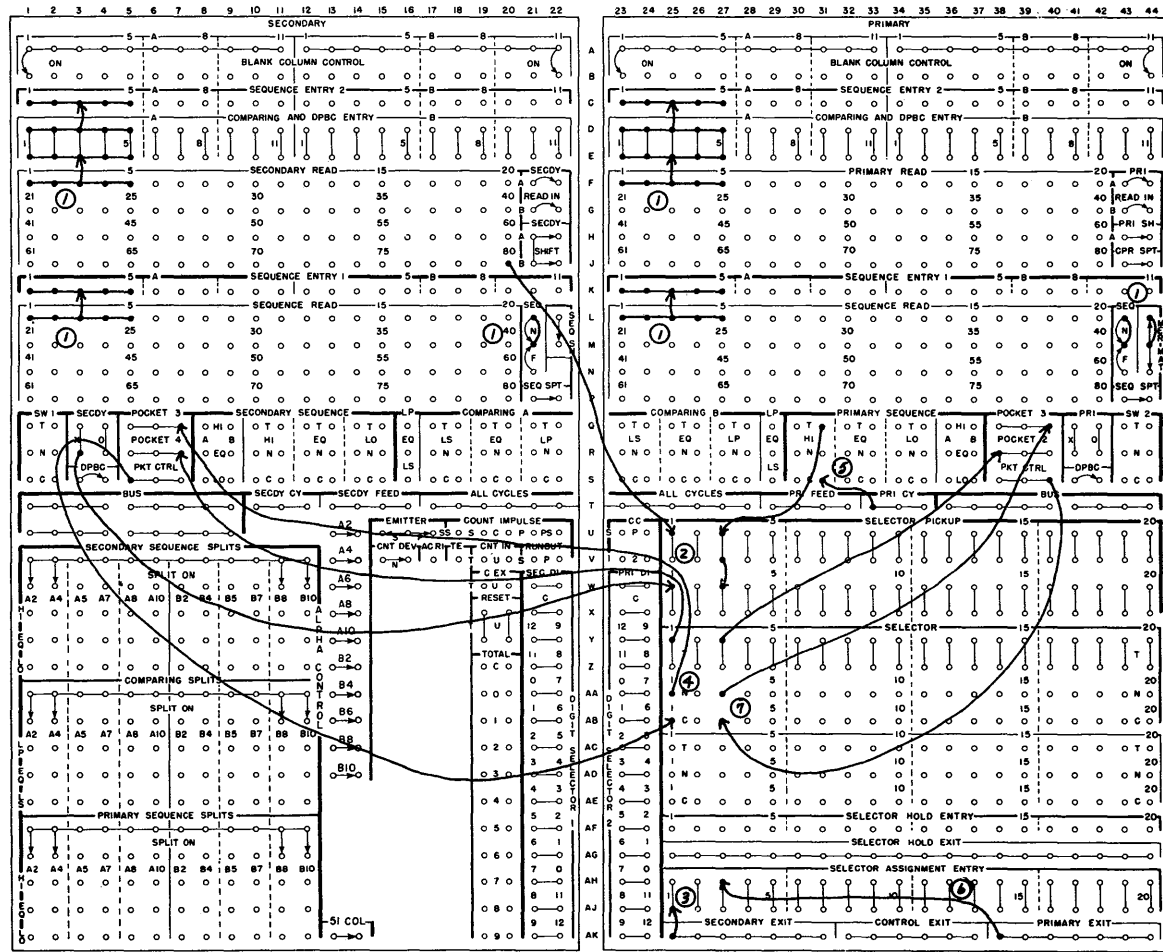
Figure 7-33.—Card selection.

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Figure 7-34.—Editing.

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COLLATOR, TYPE 188

The IBM type 188 collator shown in figure 7-35 performs all operations mentioned previously for the type 88, and the type 188 can also process alphamerical data. The alphamerical collating sequence can be selected on the control panel for the desired application. The three modes are ALPHAMERICAL, NUMERICAL-BLANK EQUAL ZERO, or NUMERICAL-BLANK DETECTED. Another exception is the addition of four magnetic-core storage units, two in primary and two in secondary. Information is read into storage on read-in cycles by internal circuitry for feed control, selection, and all other operations as determined by control panel wiring.

OPERATING FEATURES

The switches, keys, and lights on the operator's panel (fig. 7-36) allow operational control and indicate the condition of the machine while running, or indicate conditions that may have caused feed stoppage. The operating switches and keys are essentially the same as for the type 88 with the exception of the STORAGE SELECTOR SWITCH that works in conjunction with the POSITION ADVANCE KEY. The storage-selector switch has five manual settings; OFF, SS, S, P, and PS (off, secondary sequence storage, secondary storage, primary storage, and primary sequence storage). The switch can be rotated to select the desired storage unit to be interrogated for double punches or blank columns by then pressing the position-advance key. This key causes the position ring to step, one position at a time, through all the positions of storage.

Feed Stop Lights

The PRIMARY and SECONDARY LIGHTS are used with the feed stop lights to indicate the feed that caused the stop.
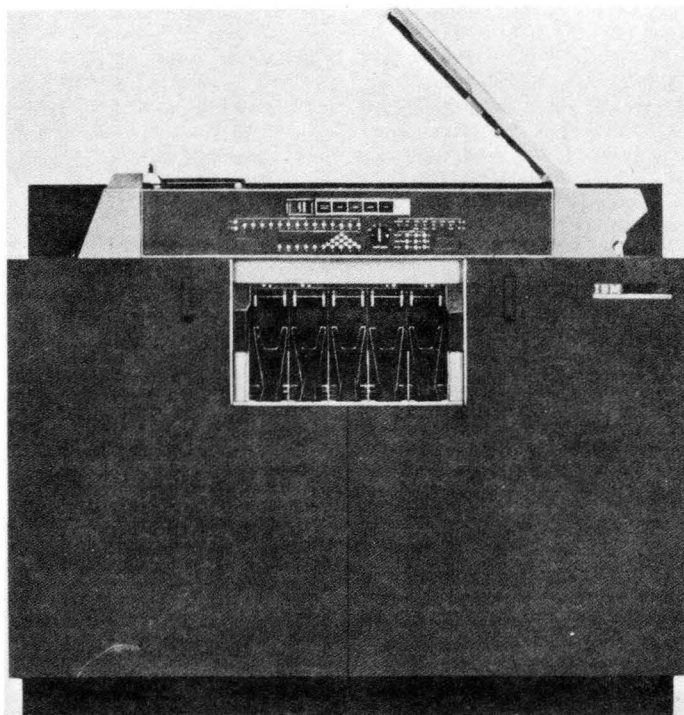
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Figure 7-35.—IBM type 188 collator.

R49.53.3X
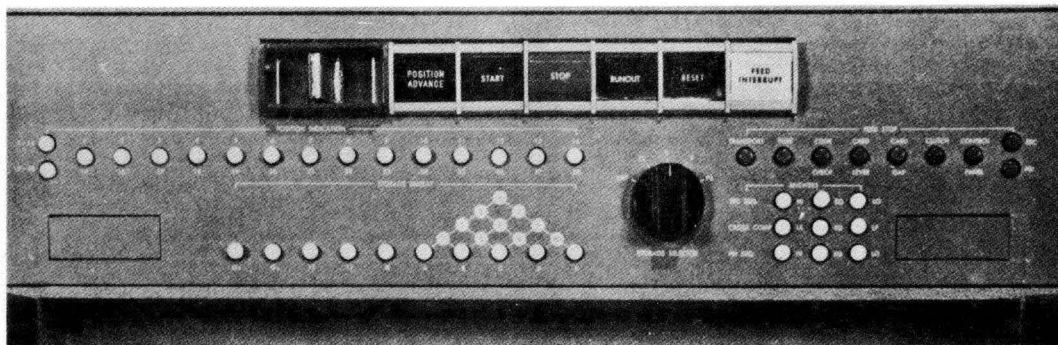
Figure 7-36.—Type 188 machine controls.

The CONTROL PANEL LIGHT indicates that the machine stopped due to an error condition recognized by control panel wiring, such as the cards being out of sequence.

The FUSE LIGHT signals a blown fuse, while the TRANSPORT, CARD LEVER, and CARD GAP LIGHTS all indicate a card jam or misfeeding.

A malfunction in the controls of the feed knives and feed rolls, which control the movement of cards is indicated by the CLUTCH LIGHT.

The position-advance key is activated for checking storage positions by the CODE CHECK LIGHT which comes on when a double punch or blank column error is detected in storage.

Indicating Lights

The FEED INTERRUPT LIGHT signals that power is on but cards are not feeding. It goes off when cards are passing through the machine.

When the code check light is on, and the storage selector switch is operated, the STORAGE DISPLAY LIGHTS are used to display the information one position at a time in each position of storage. The display lights are changed as the position advance key is operated.

The POSITION INDICATOR LIGHTS show the position of storage being interrogated while the ANSWER LIGHTS indicate the results of the comparison between the storage units.

PRINCIPLES OF OPERATION

You have learned that in any operation accomplished by collators, cards are read and their numbers compared. The results of the comparison is then used to control advancement of cards and pocket selection.

Schematic Diagram

The schematic diagram in figure 7-37 shows the five pockets, the clutching controls of the transport areas, the reading stations, and the four storage units.

Storage Units

The storage units in a full capacity machine have 28 positions of magnetic-core storage. They use a two-out-of-five bit configuration for representing numerical information and a two-out-of-five plus a zone bit for alphamerical as shown in the character code chart in figure 7-38. For example, if a position in storage contained the letter A, it would be represented on the storage display lights on the operators panel by the 12, A, and B, lights.

Information is read automatically into primary sequence storage on each primary feed cycle. The data is then transferred internally to primary storage where comparing takes place. The high, low, or equal condition sensed by this comparison is set in the machine circuitry for feed control and selection as determined by control panel wiring.

The storage units on the secondary side are of equal capacity to the primary, and are identified as secondary sequence storage and secondary storage. Operations and transfer are
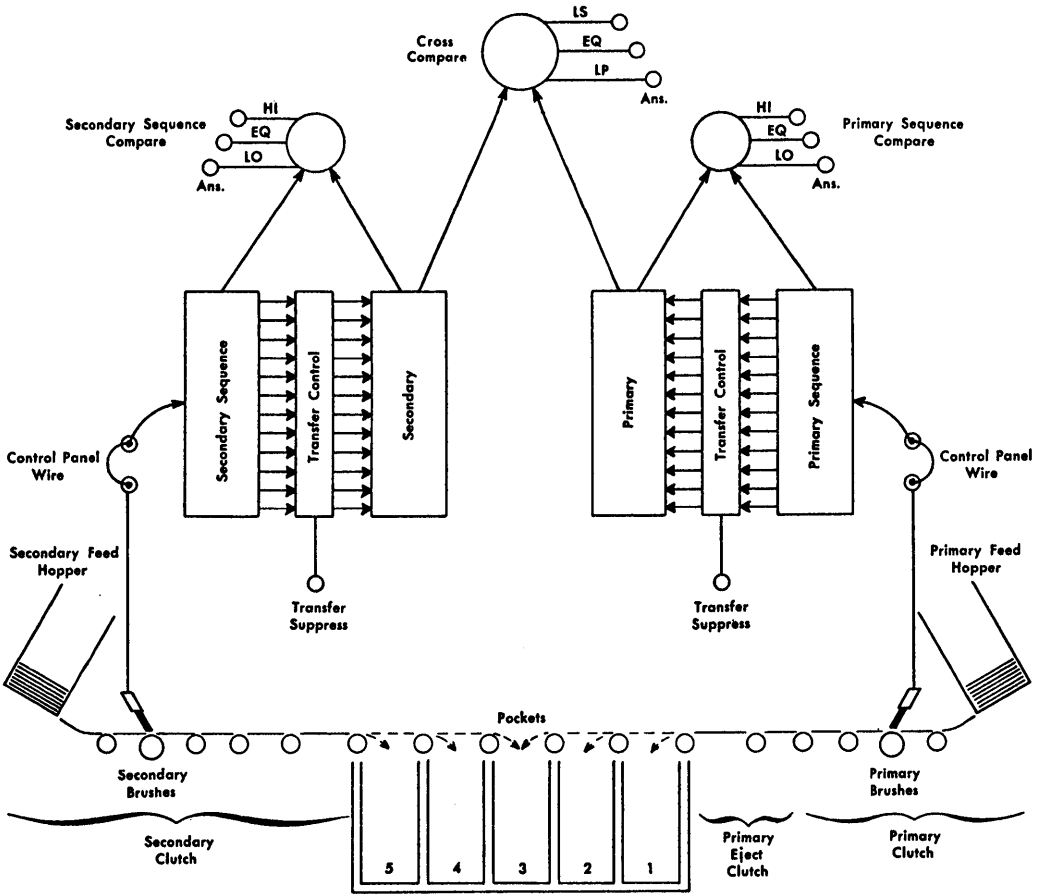
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Figure 7-37.—Schematic diagram.

performed in the same manner as in primary. The secondary sequence storage and the secondary storage can be shifted under the control of the primary clutch, expanding primary storage to double its capacity for expanded sequence checking operations. This is done by control panel wiring.

Control Panel

The control panel for a full capacity machine is shown in figure 7-39 with the shaded areas representing optional features. The upper right portion of the two-section panel corresponds essentially to the primary feed and the upper left side to the secondary feed. The lower part of each section is used for control.

The basic setup and basic machine control hubs can be located by referring to figure 7-39 as they are described below Supplemental hubs will be discussed when used.

MERGE/MATCH (C,D,E,44).— These switches are used to establish a basic setup. By wiring the switch for the appropriate
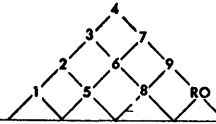
	GENERATED		ZONE			NUMERICAL				
Bit	10	9	8	7	6	5	4	3	2	1
Code	G1	G2	12	11	0	A	B	C	D	E
Blank	x	x								
· (12-3-8)		x	x			x		x	x	
□ (12-4-8)		x	x					x	x	x
& (12)		x	x							
$ (11-3-8)		x		x		x		x	x	
* (11-4-8)		x		x				x	x	x
— (11)		x		x						
/ (0-1)		x			x	x	x			
, (0-3-8)		x			x	x		x	x	
% (0-4-8)		x			x			x	x	x
# (3-8)		x				x		x	x	
@ (4-8)		x						x	x	x
A (12-1)			x			x	x			
B (12-2)			x			x		x		
C (12-3)			x			x			x	
D (12-4)			x			x				x
E (12-5)			x				x	x		
F (12-6)			x				x		x	
G (12-7)			x				x			x
H (12-8)			x					x	x	
I (12-9)			x					x		x
J (11-1)				x		x	x			
K (11-2)				x		x		x		
L (11-3)				x		x			x	
M (11-4)				x		x				x
N (11-5)				x			x	x		
O (11-6)				x			x		x	
P (11-7)				x			x			x
Q (11-8)				x				x	x	
R (11-9)				x				x		x
S (0-2)					x	x		x		
T (0-3)					x	x			x	
U (0-4)					x	x				x
V (0-5)					x		x	x		
W (0-6)					x		x		x	
X (0-7)					x		x			x
Y (0-8)					x			x	x	
Z (0-9)					x			x		x
0					x					
1						x	x			
2						x		x		
3						x			x	
4						x				x
5							x	x		
6							x		x	
7							x			x
8								x	x	
9								x		x
Run out									x	x

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Figure 7-38.—Character code chart.

188
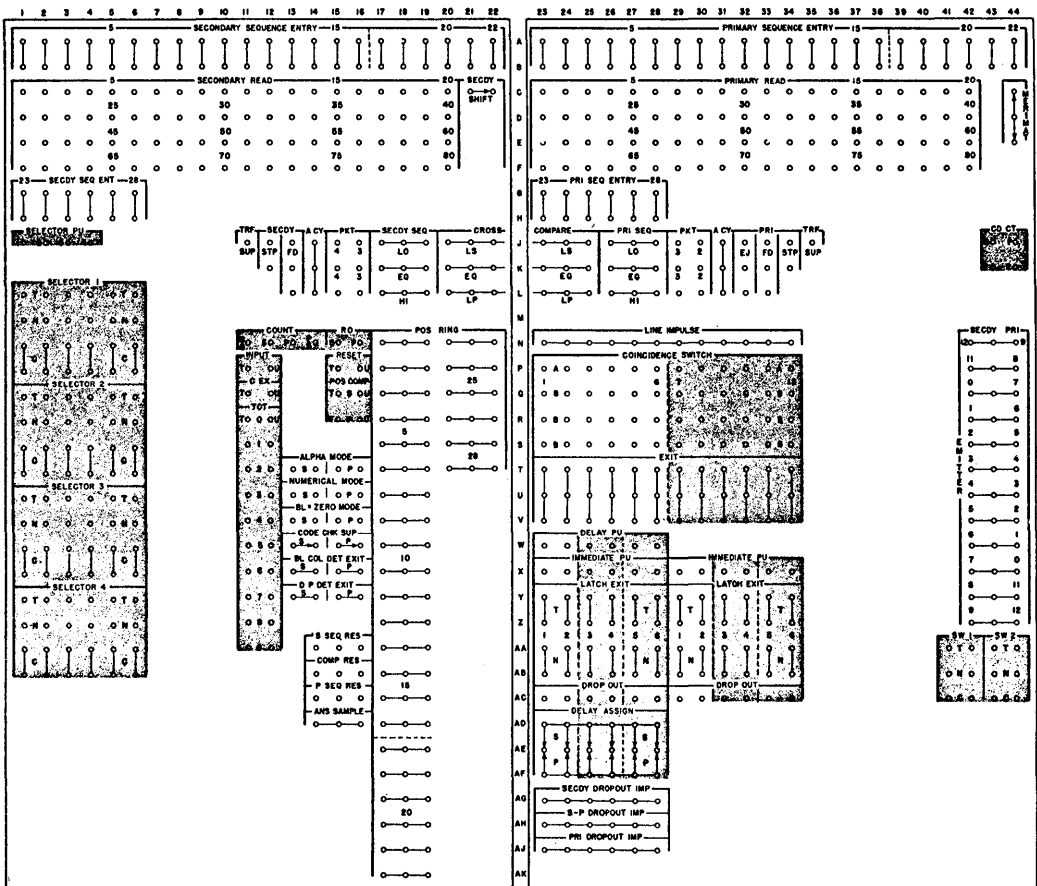
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Figure 7-39.—Type 188 control panel.

application, internal wiring automatically controls card feeding and error checking.

ALL CYCLES (J, K, L, 14, 31).—Each of these six exit hubs emits an impulse on each machine cycle. All cycles impulses are normally wired to feed entries or pocket select entries.

PRIMARY FEED (J,K,L,33).—An impulse to any one of these hubs picks the primary and primary eject clutch, causing a primary feed.

PRIMARY EJECT (J, K, L, 32).—An impulse to one of these hubs operates the primary eject

clutch to cause a card to be moved from the eject position to the stacker.

SECONDARY FEED (J, K, L, 13).—Picks the secondary clutch when impulsed, causing a secondary feed.

POCKETS 2,3, and POCKETS 3,4(J, K, L, 15, 16, 29, 30).—These are entry hubs used to control the stacking of cards into various pockets. They are normally wired from ALL CYCLES, selected impulses, or from impulses generated from compared data in the storage positions.

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POSITION RING (N-T, 17-22 U-AK, 17-19).—The number of these positions are the same as the storage capacity. They emit impulses in time with the corresponding position that is being read out of storage internally and are normally wired to the mode control hubs.

MODE CONTROL.—Data in the comparing units can be compared in three modes. However if one side of the machine is not being used, no wiring is necessary to the mode control hubs for that feed. When ALPHA MODE S, P(T, 13-16) hubs are wired from the position ring exits to the first position of an alphamerical field, the collating mode is in the order of blanks, 11 special characters, A-Z, 0-9. In this mode double punch detection is automatic. Therefore, special characters that have two digits in their coding are detected. When this condition exists, the code check suppress switch (W, 13, 16) must be wired ON for the columns containing these characters.

Impulses from the position ring exit hubs to the NUMERICAL MODE S, P, (U, 13-16) entry hubs select the numerical mode of operation for either feed. This collating mode provides comparison with a sequence of blank or zero, 1-9. Blanks are treated as zeros and do not cause an error. Columns can be overpunched with 11 and 12 punches, but double punching 0-9 is considered an error.

When wired for numerical mode the first column NOT to be collated or sequence checked must be wired from position ring exit corresponding to that position to either of the other two modes.

The BLANK EQUAL ZERO S, P, (V, 13-16) hubs, when wired from position ring exit provides comparison with a sequence of 0-9. A blank or multiple punch (0-9) is detected as an error. Card columns can be overpunched with 11 and 12 punches. When these hubs are impulsed, the alpha mode and numerical mode are off.

PRINCIPLES OF CONTROL PANEL WIRING

There are many operations that can be performed on the 188 collator and several different ways to wire the control panel to obtain the desired results. The following paragraphs describe some of the typical applications, along with illustrations of wiring diagrams.

Checking Sequence

Figure 7-40 illustrates the control panel wiring for sequence checking cards in the primary feed using the three modes of control. Three fields are to be sequenced checked. Columns 1-5 are an alphamerical field, columns 6-12 are numerical, and columns 13-15 are numerical-blank equal zero.

1. The control fields are wired from PRIMARY READ to PRIMARY SEQUENCE ENTRY. This wiring causes data to be read into the storage units.

2. The high, low, or equal comparison in the storage units is available at the answer hubs, so, the wiring to sequence check the ascending order of the cards is LOW PRIMARY SEQUENCE to PRIMARY STOP.

3. Wire ALL CYCLES to PRIMARY FEED to feed cards every machine cycle, and to POCKET 2 to stack all cards in pocket 2.

4. POSITION RING 1 is wired to ALPHA MODE PRIMARY to set the circuitry for the first field (1-5).

POSITION RING 6 is wired to NUMERICAL MODE PRIMARY for the second field (6-12).

POSITION RING 13 is wired to BLANK EQUAL ZERO MODE PRIMARY for the 13-15 field.

POSITION RING 16 is wired to BLANK EQUAL ZERO MODE PRIMARY so that the unused positions of storage are treated as zero. This conditions storage so that blank column detection will not affect the remaining positions.

Checking sequence in the secondary feed could be done by duplicating the wiring, but utilizing the secondary hubs, and stacking secondary cards into pockets 3 or 4.

Merging

The MERGE SWITCH controls card feeding from either feed in a merging operation. The machine automatically stops on a low sequence condition.

Wiring for a numerical merging operation is illustrated figure 7-41.

1. The primary and secondary control fields are wired to the primary and secondary sequence entries.

2. Merge switch is wired to control card feeding.

3. All cycles wired to pocket control 3 in both feeds direct the cards to the merge pocket.

4. Position ring 1 is wired to numerical mode hubs of both feeds to set the circuitry. Position ring 6 is the first column not to be collated or sequence checked and must be wired to the blank equal zero mode.

Merging With Selection

The cross compare hubs are associated with their respective storage areas. They are used for controlling the machine operation according to the results of the comparisons made between the data in primary and secondary storage.

Wiring for merging with selection is illustrated in figure 7-42.

1. The control fields are wired the same as for straight merging.

2. Wire merge switch to control card feeding automatically.

3. Wire equal cross compare answer hubs to select pocket 3 for both primary and secondary cards.

All cycles wired to pocket 2 selects low primary cards into pocket 2. All cycles wired to
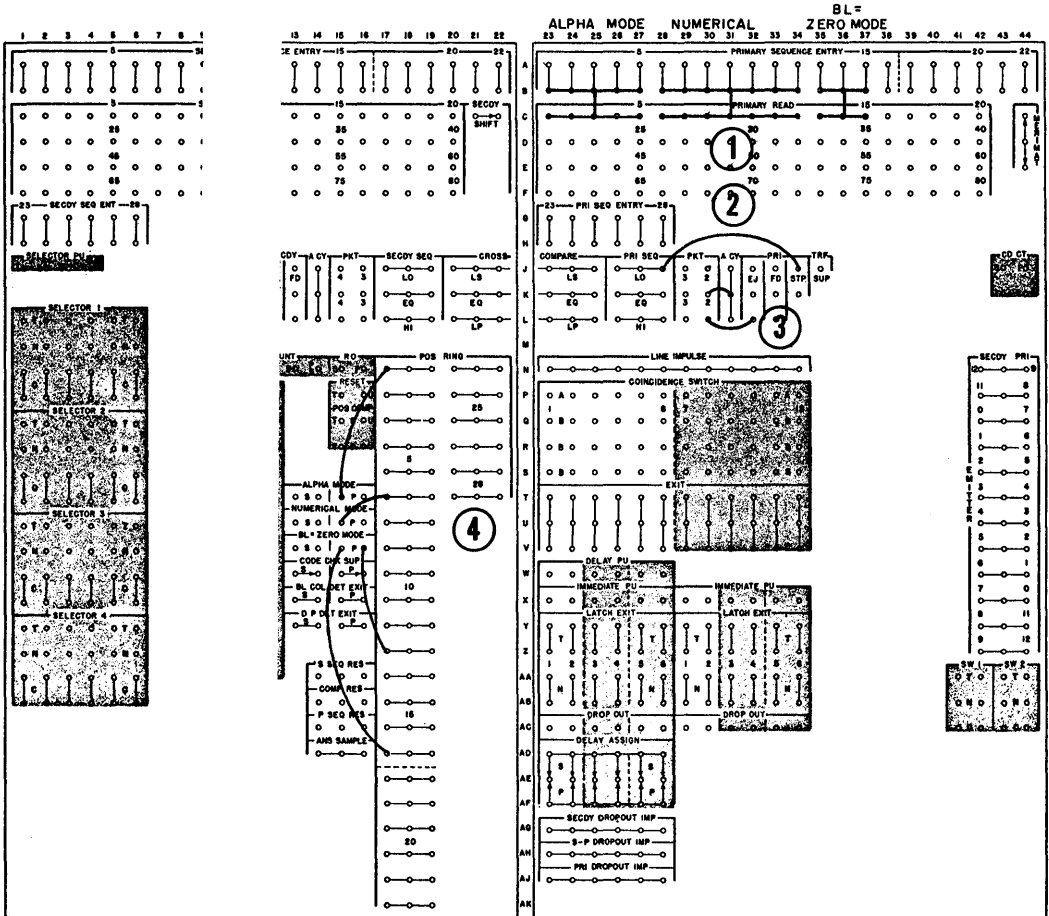
Figure 7-40.—Checking sequence.

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pocket 4 selects low secondary cards into pocket 4. When equals feed, the impulse to pocket 3 takes precedence.

4. Wire position ring 1 to alpha mode.

Matching

The match switch controls card feeding on a matching operation by internal circuitry. The machine stops automatically on a low sequence condition and operates in the same pattern as the merging operation, with the exception that the primary and secondary feed simultaneously when the comparing areas are equal.

The wiring for matching is illustrated in figure 7-43.

1. The control fields are wired the same as for straight merging.

2. Wire match switch to control card feeding.

3. Equal cross compare answer hubs are wired to pockets 2 and 4 This causes the matched cards in the primary and secondary to stack in

49.353

Figure 7-41.—Merging.

pockets 2 and 4 respectively The unmatched primaries and secondaires stack into pockets 1 and 5 respectively.

4. Position ring 1 is wired to numeric mode, and the first column to be ignored is wired to blank equal zero.

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Figure 7-42.—Merging with selection.
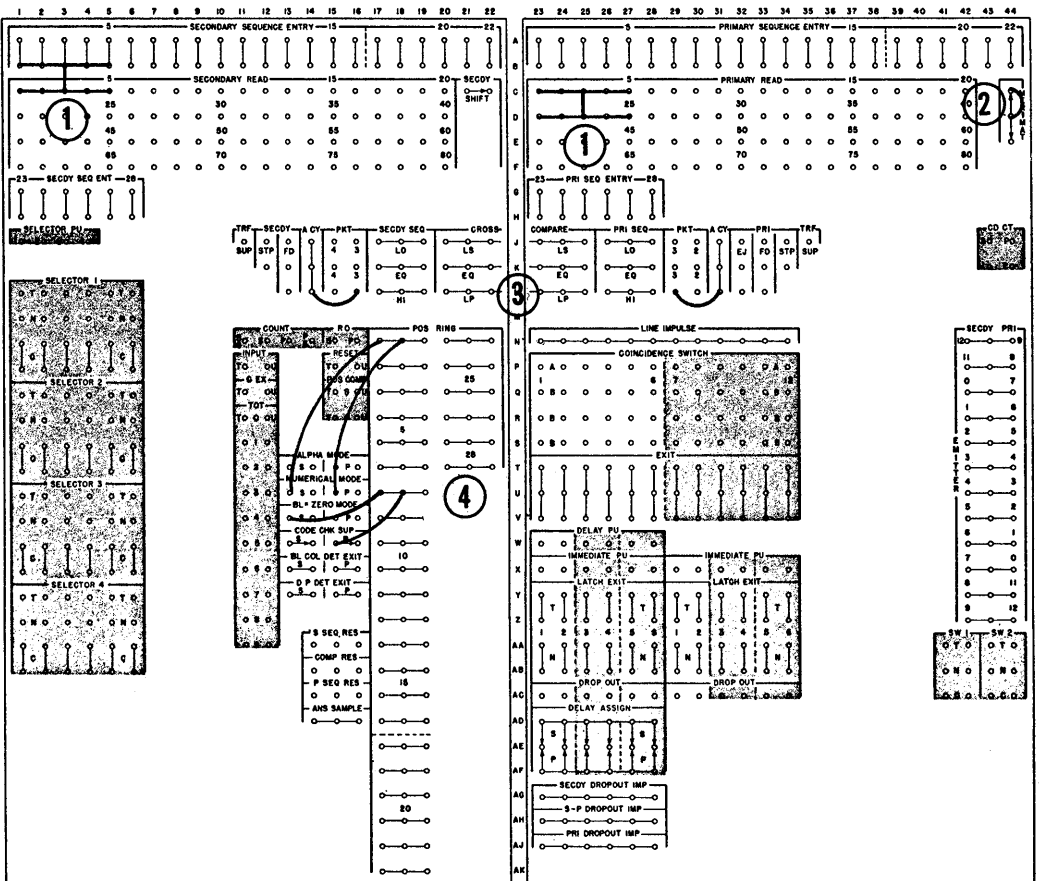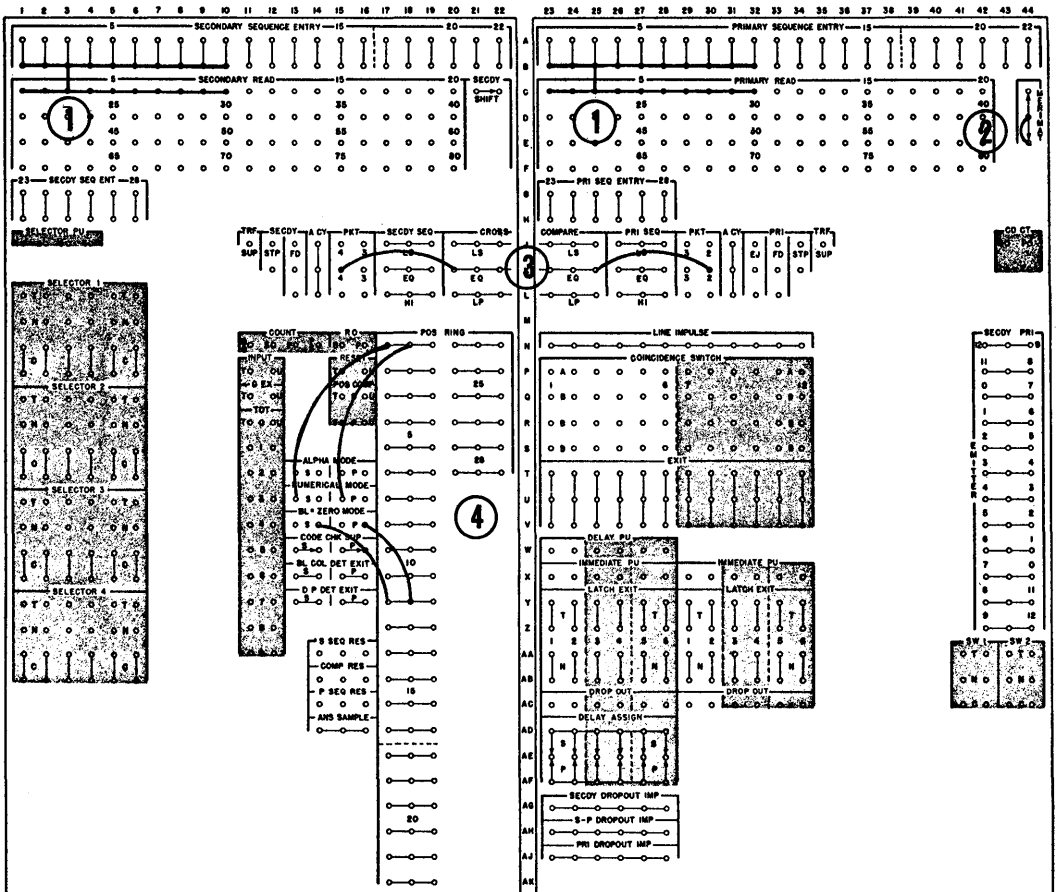
49.355

Figure 7-43.—Matching.

CHAPTER 8

ACCOUNTING MACHINES

The punched card accounting principle is composed of three basic steps. First, source data must be converted to punched cards. Second, these cards must be sorted to the sequence in which they are to be used. Third, the finished product, usually in the form of a printed report, must be prepared. This chapter discusses the machines used to accomplish the third step.

Accounting machines are designed to print and accumulate data contained in punched cards at speeds to 150 cards per minute. The speed of operation depends upon the type of machine used and the particular job being performed. Operations which accounting machines are capable of doing can be grouped in five general categories as follows:

1. DETAIL PRINTING. Detail printing is the printing, or listing, of data from each card that passed through the machine. All or any part of the card can be printed in any sequence desired, through proper control panel wiring.

2. GROUP PRINTING. Group printing differs from detail printing in that only the identifying data for a particular group of cards is printed. This information usually is taken from the first card of a control group, and all other cards in that group are tabulated without any data being printed from them. This type of printing is used primarily to identify totals that are being accumulated.

3. ACCUMULATING. Totals punched in cards, or a count for each card, can be accumulated and stored in counters until such time as it is desired to have these totals printed. The machine can be directed through proper control panel wiring to add or subtract certain cards and disregard others.

4. PROGRAMMING. This is the process by which the machine can tell the difference between cards in one control group and those in another. This is done by comparing a card at one reading

station with a card at the following reading station, much as comparing is performed in a collator. Impulses resulting from an unequal reading normally are used to start an automatic program cycle so that accumulated totals can be printed.

5. SUMMARY PUNCHING. When the accounting machine is connected by cable to an automatic punch, totals which have been accumulated in counters of the accounting machine can be punched into summary cards in the automatic punch. Identifying data also can be punched in the summary cards to identify the particular totals punched. Information punched in summary cards usually is printed by the accounting machine after the summary punch cycle has been completed.

There are several types of accounting machines which may be used to perform the operations listed above. However, only the IBM type 407 is discussed in this chapter, since it is the accounting machine you will most likely be required to operate. You will notice that certain operations discussed will be familiar to you already, because of a similar operation discussed in one of the preceding chapters. For example, you know that a machine differentiates between a control field in one card and a control field in another by comparing the two cards in a comparing unit. You know also how an impulse is allowed to travel through the normal and transferred sides of a selector, depending upon whether the selector is normal or transferred.

This chapter presents the basic principles involved in wiring a control panel for performing some of the common accounting machine applications.

If you have a thorough understanding of these principles, you can develop a skill for wiring control panels to perform more complicated jobs, limited only by the capacity of the machine

and your own ingenuity. Additional information concerning accounting machines can be obtained from the appropriate machine reference manual, printed by the manufacturer. Consult your supervisor for assistance in obtaining such manuals.

OPERATING FEATURES

The IBM type 407 accounting machine, shown in figure 8-1, can perform all operations previously listed at the beginning of this chapter. Detail printing (listing) or group printing (tabulating) can be performed at the rate of 150 cards per minute.

MACHINE CONTROLS

The keys for controlling machine operations, and lights for indicating certain conditions, are illustrated in figure 8-2.

- MAIN LINE SWITCH (not shown) - Located on the upper left end of the machine, must be ON for all machine operations.
- START - The start key must be depressed to start cards feeding through the machine.
- STOP - When the stop key is depressed, card feeding stops before the next card is fed.
- FINAL TOTAL - The final total key provides for a manual control of total

STACKER

FEED HOPPER

CARRIAGE

OPERATING KEYS AND SIGNAL LIGHTS

FUNCTIONAL SWITCHES

CONTROL PANEL
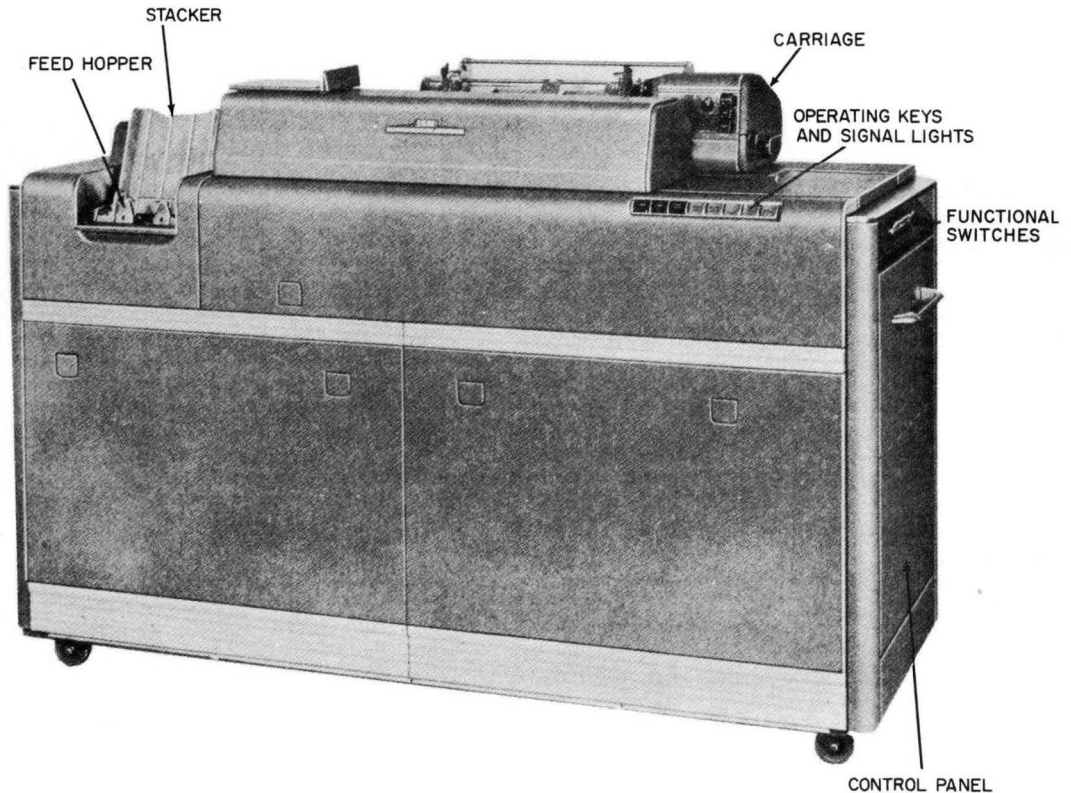
R49.106X

Figure 8-1.—IBM Type 407 accounting machine.

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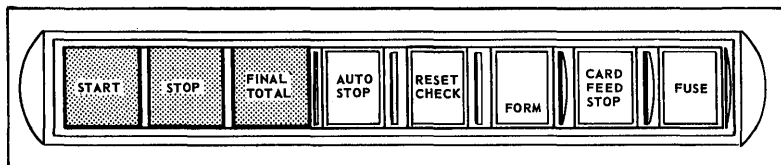
R49.107X

Figure 8-2.—Machine controls.

printing. Final totals can be printed when this key is depressed, provided the following conditions have been met:

1. The final total toggle switch is ON
2. The last card has been run out of the machine.
3. The machine is idling.

- AUTO STOP - When the automatic stop hub on the control panel is impulsed, this light goes on and card feeding stops. The light goes off and card feeding resumes when the start key is depressed.
- RESET CHECK - The type 407 has a reset check circuit installed which is designed to determine whether counters in the machine are reset correctly. This circuit is controlled by a reset check toggle switch, located on the right end of the machine. The reset check circuit is made inactive when this switch is OFF, and the reset check light flashes during machine operation to call this to your attention. If the reset check switch is ON and a counter fails to reset correctly, card feeding stops and the reset check light comes on. On later model machines, the counter which fails to reset correctly is identified by a light under the cover near the feed hopper. You will find that a reset error usually is caused by improper counter wiring on the control panel.
- FORM - An unlabeled light, which is the upper half of the form light, goes on when the main line switch is on and the machine is idling. The form light (lower half) goes on and the machine stops when the last form has passed the form stops, provided the form stop toggle switch is ON. This light can be turned off by inserting new forms and depressing the start key.

- CARD FEED STOP - This light goes on when a summary punch cycle is started, and remains on until the summary punch cycle is completed. This light comes on also if a card fails to feed from the hopper. In case of a card feed failure, remove all cards from the hopper, correct the card that failed to feed, and replace cards in the hopper. Depress the stop key to turn out the card feed stop light; then depress the start key. Card feeding will be resumed without having disturbed normal controls or spacing operations.
- FUSE - If a fuse burns out, the fuse light goes on. This light goes out when the bad fuse has been replaced.

Functional Switches

The functional control switches are located on the right end of the machine. These toggle switches can be seen in figure 8-3.
- ALTERATION 1, 2, 3, 4 - When any of the four alteration switches are turned on, a corresponding alteration switch selector in the machine transfers. These selectors can be wired on the control panel so that one panel may be used for more than one operation without changing the wiring. The switches function in both positions, transferred (T) or normal (N).
- INVERTED - The inverted form switch is turned on only when inverted forms are used. Inverted forms are those in which detail cards are printed before the heading cards. It is set to CONVENTIONAL for normal operations.
- FINAL TOTAL - This switch works in conjunction with the final total key, provided the control panel has been wired for final totals. With this switch off, the final total remains in the machine indefinitely and may cause subsequent erroneous totals if the counter are not reset.

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- FORM STOP - When a form is inserted in the carriage, it passes under a set of form stop levers. These levers drop into slots in the carriage when the bottom edge of the last form passes by them, and cause card feeding to stop, provided the form stop switch is turned on. They will not stop card feeding if the form stop switch is turned off.
- RESET CHECK - The function of this switch is described under RESET CHECK LIGHT.

FEED UNIT

Cards are placed in the feed hopper face down, with the 9-edge toward the throat. The capacity of the hopper is approximately 1,000 cards. Card feeding stops when the last card feeds from the hopper, and the start key must be depressed to run the cards remaining in the machine into the stacker. When the RO (Run Out) ON switch on the control panel (G-H, 79) is wired, these cards run into the stacker automatically. You are cautioned to utilize this feature only on small batches of cards for obvious reasons.

The stacker is located above and behind the hopper (figure 8-1). A stacker stop switch (not shown) causes card feeding to stop when the stacker becomes full. Cards can be added to the hopper or taken from the stacker without stopping the machine.

Card Reading

As cards feed through the accounting machine, they pass two reading stations, the first, then the second reading stations, illustrated in figure 8-4. Each card stops momentarily at each reading station so that it may be read by 960 brushes corresponding to the 960 possible punching positions in a card. Any hole punched in the card allows a corresponding brush to make contact with a metal segment, and causes an electrical impulse to be emitted. This impulse is transmitted from the commutator, which rotates clockwise to the brushes in that position, causing an impulse to become available from the corresponding reading hub on the control panel. There are 80 commutators at each reading station, one for each column of the card.

Impulses from the first reading station usually are wired to selector pickups or other machine control hubs to control machine operation on the following cycle. Impulses from the second reading station normally are wired to print or to counter entries, either directly or through selectors which are controlled from the first reading.

Jam Removal

In the event of a jam occurring in the card bed, the cards can be easily removed from the machine by first pressing the stacker lock, thus allowing the stacker itself to raise and swing toward the back of the machine. The brush holder may then be raised toward the front of the machine and the cards removed. The brushes recede into the holder when it is in the raised position to prevent any possible damage to the machine.

PRINT UNIT

The function of the print unit is to record information on a report form or document. This information can be printed one line for each card
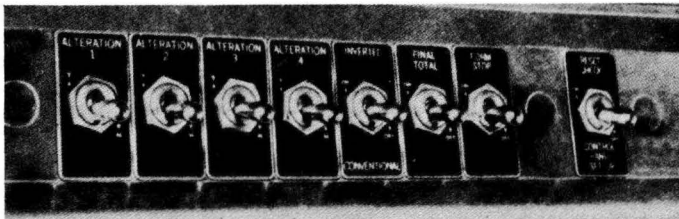
Figure 8-3.—Functional switches.

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STACKER LOCK

SPRING
FINGERS

STACKER

CARD WEIGHT

SWINGS UP

STACKER
DRUM

Pivot

SWINGS UP

FEED ROLL

Pivot

CARD GRIPPERS

READING
BRUSHES

READING
BRUSHES

CARD
LEVER

CARD
ALIGNER

CARD
ALIGNER

CARD
ALIGNER

CARD
LEVER

FEED ROLL

COMMUTATOR

COMMUTATOR

PRE-TEST STATION

SECOND READING STATION   FIRST READING STATION
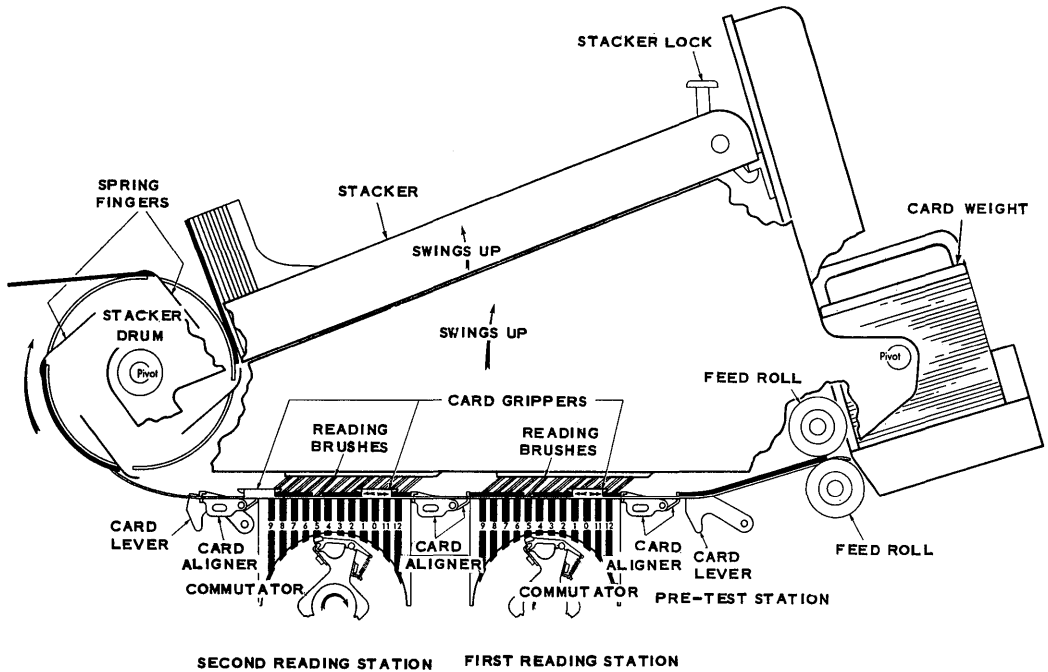
R49.110X

Figure   8-4.—Card feed schematic.

(detail printing), or one line for a group of cards (group printing).

The print unit consists of 120 printwheels arranged in a solid bank that prints within a width of 12 inches, 10 characters to the inch. Each printwheel, illustrated in figure 8-5, contains the 26 alphabetic characters, digits 0 through 9, and 11 special characters.

The character in the printwheel to be printed is determined by the holes punched in the card, or by the totals that the machine has accumulated. The printwheel rotates at a high rate of speed until printing time, when its speed is reduced to 25 percent of normal. At the actual time of printing, the wheel is moved against the platen in a straight line, producing maximum legibility. The rotary motion of the printwheel is compensated by a special cam. Printwheels which are not impulsed remain stationary.

A ribbon, similar to that used on typewriters, moves behind the printwheels from a spool on the right, through the ribbon guides, to a spool on the left. When the right spool is completely unwound, the action is automatically reversed.

TAPE CONTROLLED CARRIAGE

Automatic feeding and spacing of continuous forms used for preparing reports on the accounting machine is made possible by the tape controlled carriage, mounted atop the machine. A forms tractor is used for feeding marginally punched continuous forms. It has two adjustable tractor-type pin feed units, one for each side of the form. The standard forms tractor provides spacing of either six or eight lines to the inch.

This carriage is controlled by punches in a narrow paper tape which is inserted in the carriage, as shown in figure 8-6. The tape corresponds to the exact length of one or more forms, and is punched with holes which are

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Figure 8-5.—Printwheel schematic.

generally used to stop the form after it has skipped to a predetermined line on the form, and to skip from one form to another.

OPERATING FEATURES

Several of the carriage operating features can be seen by reference to figure 8-6.

When the PLATEN CLUTCH KNOB is pointed upward, the platen is engaged so that automatic line spacing and skipping can be accomplished. When the platen is engaged, it can be rotated manually only by turning the VERNIER KNOB. The primary purpose of the vernier knob is to provide a means of obtaining the correct printing position between lines when ruled forms are being used. The platen can be disengaged by turning the platen clutch knob to the right. The platen can then be turned manually by rotating the PLATEN KNOB in order to position the form at the desired printing line.

The RESTORE KEY must be depressed before an operation is started in order to set the carriage tape for the first printing line (home position) on the form. The platen should be disengaged when the restore key is depressed if skipping from one form to another is not desired.

When the STOP KEY is depressed, carriage operation stops immediately and card feeding

stops at the end of the cycle. It should be used only to stop undesired carriage skipping, or setting up for an operation, and should not be used to stop card feeding.

The SPACE KEY can be depressed when the accounting machine is stopped and the platen clutch is engaged, to advance a form one line for each key depression.

Form Thickness Adjustment

The distance between the printwheels and the platen can be increased or decreased, depending upon the number of copies in the report being prepared. The form thickness adjustment dial, located at the left end of the carriage, contains seven positions numbered 0 through 6. It should be set at the position where best printing results are obtained.

Pressure Release Lever

The pressure release lever is set in the forward position when a form feeding device is not used, so that pressure is applied to the paper by the form feed wheels to cause proper form feeding. When a form feeding device is used, this lever must be pushed back so that the feed rolls are released and the paper can be moved freely around the platen.

End-of-Form Stop

When a form is inserted in the carriage, it passes under a set of end of form stop levers. These levers drop into slots in the carriage when the bottom edge of the last form passes by them, and cause card feeding to stop, provided the form-stop toggle switch is turned on. They will not stop card feeding if the form-stop toggle switch is turned off.

Platen Shift Wheel

The platen shift wheel can be rotated to shift the platen, either right or left, a total of four inches. It is used primarily to align a form so that printing will occur in the desired space across the form. This wheel can be turned while the machine is in operation.

CARRIAGE TAPE

The carriage control tape, shown in figure 8-7, has 12 channel punching positions, represented by a numbered vertical line for each

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position. The numbered horizontal lines correspond to the printing lines on a form when six lines to the inch are printed. The round holes in the center of the tape are prepunched for the pin feed drive that advances the tape as the printed form moves through the carriage.

Tape Channels

The following functions are controlled by punches in the tape channels:

FIRST PRINTING LINE STOP. Channel 1 is usually punched for the first printing line on a

form, and is called the starting, or home, position. When the restore key is depressed, the tape revolves until the punch in channel 1 is read by the tape reading brushes.

NORMAL SKIP STOPS. Channels 2 through 10 are used to stop the form at one of nine positions. They may be used to identify the first body line when 2-part (heading and body) forms are used. Any class of total can be printed on a predetermined line by starting a skip when program start is initiated, and stopping the skip by a punch in one of these channels. Single sheet forms can be processed through the carriage
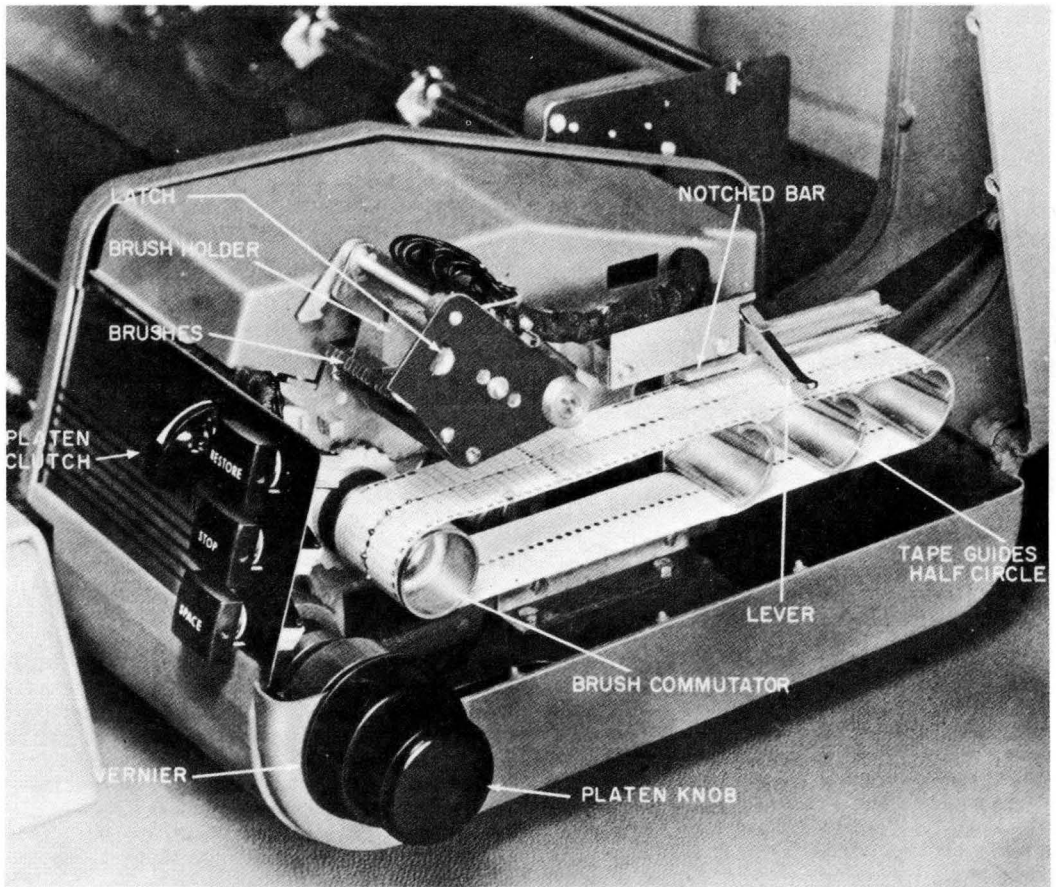
Figure 8-6.—Tape controlled carriage.
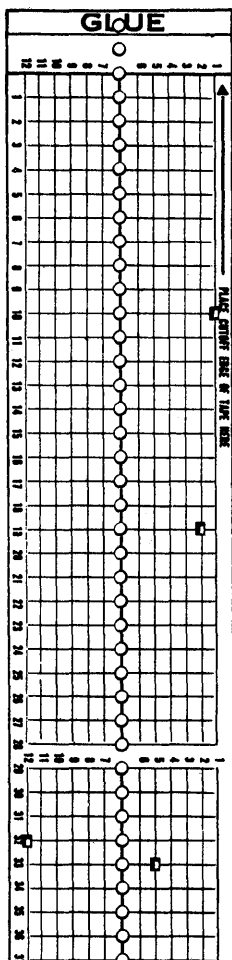
R49.118X

Figure 8-7.—Control tape.

and ejected automatically when printing is completed. These channels can be used for many other functions in which skipping between the first and last printing lines is desired. Channel 11 is normally used for selective spacing operations.

OVERFLOW CONTROL. Skipping can be controlled so that when one form is completely filled, the next form advances to the first printing or body line. This overflow skipping is started by a punch in channel 12. Unlike punch-

ing in other channels, which are used to stop skipping, the punch in channel 12 is used to start a skip. When the punch in channel 12 is sensed by a tape reading brush during normal spacing, card feeding stops and skipping starts. If head control is not wired, overflow skipping will be to channel 1, which is the first printing line. If head control is wired, overflow skipping will be to the first printing line if overflow page identification is to be printed, or the skip can be made directly to any stop used to identify the first body line.

Tape Punching

Suppose you wish to prepare a control tape for a routine operation in which head control is not used, and predetermined total lines are not required. This can be done very easily by following a few simple steps as follows:

1. Place a blank tape on top of a sheet of the continuous form paper you are going to use so that the dark horizontal line, just under the GLUE portion of the tape, is even with the top edge of the form. Now place a mark in channel 1 on the line corresponding to the first line on the form where you wish printing to start, which is usually one inch from the top of the form. Next, place a mark in channel 12 corresponding to the last line on the form to be printed, which is usually one inch from the bottom edge of the form. Finally, place a mark on the line corresponding to the bottom edge of the form. This is your end-of-tape mark.

2. The tape markings for one form should be repeated as many times as the usable length of the tape allows. In this way, the tape can be used to control several forms in one revolution through the sensing mechanism, thus increasing the life of the tape.

3. After the tape has been marked with channel punching positions and the end-of-tape mark, insert the tape in a tape punch similar to the one shown in figure 8-8 and punch the channels that you have marked. If your installation has an accounting machine with a tape controlled carriage, you will be furnished with a tape punch and plenty of blank tapes.

4. After all channel markings have been punched, cut the tape along the line corresponding to your end-of-tape mark. Roughen the GLUE end of the tape to remove the glaze. Now loop the tape into a belt, and glue the ends so that the bottom end-of-tape line is lined up exactly with the dark line just under the GLUE

portion. The center feed holes must be aligned to present the appearance of a continuous tape. The tape is now ready to be inserted in the carriage.

OPERATING SUGGESTIONS

When a report leaves the accounting machine, it has passed the final phase of machine processing required for its preparation. The following operating suggestions are listed to help you, the operator, make sure that the report has been prepared in accordance with instructions given you, and that the format and contents are correct to the best of your knowledge.

OPERATING THE MACHINE

Preparation of an accurate report hinges primarily upon a correctly wired control panel and a properly functioning accounting machine. Therefore, each operation should be tested for proper control panel wiring and machine operation prior to starting the actual job. Some reports which take hours to prepare are later found to be worthless because the operator failed to test the operation before he began turning out the report.
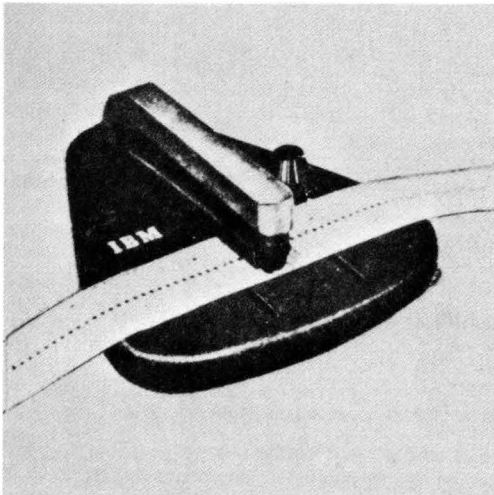
R49.357X

Figure 8-8.—Tape punch.

In addition to testing the operation, the following points should be kept in mind when operating an accounting machine.

Starting the Operation

Always depress the final total key before starting any operation, and before placing cards in the feed hopper, in order to clear any counters which may have totals in them from a preceding operation.

To protect yourself from a possible electrical shock, make sure the main line switches on both the accounting machine and the automatic punch are OFF before connecting the summary punch cable for a summary punch operation.

Joggle cards into perfect alignment before placing them in the feed hopper in order to ensure proper feeding.

During the Operation

Check the report from time to time as it is being prepared to make sure it is being prepared correctly. If totals are supposed to balance to predetermined totals, be sure to check these off as they print. Unless it is absolutely necessary for you to be somewhere else, stay with the machine while it is in operation so that you can make sure cards and paper are feeding properly, and that the printed forms are stacked correctly.

Stopping the Operation

Always use the stop key to stop card feeding. Never turn off the main line switch when the machine is in operation.

Depress the start key at the end of an operation in order to run the cards remaining in the machine into the stacker.

In case of a card jam, stop the machine immediatly and call your supervisor if you do not know what to do. He will demonstrate the correct procedure for removing a card jam.

OPERATING THE CARRIAGE

You can save yourself considerable time and effort at the beginning of an operation on the accounting machine by first making sure that the carriage is properly set for operation. The following paragraphs should assist you in seeing that this is done.

Inserting the Tape

Figure 8-6 shows a control tape inserted in the carriage. Before attempting to insert the tape, first make sure the platen clutch is disengaged and the brush holder is raised. The brush holder, which contains the brushes that read the punches in the tape channels, can be raised by pushing the latch to the left. The numbered edge of the tape must be placed in the outward position, toward you. The center feed holes are placed over the pinfeed drive wheel and the tape is then placed around the tape guides. Either guide may be used, depending upon the length of the tape. The lever just above the tape guides can be raised so that the guides can be moved to the desired position. Always leave a little slack in the tape after it has been inserted to prevent the tape from tearing under undue strain. Lower the brush holder and push it down until it latches. Depress the carriage restore key in order to place channel 1 at the home position. The platen clutch must be engaged before printing is started.

Inserting the Forms

The form thickness adjustment should be set at the position where the best printing for the particular forms used is obtained. If a form feeding device is used, make sure the pressure release lever is pushed back so that the forms will feed properly. Be sure the forms are fed under the form stops and not over them. Position the paper so that the first printing line is in position to be printed, and align the paper so that printing will occur in the desired locations across the form.

Operating the Carriage Controls

Do not use the carriage stop key to stop card feeding in the accounting machine. Although this key will stop card feeding when depressed, it is not intended to be used in place of the regular stop key on the accounting machine. Use it only to stop a carriage operation. Make sure the carriage has been restored and the platen clutch is engaged before beginning an operation. Failure to restore the carriage causes improper spacing of forms, and failure to engage the platen causes overprinting.

PRINCIPLES OF CONTROL
PANEL WIRING

Automatic operation of the accounting machine is made possible by the control panel, illustrated by the diagram in figure 8-9. A universal control panel is used with the 407, 408, and 409 machines. The hubs with the heaviest outlines are used for the 408 and 409 only; the hubs outlined with cross-hatching are used for the 409 only. Shaded areas represent special devices or optional features. Operations described herein are limited to those features standard for the type 407.

There are many operations that can be performed on the type 407 accounting machine, and several different ways to wire the control panel to obtain the desired results. The following paragraphs describe some typical applications, with descriptive control panel wiring.

PROGRAM CONTROL

Before we go any farther, lets see what is meant by programming on accounting machines. Programming in a machine is a sequence of activities, or, to use machine terms, operations. The operations to be performed, and their sequence, are determined by control-panel wiring. Actually, a series of machine cycles is set aside for this purpose. These machine cycles are generally called PROGRAM CYCLES, PROGRAM STEPS, or TOTAL CYCLES.

Program control is the process by which the 407 distinguishes cards of one classification from those of another. The cards in a single classification are considered a program group.

The machine can compare, by means of the first and second reading stations, the holes punched in two successive cards. Therefore, each card is compared twice as it passes through the machine, once with the card ahead of it and once with the card following it. When the punching in one card does not compare with the punching in the card ahead of it, the machine automatically starts a program cycle, if the control panel is wired properly.

Three types of automatic totals can be obtained on the 407 and are classified as follows:

1. Minor - Program level 1
2. Intermediate - Program level 2
3. Major - Program level 3

A minor program is used for the classification of the smallest group, intermediate program

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Figure 8-9. —Type 407 control panel.

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for the next group, and major program for the largest group.

Comparison is accomplished by wiring the control field from first reading to one set of comparing entry hubs and from second reading to the corresponding positions in the other set. The hubs used for wiring comparing can be located by reference to figures 8-9 and 8-10A. An impulse is emitted from the comparing exit hub of each comparing position that recognizes a difference in card comparing.

Each comparing position, containing two comparing magnets, is represented on the control panel by a comparing entry hub for each comparing magnet and a common comparing exit hub. If both magnets in a comparing position receive an impulse at the same time, or if neither magnet receives an impulse, no change in control groups is recognized, and the comparing exit hub is inactive. If one magnet receives an impulse at a time different from the other, a change in control groups is recognized, and the comparing exit hub emits an impulse. When a control field consisting of more than one column is wired for comparing, the comparing exit hubs of all comparing positions are jackplugged so that an unequal condition recognized in any column can travel through the jackplugs and be available from one source.

A comparing magnet can be impulsed once while the 9-1 punching positions are being read, and again for the 11-12 zone positions, making it possible to compare alphabetic as well as numerical data. Zero punches are treated as blank, since comparing is not effective for zeros.

Comparing exits are usually wired to one of the program start hubs to cause a program cycle to be started in order to print automatic totals for that particular program. Comparing exits can be used also for other functions, such as skipping to a new page when a change in control groups is recognized.

A total cycle for each type of total, MINOR, INTERMEDIATE, or MAJOR is started by wiring a comparing exit from a control field wired for comparing to the appropriate PROGRAM START hub (fig. 8-10 B).

Each program step has 14 PROGRAM EXIT hubs shown in figure 8-10 C that emit an all cycles impulse whenever the corresponding PROGRAM START is impulsed. Counters normally read out and reset under the control of the PROGRAM EXITS.

An impulse wired to program start MINOR starts a minor program, and allows counters wired for minor totals to print and clear. An impulse wired to program start INTERMEDIATE starts an intermediate program, and counters wired for intermediate totals can print and clear. An impulse received by program start MAJOR causes a major program to be started, and counters wired for major totals can print and clear. If program start intermediate is impulsed but minor is not, a minor program is forced before the intermediate. If program start major is impulsed but minor and intermediate are not, minor and intermediate programs are forced before the major. Card feeding stops when a program start is initiated and resumes automatically upon completion of the required number of total cycles.

By reference to figure 8-10D, you will notice a group of FIRST CARD hubs. The common hubs on the left, labeled MINOR, INTERMEDIATE, and

A   C-F, 1-20

B   C-D, 31-34
E, 31-32

C   AP-AT, 53-66

D   M-O, 73-77

49.358

Figure 8-10.—Program control hubs.

MAJOR, emit an impulse for the first print cycle of the first card of their respective group, regardless of whether that card is a heading or detail card. FIRST CARD hubs are normally wired to cause a counter to add or subtract the first card of a group, to control transfer print entry, or to control a co-selector.

Each first card hub has a first card selector which transfers automatically when the corresponding first card hub is active, and remains normal at all other times. These selectors can be used to select card cycle impulses, cycle count impulses, or single card columns to be group indicated. Further use of all the aforementioned hubs will be demonstrated in the following applications.

PRINTING

There are two sets of exits on the control panel from the second reading brushes; they are completely interchangeable. Only one wire from second reading to any of the 120 printwheels is required for printing any number, letter, or special character. Impluses from first reading are usually wired to control hubs, as stated earlier.

Three sets of entries to the printwheels are provided in the 407, they are:

● NORMAL PRINT ENTRY
● TRANSFER PRINT ENTRY
● COUNTER CONTROLLED PRINT

NORMAL PRINT entry is usually used for information read from cards, from an emitter, or from the storage units of the machine. NORMAL PRINTING can be performed as illustrated in figure 8-11.

1. Card columns 6-10 of second read are wired into printwheels 10-14 of normal print, and this wiring will perform printing of every card.

Data entered in transfer print entry reaches the printwheels only when the TRANSFER PRINT PICKUP hub (TR PR) is activated by a control impulse. The unit remains transferred only for the duration of the impulse wired to the pickup hub.

Printing can be controlled so that one type of card prints on one print cycle and other types on other print cycles. This is possible by using two sets of entries to the printwheels; normal print entry and transfer print entry. When TR PR (transfer print) is impulsed, the transfer print entry hubs are active and provide entrance to the printwheels. The normal print entry hubs provide entrance to the printwheels at all other times. As the transfer print entry hubs are active only for the duration of the impulse wired to TR PR, it is not practical to impulse TR PR from digit punches. TR PR should be wired from cycles impulse, such as CARD CYCLES, FIRST A CARD impulses, and program exits. Figure 8-11 illustrates one method of printing using the TRANSFER PRINT method.

2. Card colums 15-19 of second read are wired into printwheels 16-20 of transfer print entry. The only cards that will be printed will be the first card of each control group.

3. Card columns 25-28 of each card are compared to card columns 25-28 of each succeeding card. When there is a difference, a minor program will be initiated.

4. Whenever a minor program is initiated, the first card minor hubs emit an impulse. This impulse is wired to transfer print pickup and transfer print will be activated for the first card of each control group and therefore will print the first card of each new minor program control change.

COUNTER CONTROLLED PRINT accepts only numerical information, and is internally common to either NORMAL or TRANSFER PRINT ENTRY, whichever one is active during a print cycle. These hubs provide the only means of resetting the counters as the total is printed. A cycle on the 407 is divided; on the first half of the cycle counter controlled print receives impulses from the counter exit and sets up the printwheels for printing. On the second half of the cycle the information is read back from the printwheel through counter controlled print to the counter exit from which it originated. This return impulse during the second half of the machine cycle is called the ECHO IMPULSE. If the counter is wired to reset, the information is either added or subtracted in the counter to reach a zero balance, thus affording a check between the amount printed on a report and the amount accumulated in the counter. Figure 8-11 (items 5-12) depicts a method of wiring for COUNTER CONTROLLED printing.

Assume that we want to count each card of a particular control group as it passes through the machine, but we only want to print the total number of cards when there is a difference in card columns 1-2.

5. Card columns 1-2 of first and second read are wired to comparing positions 10-11.
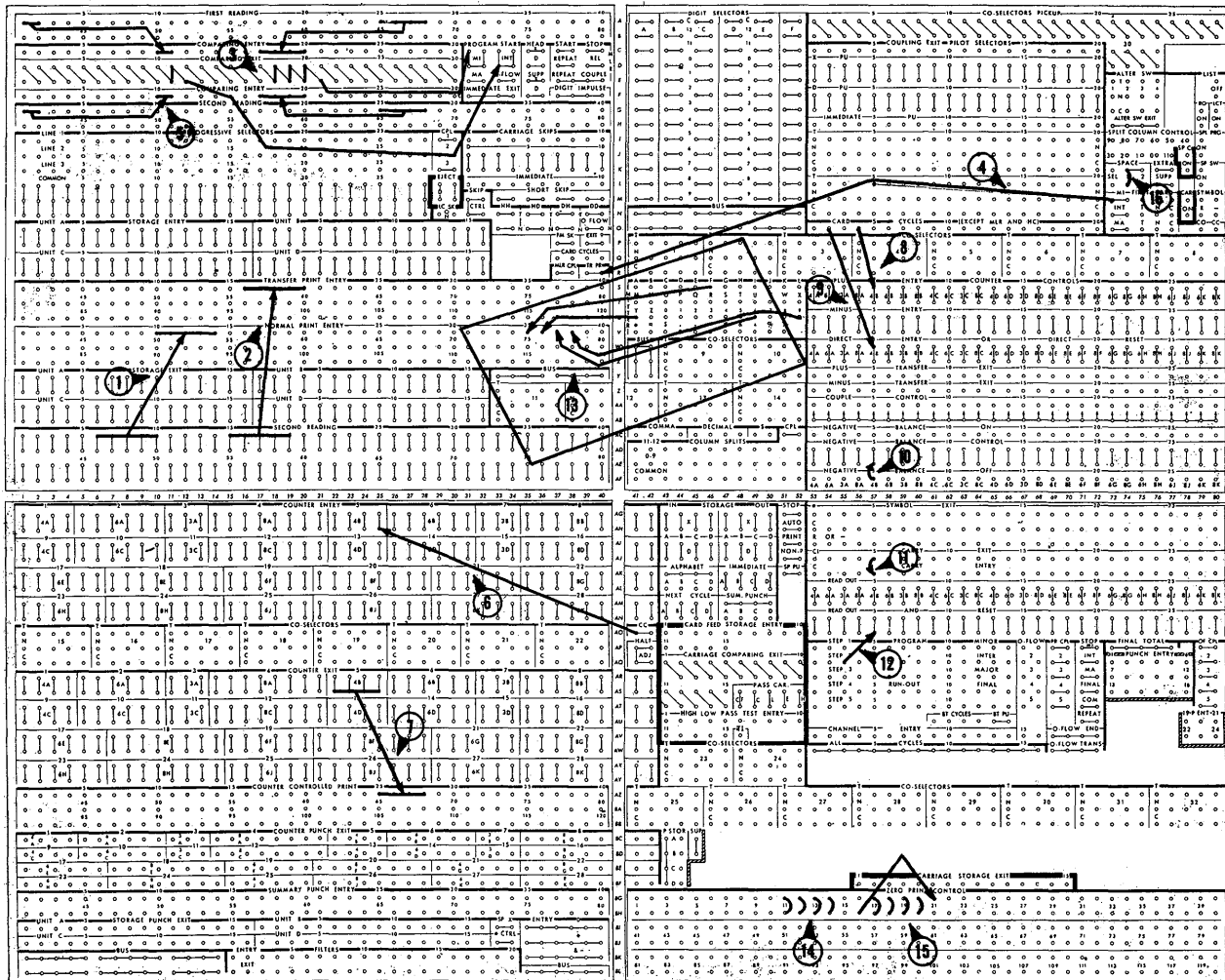
Figure 8-11. — Printing.

Where there is a difference of controls, program start INT will be activated.

6. Cycle count is wired to the unit position of counter 4B entry. This provides a means of accepting the cycle count for accumulation.

7. Counter 4B exits are wired to counter controlled print. This provides a passage of accumulated amounts to the printwheels for printing.

8. A card cycle wired to 4B entry plus hub will allow the counter to accept the cycle count, therefore adding a one for each card that passes through the machine.

9. An additional card cycle is wired to direct entry of counter 4B. This impulse causes the connection between counter entry and exit to be broken and allows adding in the counter to be direct as opposed to adding from counter controlled print on the second half of the cycle. Printing for each card is suppressed.

10. Negative balance OFF is wired to negative balance control to convert the complement of zero balance, and should always be wired when dealing with positive totals.

11. CI and C must be wired to provide a carry back to compensate for shortages that would result because the counter resets to 9 instead of zero, and also because the use of the 9s complements method of subtraction.

12. When a change in controls occurs in card columns 1-2 and program start INT is activated, the INT program exit hubs will emit. When wired to read out and reset of counter, 4B will clear so that accumulations for the next control can be initiated.

Character Emitting

The character emitter supplies character impulses on each machine cycle, which correspond to the characters that can be punched in a card. These emitted characters can be printed each time a card is printed, or when totals are printed. Step number 13 in figure 8-11 shows in the enclosed box the character emitter wired to print FY 69 (fiscal year, 1969) as each card is printed, or on each machine and total cycle.

Zero Printing

Printing of zeros is controlled by the zero print control feature in a manner similar to that used in the type 557 interpreter. Each printwheel has two zero print control hubs, arranged so that the hub in the lower row is diagonally connected to the hub in the upper row to the right. When the upper hubs, representing the printwheels used

for printing a numerical field are jackplugged to the lower hubs directly beneath them, each zero print control position is connected to the position to the right. Thus, zeros will print to the right of any significant digit in the field. Wiring for printing zeros to the right of significant digits is illustrated in wiring step number 14 in figure 8-11.

If zeros are to print to the left of the high order significant digit, then the lower hub of the high order zero print control position in the field must be wired to the upper hub of the low order printing position. All other zero print control positions must be wired the same as for printing zeros to the right of a significant digit. Wiring for printing zeros to the left of significant digits is illustrated in wiring step number 15 in figure 8-11.

Zeros can be printed only if they actually reach print entry. For example, if a field wired to print entry contains blank colums, the printwheels to which those blank columns are wired will not print anything.

Special characters actuated by single 11 and 12 zone punches must be wired for zero print control in the same way as zeros.

Spacing

Spacing of printed reports usually is controlled by the SPACE hubs (fig. 8-9, K-L, 74-77). The two common hubs are exits which may be used to control spacing. Six lines to the inch are printed if SPACE 1 is wired, and three lines to the inch if SPACE 2 is wired. If EXTRA is wired, an extra space occurs after each card prints. If SPACE 1 and EXTRA are impulsed at the same time, the result is double spacing. Impulsing SPACE 2 and EXTRA at the same time results in quadruple spacing. When space suppress (SUPP) hub is impulsed, space suppression takes precedence over all normal spacing. Either SPACE 1 or SPACE 2 must be wired for all machine operations. Failure to wire either hub results in continuous carriage skipping, which can be stopped by turning off the main line switch. Wiring for single spacing is illustrated in wiring step number 16 in figure 8-11.

SELECTION

Cards of different types which require processing in different ways usually are identified with an X or digit control punch in a designated column. Then, through proper wiring of selectors, the accounting machine can handle these different types of cards in different ways. For

example, if you wished to add one type of card and subtract another, you would need a PILOT SELECTOR. If you wished to print one field from one type of card and another field from another type, chances are you would need at least one pilot selector and one CO-SELECTOR. The operation of these two types of selectors is basically the same. Once either type is transferred, an internal connection is established between the common and transferred hubs, and any impulse entered into one hub is available from the other. If a selector is not transferred, it is said to be normal, and an internal connection exists between the common and normal hubs. An impulse entered into one hub is available from the other.

Pilot selectors and co-selectors differ only in the manner in which they are picked up, and the time at which they transfer. A pilot selector has three different pickup hubs. The X pickup (X PU) will accept 11 and 12 punches only, while the digit pickup (D PU) will accept any digits 9 through 12 and most machine impulses. Thus, if an X is used to control a pilot selector, digits 9 through 0 on the control column will not affect the selector pickup, provided the control column is wired to X PU. However, if a specific digit is used to control a pilot selector and there are other digits punched in the control column, then the column used for control must first be wired through a digit selector so that only the desired digit reaches D PU. When the X and D pickup hubs receive an impulse, the selector will transfer at the end of that cycle, and will remain transferred through the following card cycle, including any intervening total cycles. This means that if first reading is wired to X or D pickup, the pickup hub will receive the impulse from a card at first reading and the selector will be transferred when the card reaches second reading. The selector will remain transferred until the controlling card has been read at second reading.

The immediate pickup (I PU) of a pilot selector will accept any impulse, and will cause the selector to transfer immediately (within four to seven degrees) instead of at the end of that cycle. This means that if I PU is impulsed with a 9 punch, the selector will be transferred for the digits 9 through 12 at the same reading station.

If the immediate pickup hub is impulsed on a card cycle, the selector will return to normal at the end of that card cycle; if impulsed on a program cycle, it will return to normal at the end

of the following card feed cycle. Each pilot selector has a COUPLING EXIT hub, which emits an impulse at the time the corresponding pilot selector transfers, and will emit this impulse each cycle thereafter for as long as the selector remains transferred. These hubs are usually wired to co-selector pickup hubs in order to expand the capacity of a pilot selector beyond two positions.

Each co-selector has two common immediate pickup hubs. When one of these hubs is impulsed, the co-selector transfers immediately and remains transferred for the duration of the cycle on which impulsed. If the pickup hub is wired from the coupling exit of a pilot selector, the co-selector will transfer with the pilot selector and will remain transferred for the same length of time as the pilot selector.

Figure 8-12 is used to illustrate selector wiring for two different problems; controlling addition and subtraction, and performing class selection.

1. First reading 80 is wired to the X pickup of pilot selector 1.

2. NX-80 cards are added by wiring a card cycles impulse through the normal side of pilot selector 1 to counter control plus entry.

3. X-80 cards are subtracted by wiring the card cycles impulse from the transferred side of pilot selector 1 to counter control minus entry. The pilot selector will be picked up if a card at first reading is punched with a control X, and will be transferred when that card reaches second reading.

4. A 5-digit field can be class selected by using a co-selector. However, since the co-selector transfers as soon as a pickup impulse is received, this impulse must be delayed until the controlling card reaches second reading. This is done by wiring the control field from first reading to the pickup hub of a pilot selector, and wiring the pilot selector coupling exit to the pickup hub of the co-selector. Thus, since the pilot selector will not transfer until the end of the cycle on which impulsed, the co-selector will not be transferred until the controlling card reaches second reading.

5. The field to be selected is wired to common of the co-selector since it is to print in one place for X cards and in another for NX cards.

6. The normal hubs of the co-selector are wired to print in one place for NX-78 cards, and the transferred hubs are wired to print in another place for X-78 cards.
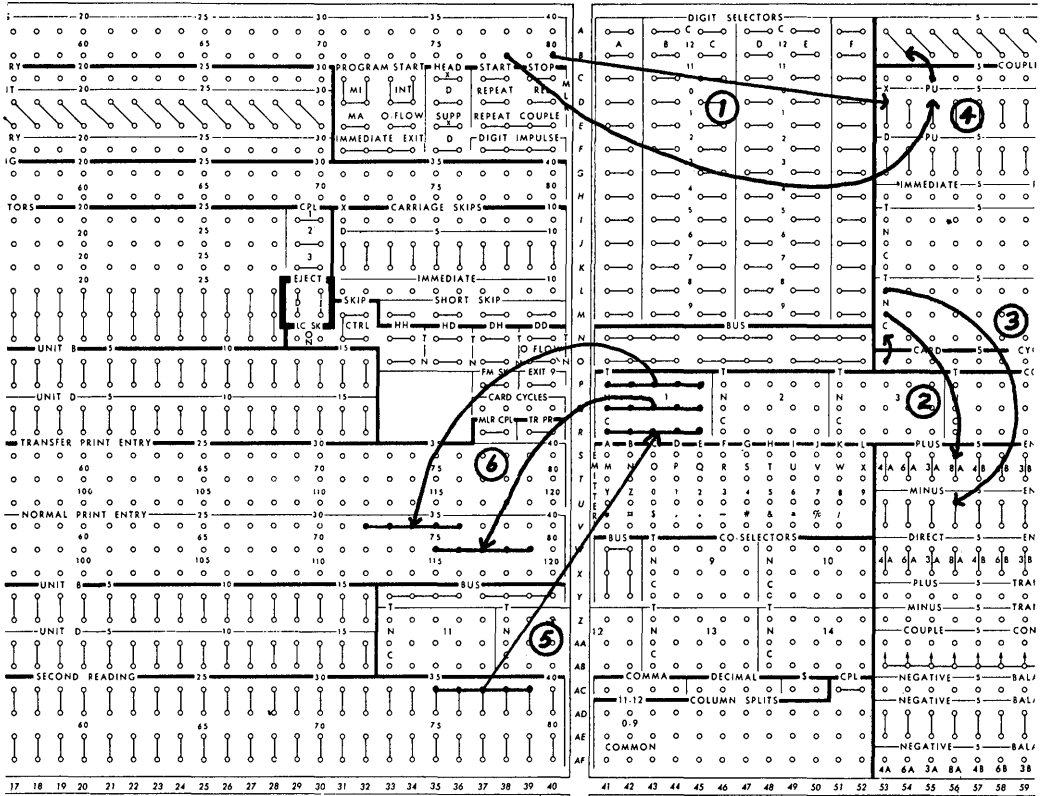
49.112

Figure 8-12 —Selection.

ADDITION

Adding can be defined as the accumulation of individual amounts to obtain a total. These amounts can be either punched in cards or a 1 count emitted by the accounting machine for each card cycle.

Accumulation is performed by a series of single position accumulators, or counter wheels, each of which is capable of adding up to 9. These counter wheels are grouped into units called counters, which vary in size from three positions to eight positions. Each position will add up to 9 and then carry any amount over that to the next position to the left. For example, if a cycle count is wired to the units position of a counter to count each card, the units counter wheel will add the first nine cards, and will

transfer, or carry over, a 1 to the tens counter wheel when the tenth card is counted.

When a counter is directed to read out and reset, totals which have been accumulated will clear. However, the counter wheels reset to 9 in place of zero, so some adjustment in the counter must be made if the next accumulation is to be performed correctly. For example, assume a 1 count is received by the units position of a 3-position counter. Prior to adding the 1, the counter wheels stand at 999. When the 1 is added, the total of (1) 000 will result, the (1) being the carryover from the high order counter position. Through proper control panel wiring, this 1 can be carried from the high order position to the low order position and added. Thus, (1)000 becomes 001, the true count which has been added.

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When amounts punched in cards are wired to add, each counter wheel adds the specific number punched in the card column wired to it, and carries over to the position to the left any amount in excess of 9.

When a counter is wired for addition, a counter wheel will not start to turn until it receives an impulse. For example, if a 4 is wired to add, the counter wheel does not start to turn until the 4 position of the card is read by the reading brushes. The counter wheel then turns one number for each punching position remaining in the card until the zero position of the card has been read. Thus, the counter wheel has turned four times, adding a total of 4.

There are four basic steps in wiring a counter for adding.

1. Determine the information that is to be added. (Counter entry).
2. Determine which cards are to be added. (Counter control).
3. Determine when the total should be printed. (Counter read-out and reset).
4. Determine where the total should be printed. (Counter exit to printwheels).

The first basic step can be accomplished by wiring the amount to be added to the counter entry hubs. This may be amounts punched in cards and wired from second reading, or it may be an impulse wired from CYCLE COUNT, which emits a 1 impulse each machine cycle.

The second basic step is to tell the counter which cards are to be added. This is done by wiring a card cycles impulse, which is emitted each card cycle, to the counter control plus hub, either directly to add all cards or through selectors, to add only certain types of cards.

Next the counter must be told when it is to print the total. This is usually done when the machine has recognized a change between different control groups, or after the last card has passed through the machine. An impulse wired from a program exit to the counter read-out and reset hub causes the counter to clear the total and reset to 9's. If the total in the counter is to be printed without clearing, the counter-read-out hub would be wired in place of read-out and reset.

Finally, the counter must be told where to print the total. This is accomplished by wiring the counter exit hubs to COUNTER CONTROLLED PRINT. The counter controlled print hubs are internally connected to either normal or transfer print entry, whichever is active. How-

ever, because of the method by which the counters are reset, counter exits must be wired to counter controlled print when a counter is instructed to read out and reset. They may be wired to normal or transfer print if the counter is told to read out without resetting.

The counter exits are internally connected to the corresponding counter entry hubs except when the DIRECT ENTRY hub for that counter is impulsed. This makes it possible to use the exits as entries under certain conditions, such as when transferring totals from one counter to another. If direct entry is not impulsed, amounts which are being accumulated are available from the counter exit hubs each time an amount is added. They will print for each card cycle when detail printing, and for the first card of a control group when group printing. If printing is not suppressed on the indicated D cycle when group printing, overprinting will occur during the program cycle, since totals print on the same line as the group indication. This overprinting can be prevented by wiring a card cycles impulse to the counter direct entry hub so that the connection between counter entry and counter exit is broken on a card cycle.

Since all counter positions reset to 9 instead of zero, the carryover impulse from the high order position of each counter must be directed to the units position of the same counter when accumulating. This is accomplished by wiring CI (carry impulse) to C (carry). When the high order counter position turns from 9 to 0, an impulse is emitted by the CI hub. Wiring CI to C causes a 1 to be added in the units position of the counter, resulting in accumulation of the true amount.

Suppose nothing has been added into a counter, although the counter is wired to add. You would not want to print all 9s, so the counter must be prevented from printing. This is done by wiring the NEGATIVE BALANCE OFF hub of the counter to NEGATIVE BALANCE CONTROL. The negative balance off hub emits an impulse whenever all 9s are standing in a counter, either at detail print time or at total print time, and by wiring this impulse to negative balance control, printing of all 9s from that counter is suppressed.

Each program level has a group of PROGRAM EXIT hubs which emit impulses when the corresponding program start hub is impulsed. They are normally wired to counter readout and reset hubs to cause totals to print and counters to reset.

There is one more set of control panel hubs you should be familiar with in order to wire a control panel for adding more than one class of total. These are the TRANSFER EXIT PLUS hubs, one for each counter. Each of these hubs emits an impulse when the corresponding counter is controlled to read out and reset, provided a plus total is present in the counter. They are normally wired to the plus hubs of receiving counters when transferring totals from one counter to another on a total cycle.

Suppose you have sorted a file of detail cards to paygrade code (minor field) within rating group (intermediate field) within activity code (major field). You now wish to wire a control panel to obtain a total card count of these classifications. Wiring for this type of report is illustrated in figure 8-13.

1. The LIST switch is wired OFF to cause the report to be group printed.

2. The report is single spaced by wiring SPACE 1.

3. Each control field is wired from first and second reading to the comparing entries so that differences between control groups can be recognized.

4. The comparing exit from the minor field is wired to program start minor to a minor program when a change in control groups in the minor field is recognized.

5. The comparing exit from the intermediate field is wired to program start intermediate.

6. Program start major is wired from comparing exit of the major control field.

7. All three fields are wired from second reading to normal print entry in order to group indicate all controlling information from the first card of each minor control group.

8. A cycle count is wired to counter entry 4B, the minor counter, to add a 1 for each card.

9. Counter control plus of counter 4B is wired from a card cycles to cause that counter to add on each card cycle.

10. The cycle count wired to counter 4B entry is prevented from printing on the group indicate cycle by wiring a card cycles impulse to direct entry.

11. Counter 4B is controlled to read out and reset on a minor program.

12. Since all three classes of totals are to print in the same place, counter 4B exit hubs are wired to counter controlled print through the counter exit hubs of counters 4D (intermediate counter) and 6D (major counter).

13. Counter 4D adds all minor totals by wiring the transfer plus hub of 4B to plus entry of 4D. Minor totals are sent from 4B to 4D by wiring the counter exits of 4B to the counter exits of 4D.

14. Counter 4D is controlled to read out and reset on an intermediate program.

15. Counter 6D adds all intermediate totals by wiring the transfer plus hub of 4D to plus entry 6D. Intermediate totals are sent from 4D to 6D by wiring counter exits of 4D to the counter exits of 6D.

16. Counter 6D is controlled to read out and reset on a major program.

17. Negative balance off is wired to negative balance control for each of the three counters.

18. CI to C for each counter is wired.

SUBTRACTION

Subtraction is performed in a manner similar to addition. That is, a counter must be told what to subtract, when to subtract, when to clear, and where to print the results.

Each counter wheel turns forward during subtraction as it does in addition, since it is impossible to turn the wheels backward. However, if the counter is wired to subtract, each counter wheel starts to turn when the 9 position of a card starts under the reading brushes and continues to turn until it receives an impulse. Thus, if a 4 is punched in a column wired to a counter entry position, the counter wheel starts to turn when the 9 position passes the reading brushes, and continues to turn until the 4 punch is read. The counter wheel would have turned five positions by this time, and since counters reset to 9 instead of zero, the wheel could be standing at 4. But what has happened to the other wheels in the counter? Remember that when a counter is wired to subtract, all wheels in that counter will turn until they receive an impulse. So, if a 3-position field containing 004 is wired to a 4-position counter, the units wheel will turn five times and the remaining wheels will turn nine times, resulting in a counter total as follows:

$$9999 \text{ (before subtraction)}$$
$$+ \ \underline{9995} \text{ (minus 4)}$$
$$(1)9994$$

Since a 1 carryover has occurred from the high order counter position, it must be brought back to the units position and added by wiring
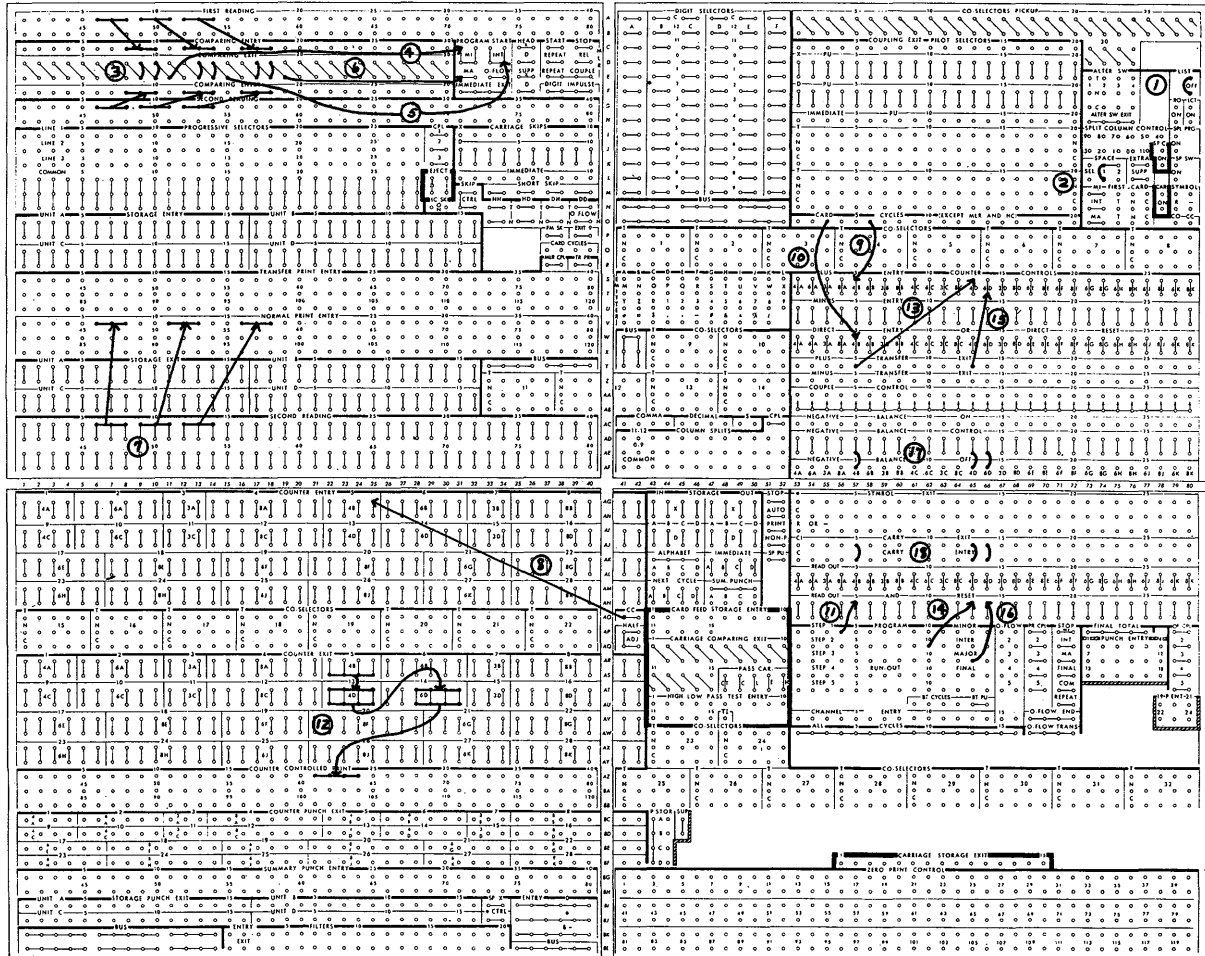
Figure 8-13.—Addition.

49.113

CI to C of that counter, resulting in the following:

$$9994$$
$$+ \underline{1}$$
$$9995$$

What you have in the counter now is the 9's complement of the number subtracted. The 9's complement of a number is that number subtracted from 9. Since 4 subtracted from 9 equals 5, then 5 is the 9's complement of 4. However, the machine converts the complement figure of 9995 to a true figure before printing, resulting in a 4 being printed. It then adds the amount printed to the amount standing in the counter in order to reset the counter. Thus, 9995 plus 4 equals 9999, which is the number that counters reset to.

When a counter is wired to subtract, the NEGATIVE BALANCE ON hub emits an impulse when a 9 is standing in the high order counter position. For this reason, the high order position should not be wired for accumulating when subtraction is being performed. The NEGATIVE BALANCE ON hub is wired to NEGATIVE BALANCE CONTROL so that printing of zero balances (all 9s) will be suppressed, and complement figures will be converted to true figures.

When a complement figure is converted to a true figure, the C and R or - hubs of the corresponding counter emit an impulse, which may be wired to normal or transfer print entry to identify minus amounts. They cannot be wired to counter controlled print, since these hubs will not accept 11 or 12 zone impulses. If CR is to be printed, it must be printed from two printwheels. The C is wired to one printwheel and the R to another. In order for the R to print, the symbol R switch (figure 8-9, M-N, 79) must be wired on. If the symbol R switch is not wired, the R or - hub emits a minus (-) impulse. The two minus hubs in the symbol switch are inactive.

Minus totals can be transferred from one counter to another by wiring the TRANSFER EXIT MINUS hub of the transferring counter to the COUNTER CONTROL MINUS hub of the receiving counter. The transfer exit minus hubs emit an impulse when the corresponding counter is controlled to read out and reset, provided a minus total is present in the counter.

Figure 8-14 represents control panel wiring for adding and subtracting minor and intermediate totals. Counter control wiring only is shown.

1. Column 40 is wired from first reading to the X pickup of pilot selector 5, so that NX cards can be added and X cards subtracted.

2. A card cycles impulse is wired through the normal side of pilot selector 5 to COUNTER CONTROL PLUS of counter 6C (minor counter) to add all NX cards.

3. The transferred side of pilot selector 5 is wired to COUNTER CONTROL MINUS of counter 6C to subtract all X cards.

4. Plus totals are transferred from counter 6C to counter 8C (intermediate counter) if counter 6C contains a plus total when controlled to read out and reset.

5. Minus totals are transferred from counter 6C to counter 8C if counter 6C contains a minus total when controlled to read out and reset.

6. NEGATIVE BALANCE ON of each counter is wired to NEGATIVE BALANCE CONTROL.

7. CI of each counter is wired to C.

8. A minus sign is printed for negative minor and intermediate totals. Zero print control must be wired for the position in which the minus sign is printed.

9. Counters 6C and 8C are controlled to read out and reset on the appropriate program.

SUMMARY PUNCHING

Summary punching can be accomplished when the accounting machine is cable-connected to the automatic punch. The only wiring required on the automatic punch control panel is from the 80 counter exit positions to the 80 punch magnets. All other wiring is performed on the accounting machine control panel.

Figure 8-15 illustrates the wiring required for summary punching. It is to be assumed that all other wiring, such as program start, and counters has been accomplished.

The wiring is as follows:

1. The SUMMARY PUNCH SWITCH is wired ON to provide an interlock that delays the accounting machine while summary cards are being punched, and stops both machines when the last card leaves the hopper of either machine.

2. The SUMMARY PUNCH PICKUP is wired from a minor program exit to cause summary punching on a minor total cycle. If summary cards were to be punched on an intermediate or major program cycle in place of minor, then the appropriate program exit would be wired to the summary punch pickup.

3. The specific columns to be summary punched are selected by wiring COUNTER PUNCH EXIT TO SUMMARY PUNCH ENTRY.

49.114
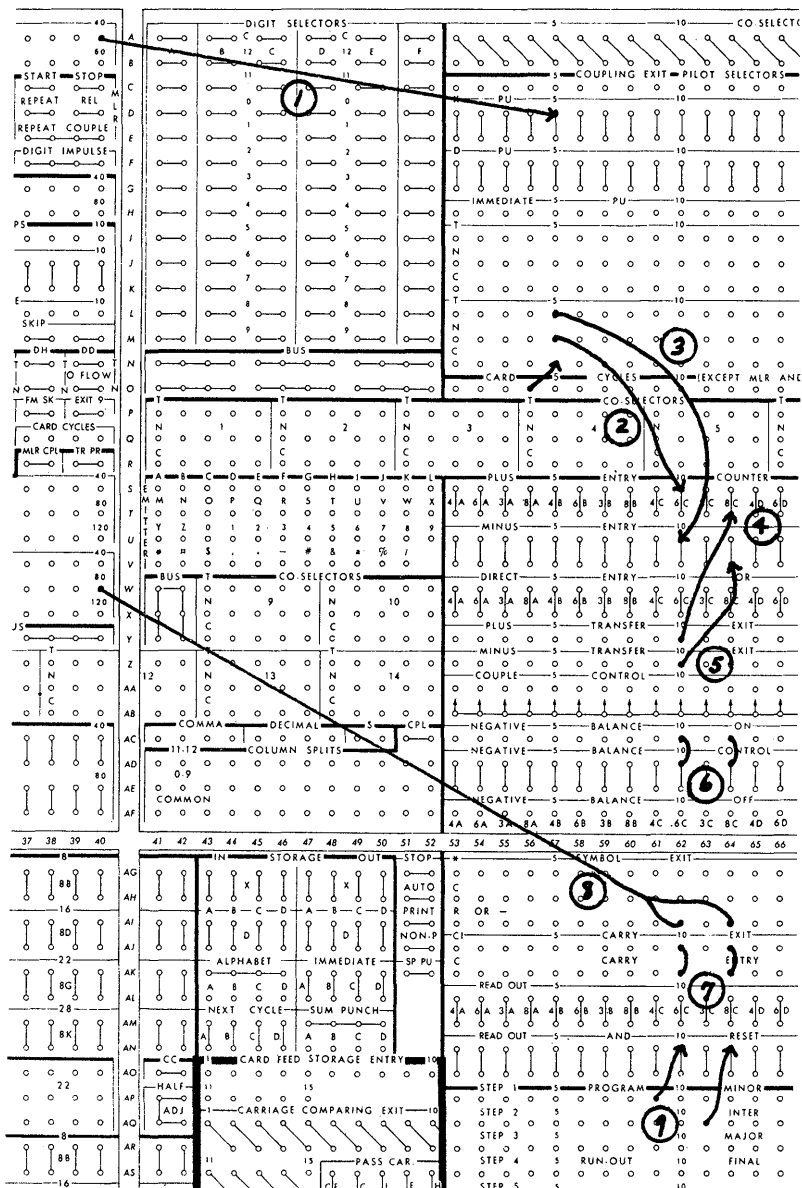
Figure 8-14.—Subtraction.

216

49.116
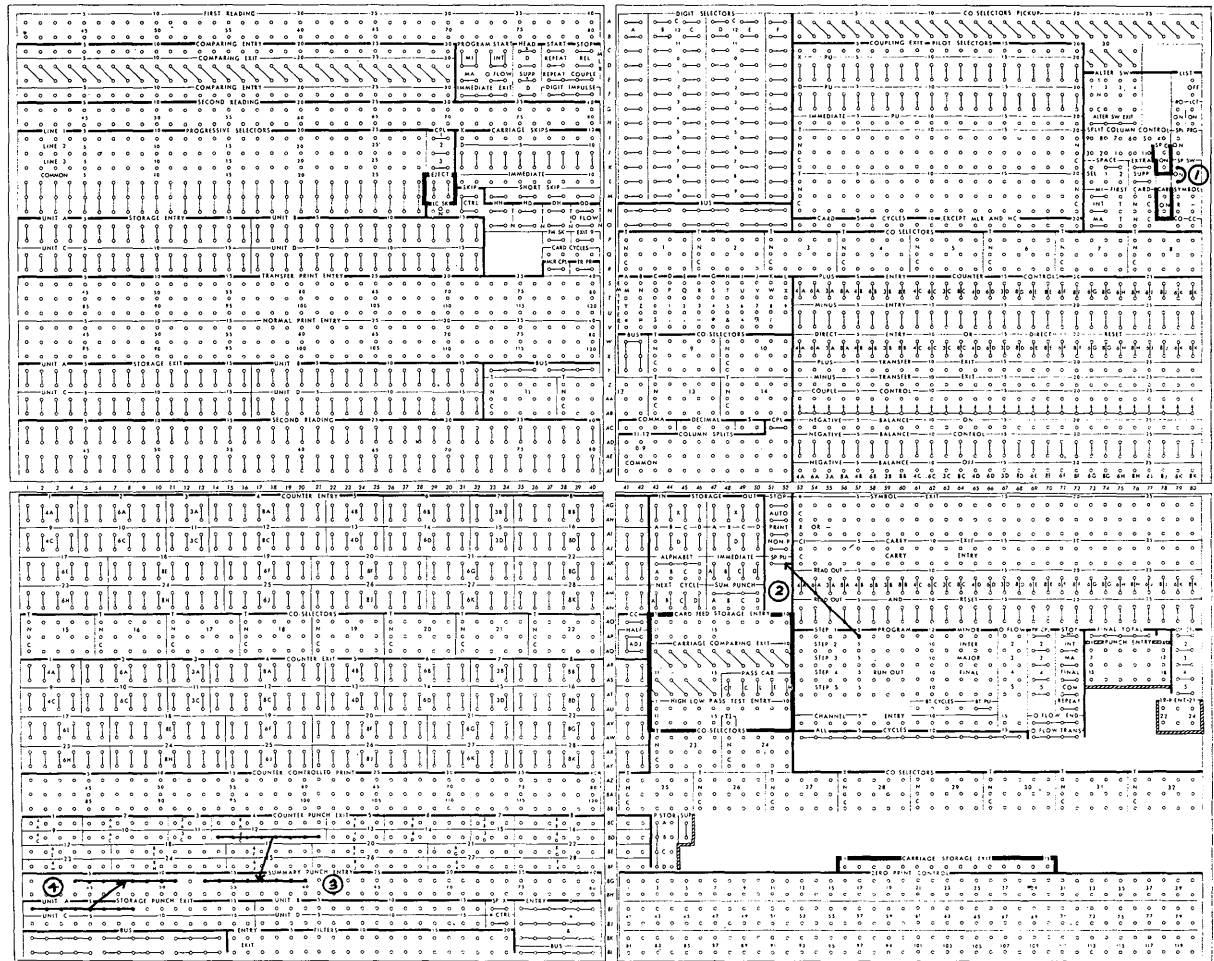
Figure 8-15.—Summary punching.

FORM CONTROL

Single, double, or quadruple spacing can be controlled by normal control panel wiring. Any other spacing must be controlled by the tape Spaces up to two inches between lines can be skipped at the same speed as normal spacing, allowing for printing of forms at the rate of 150 lines per minute. Card feeding is normally stopped for all skips in excess of two inches to prevent printing during the skip.

Carriage Skips

The first 10 channels on the carriage tape are represented by 10 carriage skip positions on the control panel. These hubs, consisting of an X, D, and IMMEDIATE hub for each channel, can be located by reference to figure 8-9, I-L, 31-49.

The X hubs accept X or 12 impulses and SKIP CONTROL HD, HH, DH, and DD impulses to cause skipping on the following cycle.

The D hubs accept any impulse, such as digits 9-12, comparing exit, program exit, card cycles, to cause skipping on the following cycle.

The I (immediate) hubs accept skip control, program exit, card cycle, or first card impulses to cause skipping on the same cycle.

When the X or D hubs are impulsed and a total intervenes, skipping is delayed until after the total prints. When the I hubs are impulsed and a total intervenes, skipping occurs before the total prints.

When an impulse is wired to one of the carriage skip hubs, the corresponding tape channel must be punched in order for skipping to be stopped automatically. If the channel is not punched, continuous skipping will result unless stopped manually by depressing the carriage stop key.

Head Control

Head control is described briefly in this section since it is mentioned several times throughout the discussions on the tape controlled carriage. However, the actual manner in which head control is wired is not discussed, because a thorough understanding is not required until you advance to the higher paygrades.

Some report forms may have a section set aside at the top of each form for printing of heading information, such as name and address. This information is usually printed on the first form of a control group from a set of heading cards, identified with a specific control punch. The detail cards are printed on the remainder, or body, of the form. After heading cards are printed, an automatic skip is made to the first body line before detail cards start to print.

The heading section on the second and succeeding forms can be skipped over by proper control tape punching and control panel wiring, or sheet identification such as activity code, date, or page number can be printed in the heading section before skipping to the body section.

Form to Form Skipping

Skipping from one form to another may be accomplished under many circumstances. To name a few, skipping can be started either before or after a card with a specific punch is printed, when a change in control groups is recognized, or after a certain class of total prints. These skips can be accomplished by wiring the appropriate exit hub to one of the channel 1 skip hubs, depending upon the type of impulse used to start skipping and the time at which skipping is desired. For example, if skipping to a new form is to occur after an X punched card has printed, then the column containing the X punch would be wired from second reading to channel 1 X hub. If skipping is desired before the X card prints, then channel 1 X hub would be wired from first reading. A comparing exit wired to channel 1 D hub causes skipping before the first card of the next control group prints. A first card impulse wired to the I hub of channel 1 causes skipping after the particular class of total, corresponding to the first card hub, has printed.

Overflow Skipping

Overflow skipping from one completed form to the next is usually controlled by the OVERFLOW hubs, shown in figure 8-9, 0, 39-40. A punch is channel 12 signals that the last printing line of a form has been reached, and causes the common overflow hubs to emit an impulse. If head control is not wired, these hubs are normally wired to the D hub of channel 1 to cause form to form skipping. If head control is wired, these hubs are usually wired to the D hub of the channel assigned to the first body line of the report.

Program Skipping

Skipping can be controlled so that a particular class of total will always print on the same line of each form. The control tape must be punched in one of the channels 2 through 10, on the line corresponding to the line on which the total is to print. A program exit hub for the appropriate class of total is then wired to the I hub of the channel punched with the predetermined total line. The program exit impulse starts the skip, which is stopped by the channel punch. Skipping to the next form can be accomplished by wiring the appropriate first card impulse to the I hub of channel 1.

Any line on a form can be used for program skipping. However, if it is likely that more than one form will be printed before skipping occurs, it is advisable to skip to a line below the line punched for overflow skipping. Otherwise, if the predetermined total line is passed before the program start is initiated, skipping will be to the predetermined total line on the following form.

CHAPTER 9

ELECTRONIC DATA PROCESSING

One of the most significant characteristics of an electronic data processing system is that a series of operations can be planned and the machines can be directed to carry them out to produce the desired result without further human intervention. Instead of the operations of separate machines, we think of a data processing SYSTEM which involves several machines and devices. The three basic elements of all data processing are:

1. The source data, or INPUT to the system.
2. The manipulation, or PROCESSING of data within the system.
3. The finished product, or OUTPUT from the system.

Once information is entered into the system, all classification, identification, and arithmetic operations are performed automatically in one or several processing routines as directed by a series of instructions in the stored program.

The use of electronic data processing systems in the Navy is becoming more widespread with each passing year. These systems are available in a variety of models and sizes and from a number of manufacturers. Unlike electric accounting machines, which basically are the same throughout the Navy, the electronic data processing systems that you may encounter can vary to a wide degree in construction, components, and method of programming. Characteristics which are more or less common to the majority of systems are discussed in this and later chapters. Specifics concerning the particular system with which you are associated generally are provided through courses of instruction presented by the manufacturer, or by the activity to which you are assigned. For any machines you are using, the reference manuals should be on hand for your reference and study.

ORGANIZATION OF AN ELECTRONIC DATA PROCESSING SYSTEM

An electronic data processing system must have several features to enable it to perform data processing functions automatically. It must have a device or devices for feeding information into the system, equipment for storing and processing the data, and facilities for releasing the data. These features, showing their relationship to each other are illustrated in figure 9-1. Notice that the heart of the system is the CENTRAL PROCESSING UNIT (CPU). The processing unit receives data and instructions from input devices, stores them, and refers to them as they are needed during the processing routine. The central processing unit performs all arithmetic operations, makes comparison between numbers or other characters, and takes the necessary action called for by the results in accordance with the stored program. It directs all processing operations within itself and controls the flow of incoming and outgoing information. All communications between input and output devices are made through a storage device within the processing unit. Input-output will be discussed separately and in detail in the following chapters.

CLASSIFICATION OF COMPUTERS

Computers may be classified according to size, purpose, or method of operation.

Method of Operation

According to method of operation, there are two basic types of computers, analog and digital. Analog computers measure and answer the question, "How much?". The analog computer represents data as physical quantities and performs calculations in terms of physical analogies. Analog computers are commonly used

220
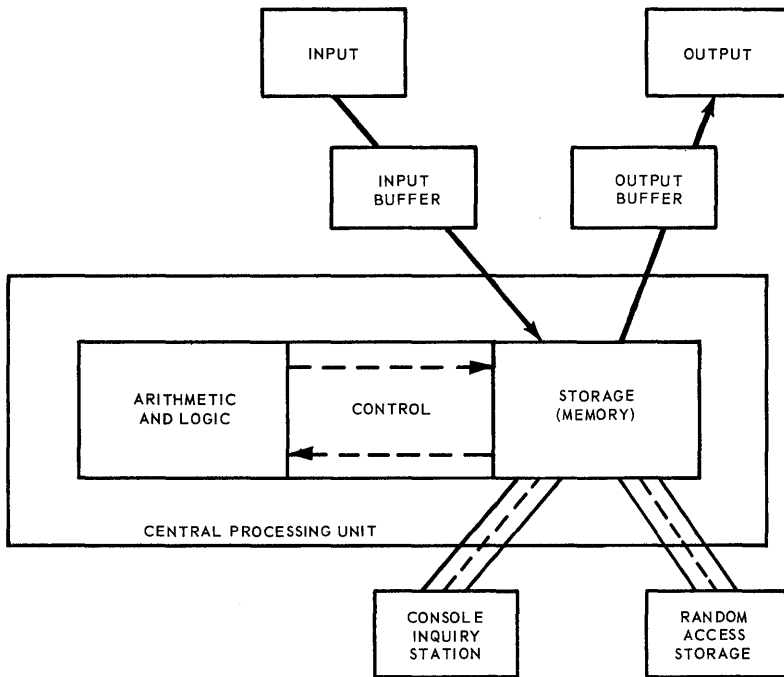
49.262

Figure 9-1.—Organization of an EDPS.

where measuring is of primary importance and an up-to-the-minute check of an entire system is required, as in a continuous check of an aircraft in flight. Some basic nonelectric examples of an analog computer are the hourglass, slide rule, speedometer, and scales.

The digital computer, on the other hand, counts and answers the question, "How many?". Data are represented by precise numbers and are manipulated mathematically. The digital computer is slower than the analog computer but is much more accurate. The computers used by Navy Data Processing Technicians are almost always the digital type, and any mention of computers in the remainder of this text will refer to the digital type.

Purpose for Which Used

Electronic computers are generally classified as general purpose and special purpose. A special purpose computer, such as the navi-

gational computers used aboard submarines, may have the sequence of instructions or program which the machine is to follow in manipulating data permanently wired into the circuitry of the machine, so as to handle one type of data processing task as efficiently as possible.

In contrast, a general purpose computer may be used for any task which can be handled by any digital computer, unless its storage capacity or speed is inadequate for a particular application. This is not to say that a general purpose computer could not be used in charting navigation, but it would not be as useful as a special purpose computer designed for that express purpose. Furthermore, even general purpose computers are frequently designed with business or scientific interest in mind. But they are complex and flexible enough to be adapted to other types of problems. Because of the variety of data processing tasks in the Navy, Data Processing Technicians will work, in most cases, with general purpose computers.

Types of Program Storages

Each computer system is designed to perform a specific number and type of operations. It is directed to perform each operation by an instruction. The entire series of instructions required to complete a given procedure is known as a program. The computer can operate from this program in one of three ways: by storing the program internally; by external storage, or in some cases, by a combination of both. The combination internal-external program storage will not be discussed due to its rarity.

Internal Program Storage.—A program compiled for internal storage is known as a stored program, and the procedural steps that are to take place in the computer system must be defined precisely in terms of operations that the system can perform. Each step must be written as an instruction to the computer. A series of instructions pertaining to an entire procedure is written and stored internally in the computer. The system has access to the instructions and can operate on them at electronic speed without human intervention.

External Stored Program.—An external program must take the same format in the planning stages as the stored program, but the machine performs all functions through the use of a plugboard or a previously wired control panel (to direct the machine through the required steps of a defined procedure to accomplish the required end results).

WHAT IS DATA?

Data is a general term used to describe raw facts. It is not to be confused with information, which may be described as facts that have undergone processing.

Data consist of basic elements of information which can be processed to produce desired results. An individual item of data may be a serviceman's serial number, the cost of an item sold, the quantity of an item ordered, or any other fact. Until some meaning has been given to it, nothing can really be determined about it, hence, it remains data. When it has been processed together with other facts it then has meaning and becomes information.

Data Representation

Data can be represented in many ways, but our discussion will be limited to symbolic representation of source data and machine data. Symbols convey information only when understood. The symbol itself is not the information, but merely represents it. Symbol meaning is one of convention (fig. 9-2). Symbols may convey one meaning to some persons, to others another meaning, and to those that do not know their significance, no meaning at all. Data must be reduced to a set of symbols that the computer can read and interpret before there can be any communication with the computer.

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Figure 9-2.—Communication Symbols.

Source Data.—Source data to be used with the computer system can be in the form of punched cards, paper tape, magnetic tape, magnetic ink characters, optically recognizable characters, microfilm and display screen images, communication network signals, etc. The list is growing larger each year. Some are pictured in figure 9-3. Data is represented on punched cards by the presence of small holes. Magnetic ink characters are printed on paper, and the magnetic property of the ink and shape of the characters permit the data to be read by both men and machines. The shape of the optical characters, together with the background paper, permits the optical characters to be read by machine as well as by people. On magnetic tape small magnetized areas are called spots or bits; arranged in a specific pattern, are the symbolic representation of data. The symbolic data on paper tape are small circular holes punched along the length of the tape.

PUNCH CARD

MAGNETIC TAPE

PAPER TAPE

OPTICALLY READABLE
CHARACTERS

MAGNETIC INK CHARACTERS

R49.201X

Figure 9-3.—Source data.

Computer Data.—In the computer, data may be represented by one or more electronic components: transistors, vacuum tubes, magnetic core, wires, and so on. The storage and flow of data through these devices are represented by electronic impulses. Just as data is represented in punched cards by the presence or absence of holes, the presence or absence of electronic impulses in specific circuitry represents computer data.

Computers function in what is called a binary mode. This means that the computer components can indicate only two possible states or conditions. For example, the ordinary light bulb works in a binary mode: it is either on or off. Likewise, within the computer, specific voltages are either present or absent; magnetic material is magnetized in either one direction or the other; transistors and vacuum tubes are either conducting or nonconducting (fig. 9-4). Thus, the combination of these internal component settings is the method by which data are represented inside the computer.
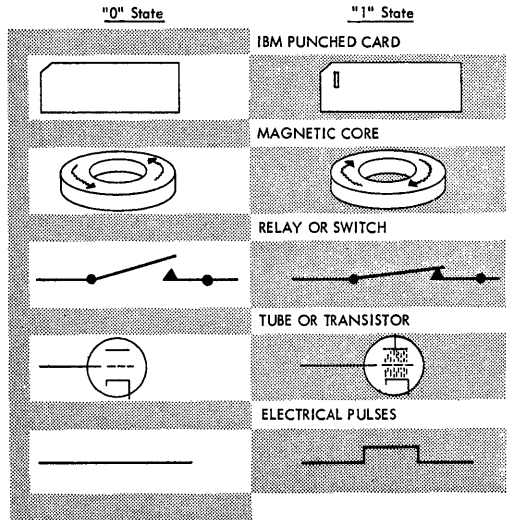
R49.270X

Figure 9-4.—Representing binary data.

DATA NUMBERING SYSTEMS

Some means of representing information—by which is meant numbers, letters and special characters, or combinations, is essential to all data handling devices. Conventional punched card machines used the standard punched card codes, which are essentially based on the decimal numbering system. That is, ten different digits

are used to represent the ten possible numbers. Thus, the value of any particular punch is conveyed to the machine in accordance with the TIME during a machine cycle that the punch is sensed. This requires an internal machine system for detecting and evaluating a number at ten different positions.

THE DECIMAL SYSTEM

The decimal number system is a POSITIONAL system; that is, the position of each digit in a number determines its value. Starting with the extreme right position, the positional values are called UNITS, TENS, HUNDREDS, THOUSANDS, and so on. Each position to the left has a value ten times greater than the position immediately to the right; thus, the decimal system is said to have a BASE of "10." Broken down by positional values, the number 7346 for example can be looked upon as meaning:

$$
\begin{array}{rcr}
6 \text{ x} & 1 = & 6 \\
4 \text{ x} & 10 = & 40 \\
3 \text{ x} & 100 = & 300 \\
7 \text{ x} & 1000 = & \underline{7000} \\
& & 7346
\end{array}
$$

The digits thus have meaning according to the position in the number; obviously 3647 is a different number, although it uses exactly the same digits.

Although the decimal system is familiar to all of us and is not really too difficult to manipulate arithmetically, there are some decided disadvantages to its use in performing calculating operations. Because ten different digits are required to express all possible numbers, a gear or shaft used to express numbers must be able to stop in ten different degrees of rotation and a punch card must have holes in ten different positions. No method has yet been developed whereby any processing means can have ten different and discrete stopping positions and still operate at any appreciable rate of speed.

Another disadvantage of the decimal system is the need for a relatively extensive table for additions and multiplications. There are 100 entries in each table, counting, for instance, 4 x 6 and 6 x 4 as two entries. Although most of us are adept in the use of the tables, this ability has been acquired largely through repeated drills and applications in addition and multiplication tables during our years in school until the tables have become second nature to us.

THE BINARY NUMBER SYSTEM

In searching for a means of performing computations rapidly, scientists naturally considered actions which take place rapidly—thousands or millions of times a second, rather than 10 or 20. Several methods are known; an electron tube for instance, can be turned on or off—that is, can be made to conduct current or not conduct it—at the rate of millions of times a second. Ferrous materials can be magnetized or demagnetized at high rates of speed. Such devices as these have only two stable states; magnetized or demagnetized, positive or negative, ON or OFF, or as they are more commonly called, BIT or NO BIT. Thus, by assigning a value to each of these two states, O for NO BIT and 1 for BIT, a number system was developed with a base of 2 rather than 10. This is known as the BINARY NUMBER SYSTEM. Such a system, used in all electronic data processing systems, has two definite advantages over the decimal system; it provides for simplicity in processing data since only two numbers are required, and it enables electronic devices to process data at fantastic speeds.

Construction of Binary Numbers

The system of counting in binary numbers is constructed in a manner similar to that of the decimal system. That is, the value of a number is determined by its positional placement. Remember that in the decimal system the value of any number is multiplied by ten each time it moves one position to the left. In the binary system however, the value of any number is doubled, or multiplied by 2, for each movement to the left, figure 9-5. Thus, in place of positional values corresponding to the decimal system, the binary number system has positional values of one, two, four, eight, sixteen, and so on. The following table shows how the binary numbers 0 and 1 are used to form the decimal equivalents of the numbers 0 through 19:

0 = 0	100 = 4	1000 = 8	1100 = 12	10000 = 16
1 = 1	101 = 5	1001 = 9	1101 = 13	10001 = 17
10 = 2	110 = 6	1010 = 10	1110 = 14	10010 = 18
11 = 3	111 = 7	1011 = 11	1111 = 15	10011 = 19

The binary table can be expanded as required to represent any number desired. For example, the number 217 is represented in pure binary form as 11011001. This can be proven by substituting

224

1024	512	256	128	64	32	16	8	4	2	1

49.272

Figure 9-5.—Place value of binary numbers.

the decimal value for each binary position, going from right to left, as follows:

$$
\begin{array}{rclr}
1 \ X & 1 & = & 1 \\
0 \ X & 2 & = & 0 \\
0 \ X & 4 & = & 0 \\
1 \ X & 8 & = & 8 \\
1 \ X & 16 & = & 16 \\
0 \ X & 32 & = & 0 \\
1 \ X & 64 & = & 64 \\
1 \ X & 128 & = & 128 \\
\hline
& & & 217
\end{array}
$$

Binary Addition

Binary addition is really quite simple once the rules are learned, because there are so few possibilities.
The complete binary addition table is as follows:

$$
\begin{array}{l}
0 + 0 = 0 \\
0 + 1 = 1 \\
1 + 0 = 1 \\
1 + 1 = 0 \text{ with a 1 carried}
\end{array}
$$

The following example illustrates the principle of binary addition:

$$
\begin{array}{ll}
 011000111100 & \\
+ \, 010100101001 & \\
\hline
= 001100010101 & \\
+ \, 1 \quad\ 1\,1 & \text{(Carry)} \\
\hline
= 101101000101 & \\
+ \qquad\ 1 & \text{(Carry)} \\
\hline
= 101101100101 &
\end{array}
$$

Binary Subtraction

The table for binary subtraction is not much more complicated than that for addition. The complete binary subtraction table is as follows:

0 - 0 = 0
1 - 1 = 0
1 - 0 = 1
0 - 1 = 1 with 1 borrowed from the next digit

Binary subtraction is illustrated in the following example:

$$
\begin{array}{ll}
 011000111100 & \\
- \, 010100101001 & \\
\hline
= 001100010101 & \\
- \, 1 \qquad\quad 1 & \text{(borrowed)} \\
\hline
= 000100010111 & \\
 \qquad\qquad\ 1 & \text{(borrowed)} \\
\hline
= 000100010011 &
\end{array}
$$

THE OCTAL NUMBER SYSTEM

Closely related to the binary system is the octal system, with the radix 8, or base 8. Admissible marks in the octal system are 0, 1, 2, 3, 4, 5, 6, and 7 (fig. 9-6). The reason why the octal system is important in automatic computer work is that 8 is the third power of 2. Thus, the octal system offers an efficient shorthand way of writing binary numbers. Each three binary places condense into one octal place when a number in the binary system is coded in octal (fig. 9-7).

OCTAL	—	DECIMAL	OCTAL	—	DECIMAL
0	—	0	16	—	14
1	—	1	17	—	15
2	—	2	20	—	16
3	—	3	21	—	17
4	—	4	22	—	18
5	—	5	23	—	19
6	—	6	24	—	20
7	—	7	25	—	21
10	—	8	26	—	22
11	—	9	27	—	23
12	—	10	30	—	24
13	—	11	31	—	25
14	—	12	32	—	26
15	—	13	33	—	27

49.273

Figure 9-6.—Octal numbering system.

49.274

Figure 9-7.—Condensing a binary representation to octal representation.

Octal Addition

In octal addition, a simple mental trick allows us to use the familiar decimal rule. All we need to remember in addition is that any sum of digits which would yield a decimal result of 8 or more would be represented in octal by a number larger by two (since, of course, 8 and 9 are missing in octal). (Fig. 9-8.) Notice that we never need to consider more than one digit-pair at a time.
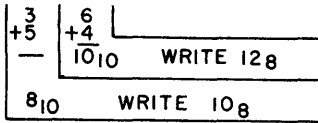
49.275

Figure 9-8.—Octal addition.

Octal Subtraction

While subtraction has simple rules, computers rarely duplicate unneeded circuitry by using these rules. To accomplish subtraction, they merely add negative numbers. Many computers represent negative numbers by complement form. This can best be described by first showing this process in decimal.

If a decimal adding device were to represent 5 digit numbers it would have a range of values from 00000 to 99999. However, if the range 00000 to 49999 were considered positive, 99999 to 50000 could be used to represent -00000 to -49999. This may not seem very logical but it works. If numbers greater than 49999 are treated as negative, these values are called complement numbers. In base 10, a complement is formed by subtracting a number from all nines, hence the name nine complement. The rules for subtraction by complement addition are simple.

RULE: Add the complement of the subtrahend to the minuend. If a carry occurs out of the high order, add the carry to the units position and the difference is in true form. If no carry occurs the difference is the complement of the true form. See example.

EXAMPLE:

Decimal

```
  00005                    00005
     10
 -00002 → becomes      + 99997
     10                    00002  Plus a carry which
 _____                        1  is added.
              yielding    00003  As an answer
                             10
```

In octal the same rules apply as in decimal with one exception: the nines complements are to be replaced by sevens complements as follows.

Octal

```
  07301                   07301
      8                       8
 -02046   becomes        75731
      8                       8
                         _____
                          5232   Plus a carry which
                             1   is added.
              yielding    5233   As an answer
                             8
```

THE CONVERSION OF NUMBER SYSTEMS

Sometimes it is necessary to know the equivalent in one numbering base of a number expressed in a different base. For instance, information displayed by various registers on the console is always binary in construction. This information is meaningless to you unless you can convert it to its decimal equivalent. On the other hand, conditions may sometimes arise which will require you to convert a decimal number to its binary equivalent. The following paragraphs describe some of the methods which may be used in converting a number expressed in one numbering base to its equivalent in another.

Decimal to Binary

One way to convert base 10 (decimal) to base 2 (binary) is to divide repeatedly by 2. Write the remainder from the first division at the right

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(the remainder will always be 1 or 0). Divide the first quotient by 2 and write 1 or 0 to the left of the preceding remainder. By continuing this process you will eventually have a succession of 1's and 0's, which will be the binary number. For example, converting the decimal number 277 to its binary equivalent can be performed as follows:

```
      138         69          34          17          8
  2⌐277    2 ⌐ 138     2⌐69        2⌐34    2 ⌐17
    276        138          68          34         16
     (1)         0           1           0          1

       4          2           1           0
   2 ⌐ 8      2 ⌐ 4       2 ⌐ 2       2 ⌐ 1
      8          4           2           0
      0          0           0           1
```

100010101

Verify the results as follows:

256	128	64	32	16	8	4	2	1	Place Value
1	0	0	0	1	0	1	0	1	Bits

= 277   Decimal

Binary to Decimal

To convert binary to decimal, division is performed repeatedly by the binary representation of decimal 10, which is 1010 (fig. 9-9). All arithmetic must be done in binary. Division proceeds as in decimal to binary conversion, except that remainders must be converted from binary to decimal form. Converting the binary number 100010101 to its base 10 equivalent is illustrated as follows:

```
            11011              10               0
  1010 ⌐100010101   1010⌐11011     1010 ⌐ 10
        1010               1010               0
        1110                111               10=2
        1010                000
       10010                111 = 7
        1010
       10001
        1010
         111 = 7
```

Thus the remainders, reading from right to left are 277, which is the decimal equivalent of the binary number 100010101.
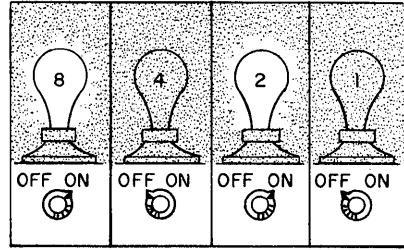
R49.276X

Figure 9-9.—Representing decimal data.

Decimal to Octal

The base 8 numbering system (OCTAL) can be used as a shorthand method for interpreting pure binary numbers. To convert decimal (base 10) to octal (base 8), divide repeatedly by 8. Each time write the remainder, starting from the right, and divide the quotient by 8 to get the next remainder. The sequence of remainders will be the number represented in octal. For example, the decimal number 277 is converted to octal as follows:

```
        34                4               0
   8 ⌐ 277          8⌐34          8 ⌐ 4
       272               32               0
         5                 2               4
```

The remainders, again, reading from right to left and written down from left to right, appear as 425, which is octal equivalent of the decimal number 277.

Octal to Decimal

To convert octal (base 8) to decimal (base 10), multiply the high order digit by 8 and add the next lower order digit to the result. When the lower order digit has been added to the answer, the process ends. For example, octal 425 is converted to decimal 277 as follows:

```
            425 (octal)
        x     8
             32
        +     2
             34
        x     8
            272
        +     5
            277    (decimal)
```

227

Binary to Octal to Decimal

The conversion of a binary number to its decimal equivalent could be a lengthy process, as illustrated in one of the preceding paragraphs. An easier method is to convert the binary number to octal, and then convert the octal representation to decimal. To convert a number from binary to octal, group the binary digits in groups of three, from right to left, and write the decimal value of each group. If the number of binary numbers is not divisible by three, the necessary amount of zeros is to be added to the leftmost position. The binary number 100010101 is converted to octal as follows.

100	010	101	(binary)
4	2	5	(octal)

The remaining step in converting binary to decimal is to convert the octal number to decimal in accordance with procedure used to convert ocal to decimal.

Octal to Binary

The conversion of a decimal number to its binary equivalent can be accomplished by first converting the decimal to its octal equivalent as previously described, and then from octal to its binary equivalent. To convert from octal to binary, simply reverse the procedure for converting binary to octal by writing the binary equivalent of each octal digit. Thus 425 octal for example, becomes 100010101 binary.

COMPUTER CODING SYSTEMS

The method used for symbolizing data is known as a code or a system. In computers, the code relates data to a fixed number of binary notations. By proper arrangement of the binary notations (bit and no bit) and with each positional notation having a specific value, each character can be represented by a combination of bits which is different from any other combination.

Perhaps the most popular coding scheme for data representation is binary coded decimal, or 8-4-2-1 scheme. Note that the decimal digits 0 through 9 are expressed by four binary digits (fig. 9-10).

The system of expressing or coding decimal digits in an equivalent binary value is known as binary coded decimal (BCD). For example, the decimal value 3246 would appear in BCD form as shown in figure 9-11.

PLACE VALUE				DECIMAL
8	4	2	1	VALUE
			0	0
			I	I
		I	0	2
		I	I	3
	I	0	0	4
	I	0	I	5
	I	I	0	6
	I	I	I	7
I	0	0	0	8
I	0	0	I	9

49.158

Figure 9-10.—Binary coded decimal.

3	2	4	6	DECIMAL DIGITS
0011	0010	0100	0110	BINARY VALUE
8421	8421	8421	8421	PLACE VALUE

49.277

Figure 9-11.—3246 in binary coded decimal.

Two of the other more common codes are described in the following paragraphs.

Six-Bit Alphameric Code (BCD)

The six-bit alphameric code is just an extension of BCD. Instead of using just the 8-4-2-1 scheme, this code uses six positions of binary notation (plus a parity bit position) to represent all characters (alphabetic and numeric), as opposed to only numeric characters. These positions are divided into three groups, as shown in figure 9-12.

CHECK BIT	ZONE BITS		NUMERIC BITS			
C	B	A	8	4	2	I

49.278

Figure 9-12.—Six bit alphameric code.

There are four positions for representing numeric data, assigned the decimal values of 8, 4, 2, and 1; two positions, called B and A zone bits, for denoting zones; and one position, called the C or CHECK position, for checking the validity of codes. There is a close parallel between the binary coded decimal system used in computing devices and the Hollerith code used to represent data in punched cards. That is, numeric values 0 through 9 are represented by a numeric bit or combination of numeric bits; the 12 zone is represented by B and A bits; the 11 zone by a B bit; and the zero zone by an A bit. Thus, through the various combinations of zone and numeric bits, any numeric, alphabetic character, or special character can be represented.

The purpose of the C position, or CHECK bit, is to provide the computer with an internal means for checking the validity of code construction. That is, the total number of bits in a character, including the check bit, must be always even or always odd, depending upon the particular system or device used. Therefore, the binary coded decimal system is said to be either an EVEN or ODD parity code, and the test for bit count is called a PARITY CHECK.

The check bit is automatically added to each input character that requires an extra bit to bring it into consonance with the total-bit requirement. Check bits remain with their particular character throughout all data manipulation within the processing unit, providing a system for checking the validity of each character each time it is used.

While the failure of a character to pass the parity check always indicates an error, successful passing does not in itself certify that a character actually represents what was intended. That is, the accidental dropping of one bit constitutes and invalid code, but the accidental dropping of two bits results in the representation of some other valid code. However, dropping of two bits in one position occurs so seldom as not to arouse any particular concern over its happening.

Figure 9-13 represents a typical binary coded decimal chart, arranged in ascending sequence. This particular scheme represents character coding in a system based on an odd parity check. The same coding arrangement could be used in systems having an even parity check by simply changing the check bit from characters with an even number of bits to those with an odd bit construction.

Excess Three Code (X-S3)

The excess-three binary coded decimal is a variation of the 8-4-2-1 scheme. It is so-called because the binary equivalent of decimal 3 (0011) is added to the binary value of each decimal digit in the 8-4-2-1 code. For example, the value of decimal 6 in 8-4-2-1, which is 0110, is increased by 0011 to get 1001, as follows:

DECIMAL DIGIT		BINARY CODED DECIMAL
6	=	0110
+		+
3	=	0011
9	=	1001 (Excess-three)

Thus, the bit configuration of an excess-three binary coded decimal digit is three in excess of its 8-4-2-1 counterpart.

Some arithmetical operations are made easier by using the excess-three code. For example, the 9's complement of a number can be found by simply converting each 1 to 0 and each 0 to 1. To illustrate, 7 is used 1010 in excess-three code and is complemented to 0101 by converting each 1 to 0 and each 0 to 1. The complement 0101 is excess-three code and has a value of 2 (the 9's complement of 7) in binary coded decimal when the excess-three is removed.

DATA STORAGE

After information has been prepared for input—for example, after it has been inscribed on magnetic tapes—it has to be transferred to the storage device (memory) in the central processing unit before it can be further processed. The further processing of this information consists in subjecting it to a planned sequence of arithmetical and logical operations.

The locations in storage of the data to be processed, the logical and arithmetic operations to be performed on this data, and the sequence in which these operations are to be carried out, are indicated to the computer in the series of coded instructions called the program. After it has been loaded into main storage, the program is executed by means of the two units which, together with the storage device, make up

PRINTS AS	DEFINED CHARACTER	CARD CODE	BCD CODE	PRINTS AS	DEFINED CHARACTER	CARD CODE	BCD CODE
	BLANK		C	G	G	12-7	B A 4 2 1
.	.	12-3-8	B A 8 2 1	H	H	12-8	B A 8
□	□	12-4-8	C B A 8 4	I	I	12-9	C B A 8 1
	(Left Parenthesis (Special Character)	12-5-8	B A 8 4 1	—	! (Minus Zero)	11-0	B 8 2
	< Less Than (Special Character)	12-6-8	B A 8 4 2	J	J	11-1	C B 1
	≡ Group Mark	12-7-8	C B A 8 4 2 1	K	K	11-2	C B 2
&	&	12	C B A	L	L	11-3	B 2 1
$	$	11-3-8	C B 8 2 1	M	M	11-4	C B 4
*	*	11-4-8	B 8 4	N	N	11-5	B 4 1
	) Right Parenthesis (Special Char.)	11-5-8	C B 8 4 1	O	O	11-6	B 4 2
	; Semicolon (Special Character)	11-6-8	C B 8 4 2	P	P	11-7	C B 4 2 1
	Δ Delta (Mode Change)	11-7-8	B 8 4 2 1	Q	Q	11-8	C B 8
—	—	11	B	R	R	11-9	B 8 1
/	/	0-1	C A 1	⧺	≡ Record Mark	0-2-8	A 8 2
,	,	0-3-8	C A 8 2 1	S	S	0-2	C A 2
%	%	0-4-8	A 8 4	T	T	0-3	A 2 1
	= Word Separator	0-5-8	C A 8 4 1	U	U	0-4	C A 4
	' Apostrophe (Special Character)	0-6-8	C A 8 4 2	V	V	0-5	A 4 1
	" Tape Segment Mark	0-7-8	A 8 4 2 1	W	W	0-6	A 4 2
⧺	¢ , Cent (Special Character)		A	X	X	0-7	C A 4 2 1
#	#	3-8	8 2 1	Y	Y	0-8	C A 8
@	@	4-8	C 8 4	Z	Z	0-9	A 8 1
	: Colon (Special Character)	5-8	8 4 1	0	0	0	C 8 2
	> Greater Than (Special Character)	6-8	8 4 2	1	1	1	1
	√ Tape Mark	7-8	C 8 4 2 1	2	2	2	2
&	? (Plus Zero)	12-0	C B A 8 2	3	3	3	C 2 1
A	A	12-1	B A 1	4	4	4	4
B	B	12-2	B A 2	5	5	5	C 4 1
C	C	12-3	C B A 2 1	6	6	6	C 4 2
D	D	12-4	B A 4	7	7	7	4 2 1
E	E	12-5	C B A 4 1	8	8	8	8
F	F	12-6	C B A 4 2	9	9	9	C 8 1

R78.10X

Figure 9-13.—Binary coded decimal chart.

the central processing unit: the arithmetic and logic unit and the control unit. The arithmetic and logic unit executes the instructions, while the control unit times and directs the movement of data and of data processing results between the various components of the central processing unit.

In stored program machines, data and instructions must be stored in the processing unit before data processing can be performed. Storage devices provide a place for storing data entered into the system from input devices and for storing the instructions required for the processing routine. In addition, storage devices provide a place for storing processed data that are to be furnished to output devices for recording processed results.

Storage devices located within the central processing unit are called main storage or internal storage, while those located outside this unit are called auxiliary or external storage. Internal storage devices are used during the execution of a program and allow for fast access to the data stored in them. External devices are used to supplement the storage capacity of the computer system. Magnetic core devices are

normally used for internal storage, because of their fast access capability, while drum, disk, and tapes are used for external storage because of their greater storage capacity.

The smallest unit of an item of information stored in a computer system is the BIT (BInary digiT). A certain number of bits makes up a CHARACTER which occupies one storage position. Characters, in turn, are grouped into WORDS. Words may be organized into a RECORD and records into a FILE.

Some data processing machines are assigned a fixed number of storage positions for every word and are called fixed word length machines. Each word location in a fixed word length machine is identified by means of an ADDRESS.

Other data processing machines allow variability in word length and these machines are called variable word length machines. Each storage position in a variable word length machine has an address. Several storage positions can, however, be grouped to form one word, and a word mark, or control character, can be set to identify the beginning of the word, so that only one of the storage positions in a word need be addressed to enter data into, or remove data from, the entire word location.

Information placed in a storage location erases the previous contents of that location, while information taken from a storage position is merely copied, not erased. Thus, reading into storage is said to be destructive and reading out nondestructive.

The time interval between the instant when information is called for from storage and the instant when delivery is completed is called ACCESS TIME. Access time is also the time interval between the instant when information is ready for storage and the instant when storage is completed. The first access time is called read time; the second, write time.

While, for a single item of information, access time is usually no more than a fraction of a second, the time required to execute a program consisting of hundreds of thousands of items of information is significantly extended by the cumulation of individual access times.

Assess time varies according to the type of storage used—magnetic core storage, for example, has a shorter access time than magnetic drum storage.

TYPES OF STORAGE DEVICES

Many types of storage devices have been developed for use with any number of data processing systems. However, the more common types presently in use are magnetic core, magnetic drum, magnetic disk, and thin film. Sometimes magnetic tape is considered storage rather than an input/output medium. Each type is different from the others in physical makeup, and in such other characteristics as cost, access, and storage capability, but all are alike in their function, which is to store information.

Magnetic Core Storage

The magnetic core storage device is composed of tiny rings, or CORES, of ferromagnetic material. The ferrite used in this application is a ceramic iron oxide possessing magnetic properties. The ferrite particles are pressed on each core and then baked in an oven.

Magnetic cores normally have four wires passing through them (fig. 9-14). The two horizontal MAGNETIZING wires are used for read selection. (These same two wires are used for write by reversing the direction of the current flow.) A SENSE wire for sensing the magnetic state of the core, and an INHIBIT wire which ensures that the core remains in its original state after its contents have been read.
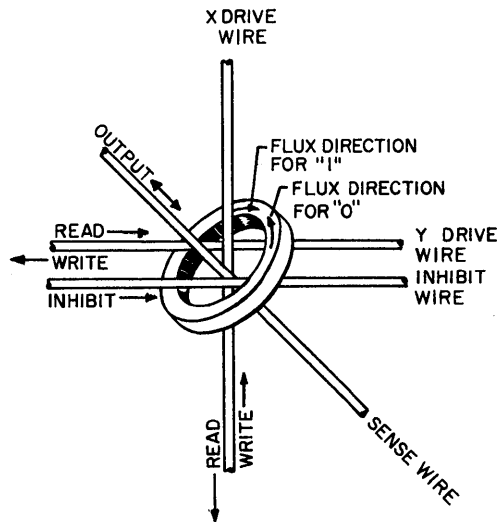
124.56

Figure 9-14.—Magnetic core showing "X", "Y", inhibit and sense wires.

Since a single core stores only one bit of a word, a large number of cores are required to handle all the bits in every word to be stored. These cores are mounted on PLANES, and the planes are stacked one upon the other. Each core is capable of containing one bit of information. A vertical column of cores consisting of one core in each plane is used to store one character, and is called a STORAGE POSITION. Figure 9-15 illustrates how magnetic cores are arranged to form a storage position, using the binary coded decimal system. Any number of adjacent storage positions can be grouped together to form a word.

LOCATION OF LETTER "A"
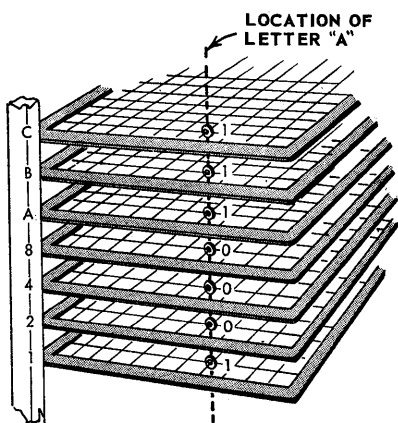
Figure 9-15.—Representing a character in core storage.

Every magnetic field has polarity. This can be demonstrated by the common horseshoe shaped magnets, which attract each other when turned one way, and repel each other when turned the other way.

In computer memory applications the ferrite core is magnetized by a flux field produced when a current flows in a drive wire that is threaded through the core. It retains a large amount of this flux when the current is removed. Flux lines can be established clockwise or counterclockwise around the core depending upon the direction of the magnetizing current. A current in one direction establishes a magnetization in a core in a given direction. Reversing the direction of the current flow reverses the direction of the flux field and the core magnetization. These two

unique magnetic states represent the binary digits 0 and 1, or NO BIT (0) and BIT (1).

Once information is placed in core storage, a means must be provided for obtaining that information when needed. This is accomplished by a sense wire, which passes horizontally through all cores in a plane. The presence of a bit or no bit in each core is transmitted through the sense wire to the location called for by the stored program.

An inhibit wire prevents writing a "1" when a "0" is to be written. Like the sense wire, the inhibit wire also runs through every core in a plane.

It is beyond the scope of this text to fully explain core storage, but a basic knowledge of how core storage works is useful in understanding the operation of all data processing systems using core memory. More detailed coverage can be found in Digital Computer Basics, NavPers 10088.

Magnetic Drum Storage

The magnetic drum storage device consists of either a hollow cylinder (thus the name "drum") or a solid cylinder that rotates at a constant velocity, and the outer surface is coated with a material capable of being magnetized. Magnetized spots can be placed on the surface of the drum to represent data. These bits are placed in a series of tracks running around the drum, as shown in figure 9-16.
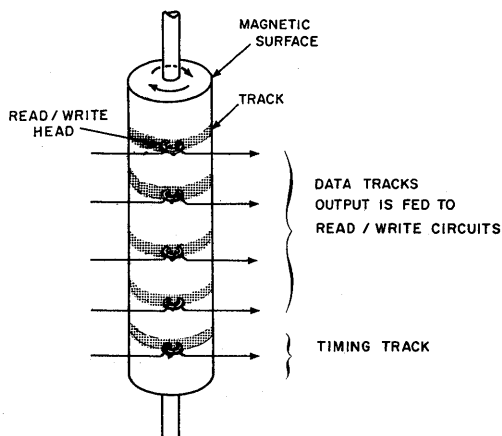
Figure 9-16.—Magnetic drum.

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Each data track has its own read-write head which is used for recording and reading. The drum is rotated so that the heads are near but not touching the drum surface at all times. As the drum rotates, the tracks are continuously passing under their respective read-write head.

The read-write heads read information from a magnetic drum by sensing the magnetized spots on the drum surface, converting it to an electrical signal, and transmitting it to the computer. Information is written on the drum by converting electrical signals from the computer into magnetized spots on the drum surface.

Data recorded on the surface of drums remains indefinitely and may be used repetitively. The old data is automatically erased each time new data is recorded.

Each drum has a specific number of storage locations which are addressable by the computer. The capacity of each storage location depends upon the design of the drum and the data representation code used. Because neither reading nor writing can occur until the particular location to be read or written is directly under the read-write heads, the speed of access is dependent upon the location of the desired storage position on the drum in relation to the read-write heads.

Magnetic Disk Storage

Magnetic disks resemble phonograph records which have been coated with iron-oxide. The disks (or records) are arranged in stacks in much the same way as a record stack in a modern "juke box." All of the disks are continuously revolving and spaced apart so that a record head, driven by an access mechanism, can be positioned between the disks.

The data are recorded at certain addresses on a specific disk. When readout of a particular section of storage is desired, the recording head is automatically positioned and the data are read from the surface of the selected disk.

Disk storage makes it possible for records to be accessible without having to read from the beginning of a file to find them. This is called either DIRECT ACCESS or RANDOM ACCESS processing as contrasted to SEQUENTIAL or BATCH processing where reels of magnetic tape or files of punched cards must be read from the beginning in order to read or write a desired record.

Assume that ten magnetic disks are used for storing all material inventory records by stock number. All stock numbers starting with zero are placed on one disk, those starting with 1 on another disk, 2 on a third disk, and so on through stock numbers starting with 9, which are placed on the tenth disk. If an issue card with a stock number starting with a 4 is fed into the system, the disk which has all stock numbers starting with 4 is selected and spun around until the particular stock number which the computer is looking for is reached.

Direct access processing has a decided advantage over sequential processing if master files have to be updated on a continuous basis. Continuous processing usually results in a small percentage of the master records being affected. In sequential processing, each master record must be read and written for each processing cycle, even though only a few records may have to be updated. In direct access processing, only those master records affected by transactions need be read and written, thus saving considerable reading and writing time.

One disk arrangement (fig. 9-17) has the disks mounted on a vertical shaft, with each disk separated from the adjacent one. As the shaft revolves, spinning the disk, magnetized spots can be placed in tracks on both sides of the disk to represent data. One or more access arms are located at the side of the disk stack, and move under control of the stored program to any desired track on any disk. Magnetic recording heads mounted on these access arms are used to write data on the disks and to read data from them. Each access arm is forked, with a recording head on each fork, making it possible to read or write on either side of the disk.

Another disk arrangement (fig. 9-18) uses interchangeable disk packs. Six disks are mounted in a disk pack which can be replaced or removed from the disk drive and stored in a library in much the same manner as magnetic tape reels may be stowed. The packs weigh less than ten pounds each, and up to 7.25 million characters of information can be stored on each disk pack.

The inside ten disk surfaces are used for recording data, while the outermost two surfaces are protective plates. When installed in a disk drive, information is written or read from the surfaces by read-write heads mounted in pairs between each two disks on a movable access mechanism.

The magnetic disk data surface remains recorded until written over. Each time new information is recorded and stored, the old information is automatically erased. Data recorded on magnetic disks may be read as often as desired.
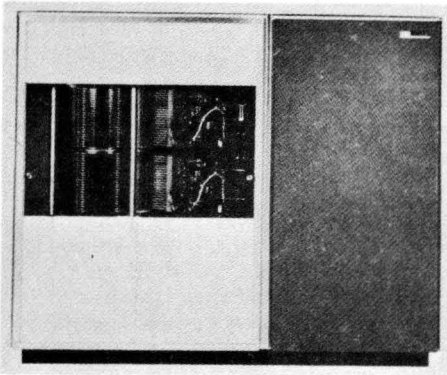
R49.308X
Figure 9-17.—1301 Disk storage.
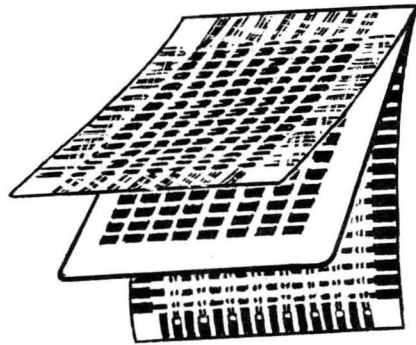
49.309
Figure 9-19.—Thin film memory.

READ/WRITE
HEADS & ACCESS
ARMS
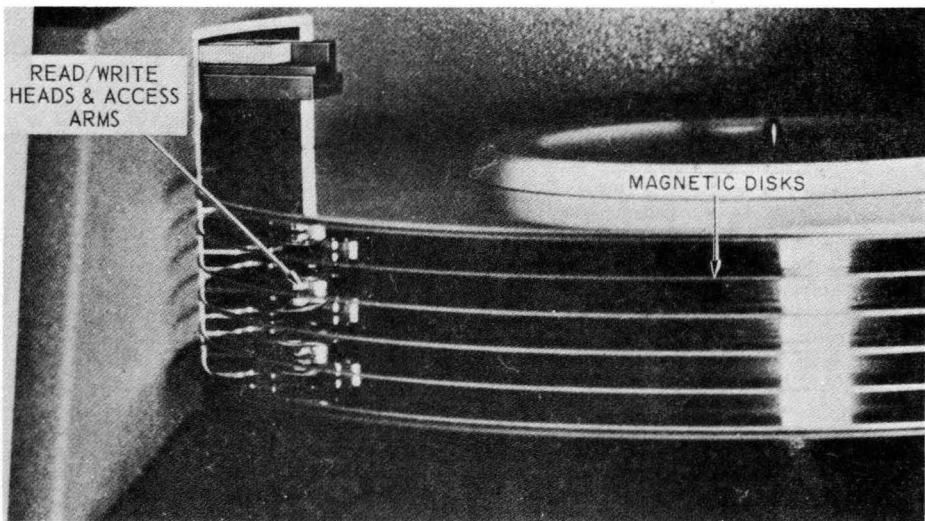
MAGNETIC DISKS

R49.359X
Figure 9-18.—IBM 2311 Disk Storage Drive showing mounted disk pack and access arms.

Thin Film Storage

Thin film storage consists of small spots of magnetic material less than one-sixteenth of an inch in diameter, deposited on an insulating base, such as a glass (fig. 9-19). The spots are made only a few millionths of an inch thick and are made by the deposition of magnetic alloys under a high vacuum in layers so thin that magnetization can be switched by rotation within time intervals of several nanoseconds. Access time of the Univac 1107 thin film memory is 300 nanoseconds (.3 microseconds).

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Magnetic drums, disks, and tape use spots of magnetization, whereas the magnetic material is continuous. In thin film the spots of magnetization and the spot of magnetic material have the same boundaries. The spots are made by evaporating the magnetic material in the presence of a magnetic field. Therefore, magnetization in the preferred direction or opposite direction can be easily made.

THE CENTRAL PROCESSING UNIT

The entire data processing system is controlled and supervised by the central processing unit (CPU), such as the one illustrated in figure 9-20. It is in this unit that all arithmetic and logical operations are performed. From a functional standpoint, the processing unit consists of two sections; the control section and the arithmetic/logic section.

Control Section

The control section times and directs all operations called for by the instructions of a program stored in the memory of the computer. This includes controlling the operations of all input and output devices, entering data into or writing data out of storage, and transferring data between storage and the arithmetic/logic section. Intergrated operation of the entire system is achieved automatically through the control section.

Arithmetic/Logical Section

The arithmetic/logical section is equipped to perform all arithmetic and logical operations. The circuitry for the arithmetic portion performs calculations, shifts numbers, sets the algebraic sign of results, rounds, compares, and
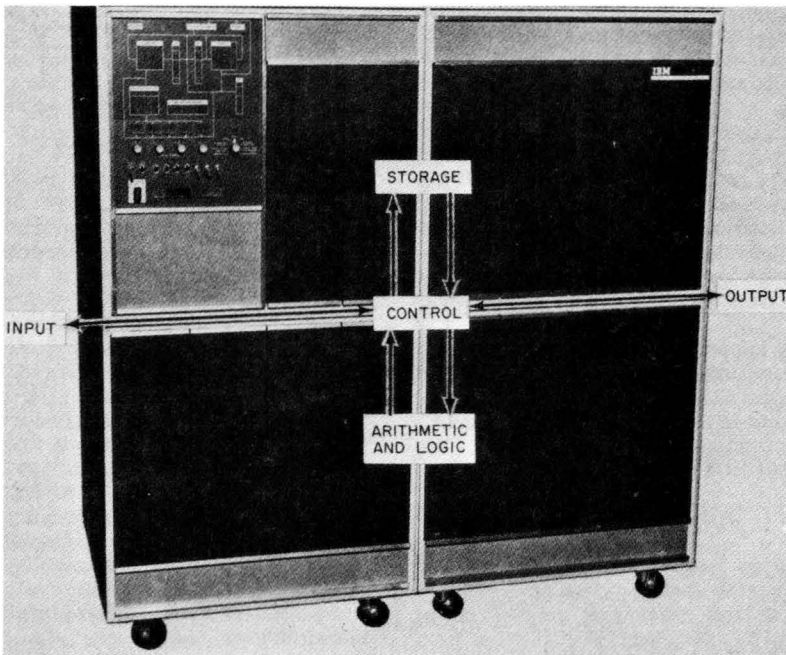
R49.170X

Figure 9-20.—Central Processing Unit in the data processing system.

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so on. The logic portion acts as a decision-making instrument to change the sequence of instruction execution, depending upon arithmetical conditions arising during the processing routine. For example, if the stored program calls for adding all X cards and subtracting all NX cards, the logical portion must decide which condition exists and pass its "decision" to the arithmetic portion of the arithmetic/logic section.

THE FUNCTIONAL UNITS

There are several devices, or functional units, located within the central processing unit that are used for holding (REGISTERING) various parts of an instruction that is to be executed, and for performing the various functions called for by the instructions. They are commonly known as registers, counters, and adders.

Registers

A register is a device capable of receiving and holding information as directed by the control circuits. Registers are named according to their function as follows:

● An accumulator is used to accumulate results.
● A multiplier-quotient holds either multiplier or quotient.
● An address register is used to hold the address of a storage location or device.
● An instruction register holds the address of the instruction being executed.
● A storage register contains information taken from or being sent to storage.

The more important registers of a system, especially those used for normal data flow and storage addressing, provide for visual display of their contents in the form of small incandescent or neon lights on the control panels of the operator consoles.

Counters

The counters are closely related to and usually perform the same function as a register. There is one notable difference; the contents of a counter can be incremented (increased by a determined amount) or decremented during an arithmetical process. The action of a counter is related to its design and use within a given system. Like the register, its contents may also be

displayed by visual indicators on the operator's console.

Adders

The adder receives the data from two or more sources (fig. 9-21), performs addition, and sends the result to a receiving register or accumulator. An adder acts upon one position of data at a time: the numbers in the units position of the input registers are brought to the adder where they are added and sent to the units position of the receiving register. Carryovers from any position are sent to the next higher order position for use with the next addition step. The number in the tens position of the input registers are then brought to the adder where they are added and sent to the tens position of the receiving register. And so the process continues until the numbers are added.
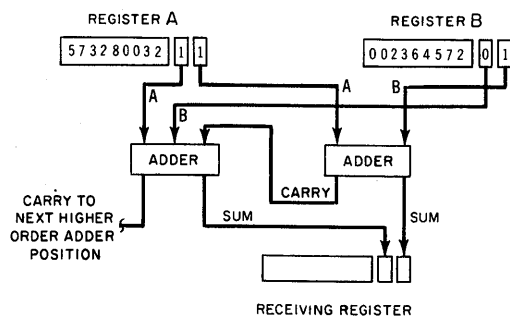
R49.312X
Figure 9-21.—Adders in a computer system.

MACHINE CYCLES

All computer operations occur in fixed intervals of time. These intervals are measured by regular pulses which are emitted from an electronic clock at frequencies as high as a million or more per second. Each basic machine cycle is determined by a fixed number of these pulses.

The computer can perform a specific machine operation within a machine cycle. The number and variety of operations required to execute one instruction depends upon the nature of the instruction. Various machine operations are combined to execute each instruction.

An instruction consists essentially of two parts: the OPERATION (or OP CODE) and the

OPERAND. The operation code tells the machine which function to perform, such as read, write, punch, compare, add, and so on. The OPERAND can be either a data address or the address of another instruction, or the address of other devices to be operated during execution of the program. The operand can also be used to specify a control function, such as shifting a quantity in a register or backspacing and rewinding a reel of tape.

The central processing unit must operate in a prescribed sequence in receiving, interpreting, and executing instructions. The sequence, which is determined by the specific instruction, is carried out during a fixed interval of time pulses. The time required by the computer to execute an instruction is divided into two phases: the INSTRUCTION phase and the EXECUTION phase.

Instruction

The instruction phase is the first machine cycle required in an execution of an instruction, and the time for this cycle is INSTRUCTION TIME, or I-time. The following numbered paragraphs describe the operations that take place during I-time.

1. The instruction is taken from its storage location and brought to the control section.

2. The op code, which tells the machine what is to be done, is decoded in an instruction register.

3. The operand, which tells the machine what it is to work with, is placed in an address register.

4. The address of the next instruction to be executed is determined.

At the beginning of a program, an instruction counter is set to the address of the first program instruction. This instruction is brought from storage, and the counter automatically steps (advances) to the location of the next stored instruction, while the first instruction is being executed. The instruction counter steps according to the number of storage positions occupied by the instruction. If only one storage position is occupied by an instruction, the counter steps one. Likewise, if an instruction occupies three storage positions, the counter steps three. The stepping action of the counter is automatic. When the computer is directed to a series of instructions, it will execute these one after another, unless directed otherwise.

Figure 9-22 illustrates the information flow lines and main registers involved when an instruction is given to add the contents of storage

location 0002 to the contents of the accumulator register.
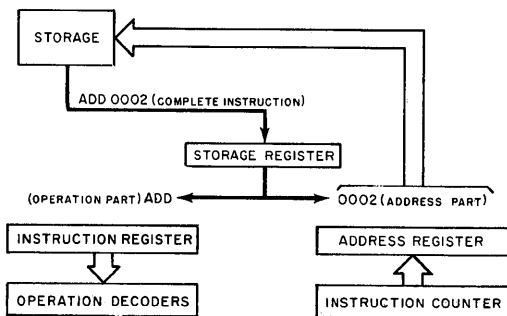
R49.313X
Figure 9-22.—Computer I cycle flow lines.

I-time begins when the address of the instruction is transferred to the address register. This instruction is selected from storage and placed in a storage register. From the storage register, the operand is routed to the address register and the operation part to the instruction register. Decoders then condition proper circuit paths to execute the instruction.

Execution

The EXECUTION TIME or E-time, consists of one or more machine cycles normally following I-time. The instruction to be executed will determine the number of execution cycles required. Figure 9-23 illustrates the data flow following I-time as shown in figure 9-22.
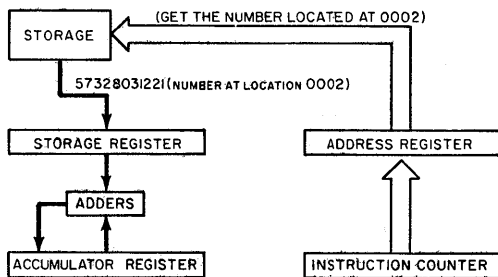
R49.314X
Figure 9-23.—Computer E cycle following an I cycle.

The EXECUTE phase begins with the removal from storage of the information located at the address (0002 in fig. 9-23) indicated by the address register. This information is placed in the storage register. In this case, the adder receives the number from the accumulator together with one of the factors to be added. The contents of the accumulator and the storage register are combined in the adder and the sum is returned to the accumulator.

The address register is not restricted to containing the storage location of data. It may contain the address of an input-output device or that of a control function to be performed. The operation part of an instruction tells the computer how to interpret this information.

Instruction/Execution

In stored program computers, a machine program must be loaded into storage before it can be executed. The load program, which usually precedes the machine program and causes the machine program to be loaded into storage, normally contains an instruction to discontinue loading and start executing the machine program at a given point. At this time, the location of the first instruction in the machine program is brought to an instruction counter automatically. This instruction is retrieved from storage and, while it is being executed, the instruction counter automatically advances to the address corresponding to the location occupied by the next stored instruction. Upon the completion of one instruction execution, the counter has located the next instruction in program sequence. Thus, instructions will be executed automatically one after the other throughout the entire processing routine unless a particular condition or instruction calls for altering the normal sequence of execution.

Instructions do not necessarily have to be executed in a sequential fashion. The process of executing an instruction other than the next sequential instruction is called BRANCHING (also TRANSFERRING or JUMPING). Certain branch instructions call for an unconditional alteration of the normal sequential execution. In this case, an instruction brought from storage indicates that an instruction located elsewhere in the program is to be executed next in lieu of the next sequential instruction. Alteration of sequential instruction execution can also be conditional; that is, branching can be performed when a certain condition or result develops during the

processing routine, such as when a comparison shows that two numbers are unequal.

PROCESSING METHODS

There are two methods employed in handling data in a data processing system: sequential, or batch processing, and in-line, or direct access processing. The main storage is normally the determining factor as to which method applies, but, in both cases all data pertaining to a single application are maintained in files (often called data sets). Figure 9-24, depicts the idea behind both methods of processing data.
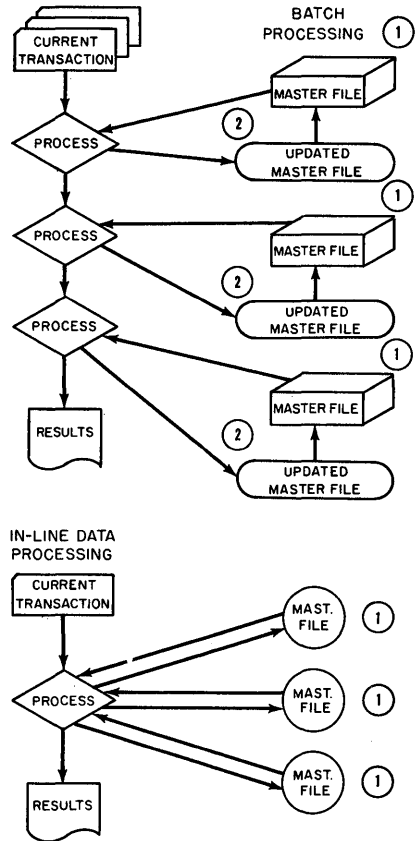
R49.315X

Figure 9-24.—Batch and in-line data processing.

Sequential (Batch processing)

The files accessed through batch processing are arranged in a predetermined sequence, and are usually stored outside the computer on magnetic tape. The data may be grouped into records containing name, rank or rate, service number, expiration of active obligated service, rotation tour date, and the like. Each file (data set) is composed of records, each containing information required to complete a given circumstance. The sequence may be by name, service number, rank or rate, or any sequence desired. But all files pertaining to a single application must be in the same sequence.

In many applications, processing of each record encompasses more than just calculating to arrive at amounts, earnings, or balances, but, may also involve many updating procedures. However, before transaction files can be applied to the master file, they must be arranged in the same sequence as the master file. For this purpose they are accumulated in groups or batches of convenient size, hence, batch processing.

The master file, together with the transaction file (data sets), now becomes input into the computer. One record, or a small group of records (also called a block), from each tape, is read into storage at the same time. Once these are processed and the results are written as output, the next group of records are read in, and the process is repeated. This process continues under the direction of the stored program instructions, record by record, until both input files are exhausted. The result is a newly updated master file in the same sequence as the original master file.

With sequential processing the information in storage is transient. Consequently, the storage capacity need only be large enough to hold the largest element of data to be processed, plus the stored program instructions.

In-Line (Direct access)

When processing by in-line, or direct access method, a large capacity storage unit, usually magnetic disk, holds all information pertaining to the particular application involved. Storage of information on magnetic disk is permanent and can be retained indefinitely.

When direct access processing is used, the transactions affecting the contents of the file (data set) are fed to the computer directly, as they occur. The computer locates the corresponding data or record in storage and adjusts the master record.

Due to the direct method of processing, transactions need not be batched or sorted prior to processing. Under the control of the stored program other outputs are available, and the contents of the entire disk file can be written out when required. Information retained on disk files is maintained constantly and is available when needed.

Serial and Parellel Operation

Computers are classified by the method by which they perform arithmetical operations and functions. The computer must perform according to a fixed mode. Arithmetical operation can be accomplished in one of two modes: SERIAL or PARALLEL.

Addition of data is said to be in a serial mode if the bits that represent the data appear successively in time one after another; that is, the units position, tens position, hundreds, and so on. Addition in the serial-mode is performed in the same way as it is with paper and pencil. Whenever a carry is developed, it is retained temporarily and then added to the sum of the next higher order position.

The time required for serial operation depends on the number of digits in the factors to be added. Serial addition is shown in figure 9-25.

The parallel-mode of addition is performed on a complete data word. The complete data word is added in one operation, including the carries. Regardless of their magnitude, any two words can be added at the same time, figure 9-26 shows parallel addition.

Data can be transferred in either serial or parallel with some advantages for each. Parallel data transfers can be accomplished more quickly than serial; however, in serial operations, fewer circuits are required to perform an operation.

	1ST STEP	2ND STEP	3RD STEP	4TH STEP
ADDEND	1234	1234	1234	1234
AUGEND	2459	2459	2459	2459
CARRY	1	1		
SUM	3	93	693	3693

R49.316X

Figure 9-25.—Serial addition.

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NUMBERS BEING ADDED	00564213
	00000824
CARRY	1
FINAL RESULTS	00565037

R49.317X

Figure 9-26.—Parallel addition.

Although any storage device can be adapted to either mode, the determining factor usually rests with the number of storage devices used.

The serial and parallel techniques are often used in the same computer during different operations. For example, a data word may be transferred to a shift register in parallel and then read out of the register serially. The reverse is also true; a data word may be read into the register serially and read out in parallel.

Fixed and Variable Word Length

Fixed and variable word lengths describe the units of data that can be addressed and processed by a computer.

In operations using fixed word lengths, handling and addressing of information is in units or words containing a predetermined number of positions. The system is designed for a specific word length, and normally corresponds to the smallest unit of information that can be addressed for processing in the central processing unit. Fields, records, factors, or characters, are all manipulated in parallel, as words, and storage, counters, accumulators, and registers will accommodate standard words for which they were designed.

In operations using the variable length word, the circuitry for data handling is designed to process information serially as single characters. The capacity of the storage unit determines the practical length of records, fields or factors. Data are available by characters instead of by words.

There is a major difference in handling data in fixed and variable word lengths, but this difference does not restrict any given system to one method or the other. Operations within the central processor may be entirely of a fixed word nature, entirely variable, or a combination of both.

PROCESSING WITH THE STORED
PROGRAM

After information to be processed has been transcribed to an input medium, such as punched cards or magnetic tape, the data processing system can take over and perform all processing steps required to produce the end result. However, the actual steps that are to be executed by the system must be defined precisely in terms of operations that the computer can perform. Each step has to be written as an individual instruction to the computer. A series of instructions required for the completion of a given data processing routine is called a program. This program is placed in storage before the processing is begun, and all instructions are automatically executed one at a time by reference to the program. When one instruction is completed, the next instruction is consulted for directions.

In the stored program, instructions consist essentially of two parts; the op code and the operand, as described in the discussion of machine cycles. (You will recall that the op code specifies the particular operation to be performed, such as read, write, add, compare, and move data, while the operand usually designates the address of the information or device that is needed for the particular operation.)

Instructions must be represented in the same form of coding as data, since both instructions and data use the same storage media. As a general rule, there is no particular area of storage reserved for instructions prior to loading the program. In most operations instructions are grouped together and placed into storage in the logical sequence written.

Since instructions and data are represented in the same form of coding, the only way the computer can tell one from the other is by the time that they are brought into the processing unit. The time required by the computer to complete one processing step is divided into two parts, instruction time and execution time. As explained under machine cycle, instruction time is the time required to locate an instruction and move it into the instruction registers. The computer then analyzes the instruction to see what is to be done. Execution time is the time required to perform the operation called for by the instruction. Information brought into the processing unit during instruction time is treated as an instruction. Information is treated as data at any other time.

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In unit record machines, we know that each step in a processing application is carried out individually by manually transferring cards from one machine to another and performing a particular part of the application on each machine. Cards are placed in a feed hopper, the start key is depressed, and cards feed continuously while a wired control panel directs the machine in performing its functions. In an electronic data processing system, all steps in the processing routine are performed in one operation automatically. Unlike unit record machines, the system must be directed through stored instructions to read a card (or tape record) each time new source information is desired, perhaps move the data in storage from one location to another; perform arithmetic calculations; perform logical decisions such as comparing or selecting; and releasing the final result, such as a printed report, a stack of punched cards, or a strip of tape.

Reading Data

All source data entering a data processing system must first be read by an input device and sent to main storage. Each input device must, like each storage location, be assigned a number to serve as an address.

A data processing system is usually concerned with large files of records which may be cards or tape. Once these files have been placed on an input device (cards or tape, for example), the computer has direct access to them as one or more instructions in the program activate the input unit and route the data to designated locations in storage.

At this point the exact location in storage where each item of information is to be placed must be determined, and an instruction must direct the system to send this information to its designated location. In order to manipulate the information in successive stages of processing, its exact location must be known at all times. Some systems automatically place the entire contents of a punched card in a fixed location in storage each time a card is read. Other systems may require that storage locations for input data be specified in the stored instructions.

Before reading begins, the input unit is selected and made ready. The chosen unit is the one that has access to the file of records as determined by the programmer. The unit is selected by its assigned address or code number.

The read instruction initiates the transfer of a record to the storage of a computer. The record is placed in the storage area reserved for it and is now available for further processing.

The sequence in which the files are read is determined by the order of the read instructions in the program.

The number of records to be placed in storage at a time depends on how the files are constructed, the available storage capacity, and the type and length of records being handled.

Moving Data

It is not always possible to process data from the locations used for input storage. For example, if comparison of control numbers in succeeding cards is being performed, both numbers cannot be in the read-in storage area at the same time. After each card is compared with the preceding card, its control number must be moved to another place in storage so that it can be compared with the following card. Another example of moving data is moving the results of arithmetic calculations from the storage locations to which they were routed from the accumulator to locations for punching and printing.

It is necessary to know at all times where information needed for each processing step is stored.

Calculating Data

All arithmetic operations require the presence of at least two factors, such as the divisor and dividend, multiplier and multiplicand, and so on. Hence, at least two storage locations are needed, one for each factor. The number of instructions required to complete an arithmetical operation depends upon the computer used. To add two factors, for example, one computer may require three instructions: one to move one factor to the accumulator, another to add the second factor to the first, and a third to move the answer to storage. Another system may require only one instruction for adding two factors, such as ADD A to B. In this case, both factors are passed through an accumulator, added, and returned to the address of factor B. In either example, however, the system cannot be instructed merely to add. The storage locations of the factors to be added must be specified in the add instruction.

Writing Data

The final phase in a data processing routine is writing out the results. The write-out can be on punched cards, tape, or report forms, depending upon the type of system and the requirements of the job. Regardless of the method of output, all steps for producing the end result in its desired form must be written as instructions in the program. For example, if a printed report is to be prepared, information to be printed must be moved to the print area, and the machine instructed to print.

If cards are to be punched, the data must be moved to storage locations corresponding to the columns in which punching is desired. Records to be written on tape must have the data arranged in storage in the sequence it is to be written.

PROCESSING WITH THE CONSOLE

Though external to the central processing unit, the console is frequently referred to as a logical part of it. The computer console has four main functions:

1. Type or key-in data, special operating instructions, and inquiries for the program during the production run.

2. Determine the contents of special registers and memory locations.

3. Revise the memory location contents.

4. Monitor the status of peripheral devices.

In a data processing system, the console and the program are the communicative links between the computer and the operator. The devices on the console provide the means to start and stop the computer, initiate computations, to select and set the proper magnetic tape units, and to control other input-output devices; and they enable the operator to check computer voltage and current levels, power input, temperature, and so on. There are wide variations in the consoles for different computers. In this section some of the features common to most consoles will be described. A typical computer console is shown in figure 9-27.

Monitoring Operations

Through the lights and signals on the console the computer informs the operator as to its internal state. There are in general three types of messages issued by these lights and signals. The first explains computer stoppage during the course of processing the program; the second presents a visual display of the contents of the various registers and storage locations; the third presents the state of the electrical power circuits. Some consoles display all conditions via a typewritten message. When a computer stops or halts, one or several lights come on, indicating the cause or causes of the halt, a final stop, or stop instruction has been executed, or an erroneous operation code in the instruction being processed, or an invalid address, or a check stop. Most consoles are constructed to display the contents of certain registers by means of rows of lights when the computer processing stops. For instance, there may be a set of neon lights to represent the contents of the instruction register, the accumulator, or of some storage location and so on. The value of register/storage content is represented by the lighted or unlighted lights.

Manual Control

The buttons and switches on the console provide the only means that the computer operator has to control the machine, other than the program itself. In addition to the on-off-switch for the electrical power, there is a start button which initiates the computations. For example, the machine may automatically take as the first instruction the contents of address 0000 when the start button is pushed. In addition, there is a stop button that causes computations to cease when pushed. There may also be a run button in addition to the start button, which is used to resume computations after a halt has occurred in the middle of a computation. The difference between the start and run button is that the run button tells the computer to continue to perform the instruction that it has in the instruction register, whereas the start button tells the computer to return to the first instruction in the program.

Generally, computers can be operated in several modes. For example, by setting the proper switch a computer can be set to execute only a single instruction each time the run or start button is depressed. By successively depressing the run button in this way, a sequence of instructions can be "stepped through" slowly. This would be done if examination of several instructions and their results, as displayed on the console, were desired. The computer can be made to sequence itself through the program instructions at a considerably reduced speed by a different setting of the mode switch. The
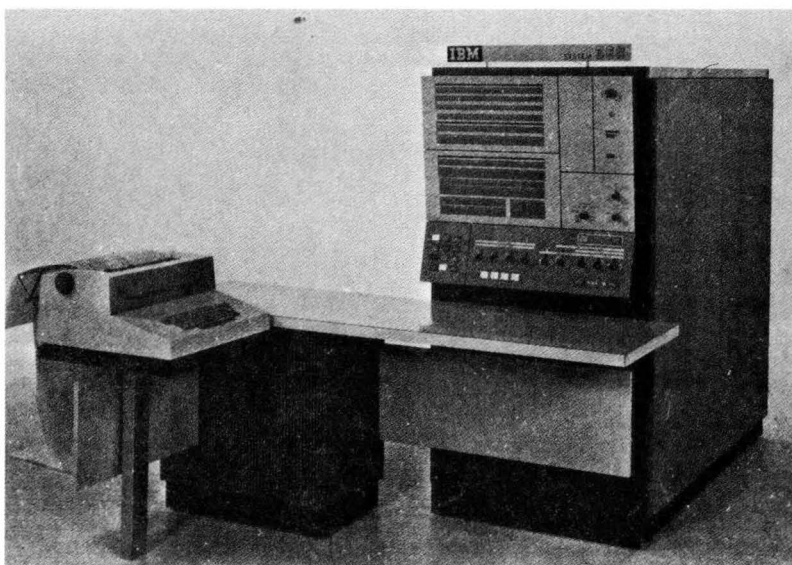
Figure 9-27.—Typical operators console.

mode switch can be set to allow the computer to operate at full speed. On many consoles there is a phase selector switch which makes the computer proceed through a single phase for each depression of the run button.

One of the most important uses of the operator's console is to enable the operator to insert data manually into particular storage locations. This may be done when it is necessary to correct one or two words in a long program that has already been entered into storage. To accomplish this, several methods are used. One method involves having one button associated with each bit position in the registers so that each bit may be displayed by lights on the console. The contents of the register may be changed by means of these buttons, once the computer has been halted. For each register that has a clear button, the contents of that register can be set to zeros, when the respective clear button has been pushed. Then 1's are inserted in the desired bit locations when the bit buttons of that register are depressed. In this case, the procedure for inserting a word into a particular storage location would be as follows: halt the computer; manually insert the

desired word in the accumulator; insert an instruction in the instruction register that will transfer the contents of the accumulator into the desired storage location; set the mode switch for a single instruction, and push the run button. The inserted instruction will then be executed, and the word will be inserted into the specified address.

Another method for inserting corrected data involves the use of an on-line typewriter, by which words and instructions are typed in the format prescribed for the particular system and introduced automatically into the computer.

Inquiry Stations

Inquiry stations are the connecting links between remote operators and information stored in a centrally located computer. The computer can be queried by an operator on site, via operator's console, or by an operator at a remote point, via a console inquiry station. To use a hypothetical situation, assume that you are working at an issue counter in a naval supply depot that has a data processing system with remote console inquiry stations. As requisitions

are brought to you to be filled, you may wish to know if your warehouse has a particular item in stock, and, if so, how many. To get this information without making a trip to the warehouse, all you have to do is type the part number or numbers on an on-line typewriter. This information is transmitted to the data processing center where a paper tape is punched and read into the computer. The computer then selects the proper storage files and transmits all information keyed to the part number or numbers back to the console inquiry station where the message is typed out automatically. In this way, information is supplied in a matter of a few minutes, enabling fulfillment of requisitions to be expedited.

CHAPTER 10

INPUT/OUTPUT

Input and output devices provide the electronic data processing system with the facilities necessary for putting in or getting out data from storage.

In this chapter we will cover several of the general used data recording media and some of the methods and techniques employed to introduce data into, and receive data from, a computer system. This chapter restricts it coverage to commonly used devices, leaving treatment of specific devices to other texts.

DATA RECORDING MEDIA

Most all input and output systems use recording media. The most popular forms of recording media are the printed pages, punched cards, punched paper tape, and magnetic tape. The more important considerations that determine the choice of recording media are:

1. Compatibility between input devices and computer.
2. Form and quality required of the recorded data.
3. Ease of handling and accessibility of data.
4. Performance, erasability, and durability of record medium.
5. Volume of bulk storage capacity, density and costs associated with storage of data.
6. Size, weight, and power consumption of recording equipment.
7. Speed of reading and recording, and reliability of data and of the recording equipment.
8. Installation, operation, and recording costs.

PUNCHED CARDS

Punched cards are commonly used for I/O on small and medium sized computers. Equipment for handling punched cards is often referred to as unit record equipment. Since punched cards may serve as records and since all may have data in the same format, a single punched card may be thought of as a "unit" record, and a quantity of punched cards constitutes a deck. Punched cards are convenient because of their low cost and unit record nature.

There are two types of punched cards in general use—the 80-column and the 90-column cards. Different equipment is required for handling the two types of cards. The 90-column card employs circular holes and is associated with equipment of Sperry Rand. However, the most common is the Hollerith code that may be used with all manufacturers computer I/O equipment.

Card Codes

The physical placement of holes in a specfic pattern in the card is the code used to represent data in punched cards. There are three card codes that utilize the rectangular holes: Hollerith, (which was discussed in chapter 2) row binary, and column binary. In general, there are 12 rows on the card and each row contains 80 columns.

Row binary describes one method of recording binary information on cards. In this system, the information is arranged serially across each row of the card. Each punched hole is regarded as a binary 1. No punching indicates a binary 0.

Binary information may also be recorded in a columnar binary fashion. With this method, data are arranged in parallel with each column of the card containing 12 information bits.

It is extremely important to realize that data formats are arbitrary and may be modified as conditions necessitate, as long as the computer program is compatible. As an example, assume it is desired to store 36 bit computer words on the card. These may be readily stored using three columns per word (a total of 26 words per card),

or they may be stored horizontally, two words per row, for a total of 24 words per card.

Data in the computer are represented by the presence of pulses; whereas, in cards, data are represented by the presence of punched holes. In a punched card application the pulses in the computer originates from electrical contact through the punched holes.

PAPER TAPE

Developed for transmitting telegraph messages over wire, paper tape is now used for data processing communication as well. For long distance transmission, machines read paper tape at one location, transmit electrical impulses over telephone or telegraph wires to produce a duplicate paper tape at the other end of the wire, for later processing.

Paper Tape is bulky, not very durable, and inconvenient to store, but the cost is practical. Paper tape is a strip of paper of indefinite length and may be either five-eighths of an inch or an inch wide. The paper base may range from something that looks like a heavy newsprint to a high-quality plastic impregnated opaque cardboard, very light in weight and flexible. A reel of paper tape ranges in length from a few feet to several hundred feet.

Data are represented on paper tape by a special arrangement of precisely punched holes along the length of the tape (fig. 10-1 and 10-2). Paper tape is a continuous recording medium and can be used to record data in records of any length, the capacity of the storage medium into which the data is to be placed or from which the data is received, being the only limiting factor. A tape punching device transcribes information from source documents to paper tape, which is then read or interpreted by a paper tape reader.

Eight Channel Code

In an eight channel tape the data are recorded (punched) and read as holes located in eight parallel channels along the tape. Figure 10-1 illustrates the eight channel tape and several coded characters. These characters consist of numeric, alphabetic, special, and function characters. All characters are coded by one column of the eight possible punching positions (one for each channel) across the width of the tape.

The four channels labeled 1, 2, 4, and 8, excluding the feed holes, are used to record numeric characters. In these four positions the numeric values 0 through 9 are represented as a punch or combination of punches. The value of the numeric character is indicated by the sum of the position values. For example, holes in the number 4 and 2 tracks would represent the numeric 6.

The X and O channels are similar to the zone punches in cards, and are used in combination with the numeric channels to record alphabetic and special characters.

The eight channel tape is said to be of odd parity. That is, the checking feature checks to be sure that each column of the tape is punched with an odd number of holes. Any time the basic (X, O, 8, 4, 2, 1) code consists of an even number of holes a check hole must be present.

The tape feed code consists of punches in the X, O, 8, 4, 2, and 1 channels and is used to indicate blank character positions. A punch in the EL (end of line) channel is a special function character used to mark the end of a record. Areas of the tape punched with the tape feed code are automatically skipped by the tape reader.

Five Channel Code

As opposed to the eight channel tape, the data are recorded (punched) and read as holes in five parallel channels along the length of the paper tape. All numeric, alphabetic, special, and function characters are represented across the width of the tape by one column of the five possible punching positions. Figure 10-2 shows a section of a five channel tape with several coded characters.

Using the five punching positions, only 31 combinations of the holes are possible. Therefore, a shift system is used to expand the number of available codes. When the figures (FIGS) code precedes a section of tape, the coded punches are interpreted as numeric or special characters (fig. 10-2). When preceded by the letters (LTRS) code, a section of tape is interpreted as alphabetic characters (fig. 10-2).

Ten of the 31 codes are used for coding both alphabetic and numeric characters. The interpretation depends on the shift code, FIGS or LTRS, which precedes the characters. These characters are P, Q, W, E, R, T, Y, U, I, and O and the decimal digits 0 through 9. Likewise, the code for special characters is identical to some of those used for other alphabetic characters.

The function characters - space, carriage return (CR), and line feed (LF) are the same
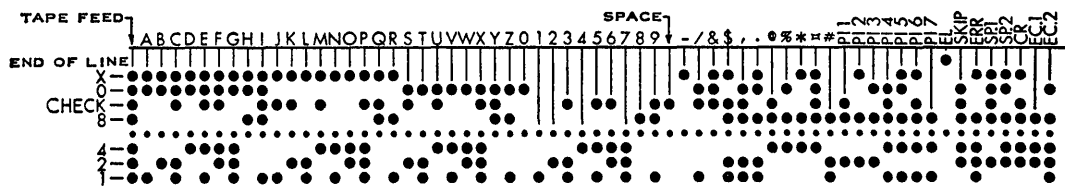
Figure 10-1.—Eight channel paper tape code.
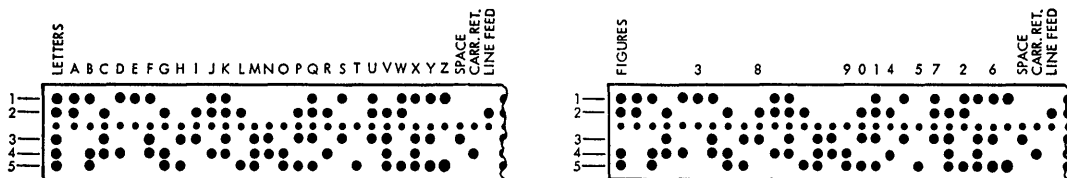
R49.285X

Figure 10-2.—Five channel paper tape code.

R49.286X

in either FIGS or LTRS shift. The space code is used to indicate the absence of data on the tape.

Like the card code, paper tape code is compatible with the codes that are used by a computer.

MAGNETIC TAPE

Magnetic tape is one of the principal recording media for computer systems; it may be used for reading input and writing output, and it may also be used for storing intermediate results of computations. One of the greatest advantages of magnetic tape is that it provides compact storage for large files of data.

Magnetic tape records information as magnetized or non-magnetized tracks along the tape. The recorded information can be automatically erased, and the magnetic tape can be used over and over again, or the recording can be retained for an indefinite period.

Tapes are wound on individual reels so that they may be handled and processed easily. Tape on the reels may run up to 2400 feet in length and 1/2 inch in width.

Data are recorded in parallel tracks along the length of the tape. The binary digits of a word are recorded on tape having densities up to many hundred bits per inch.

The tracks across the width of the tape provide one column of data. During the writing (recording) operation, the spacing between the vertical columns is automatically generated. This spacing varies, depending on the character density used for recording.

A space that is longer than usual is generated to indicate the end of one record and the start of another. This space is called the "interrecord gap" (also called the interblock gap).

Magnetic Tape Code

Data for IBM computers are normally coded on seven-track magnetic tapes in two modes-- binary coded decimal (BCD) or binary. The code used depends on the computer that originates the tape recorded data.

As shown in figure 10-3, binary coded decimal (BCD) may be used for recording decimal numbers and letters of the alphabet on magnetic tape. The BCD format also provides for coding punctuation marks as well as other special characters.

Binary code is used in some computers to record data on magnetic tape. Figure 10-4 illustrates binary notation on seven track magnetic tape.

Just as the presence of punched holes in a card represents data, the presence of magnetized spots on magnetic tape represents data.

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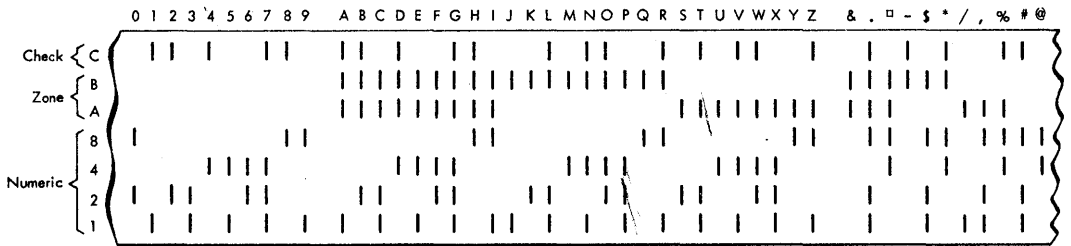
R78.25X

Figure 10-3.—BCD notation on seven track magnetic tape.

MAGNETIC INK CHARACTERS

A language readable by both man and machine is produced by printing magnetic ink characters on paper media for machine processing as seen in figure 10-5A. The magnetic property of the ink allows reading by machine, and the shape of the characters permits visual interpretation.

Once information has been inscribed on the paper documents, they are ready to be read by a reader-sorter which reads the inscribed information from the document and converts it to a machine language. After this is completed, the information is entered directly into the data processing system.

OPTICALLY READ CHARACTERS

Another method of input to a data processing system is optically readable characters on paper documents (fig. 10-5B). Included in these characters are all letters of the alphabet, digits 0 through 9, and special characters. Ordinary pen or pencil marks placed in certain locations on the document can also be read.

VISUAL OUTPUT

Visual display units provide for high-speed visual communication between the computing system and its user.

Most visual display units are table-top devices for displaying graphic reports that would take many times longer to produce by normal printing methods. The display units present tables, graphs, charts, and alphameric letters and figures on a cathode-ray tube screen, as shown in figure 10-6.

The use of a visual display unit may also be used as a system operator console by using an entry keyboard to update a record immediately and return the corrected data to main storage, either locally or many miles distant from the processing unit.

INPUT/OUTPUT DEVICES

An input/output unit is a device for putting in or getting out data from storage (fig. 10-7). Generally, I/O devices must meet two basic requirements. First, the devices must be able to modify all data so that it is acceptable to the computer during the input phase of the operation and must be able to present data in usable form during the output phase. Second, the devices must operate quickly and efficiently in conjunction with the computer.

Conventional input devices sense or read coded data from cards, magnetic tape, paper tape, magnetic ink characters inscribed on paper documents, or remote terminals via communication lines. The data is made available to the main storage of the system for processing.

Output devices record or write information from main storage in printed form, on punched cards, paper tapes, magnetic tapes, or make graphic displays. Outputs in still other forms are available for special applications.

Nearly all I/O devices suffer the same disadvantages—slowness of response. Most computers can process millions of characters of data per second. I/O devices, particularly those which require some mechanical operation, are hard-pressed to manipulate several thousand characters per second. There is, of course, a wide disparity in data exchange rates between the various devices, but the computer is faster even when the fastest of these devices are considered.

Various procedures are being used in order to more profitably utilize computer time. One such procedure, designed to minimize computer

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idling time, is to program I/O cycles to run concurrently with computation. Another is to use a number of I/O channels and provide multiplexed inputs to the computer from several I/O devices. (Multiplexing, as used here, refers to the ability of the computer to sample the data on a number of input channels while maintaining the intelligence of the data from each channel. The rate of the multiplexing action is high enough to permit the operator of each I/O device to retain immediate access with the computer.)

Common methods for improving computer usage insofar as can be accomplished by the I/O equipments themselves include the use of offline devices (i.e., devices not under the direct control of the computer), use of electronic switches to multiplex several equipments on one channel, and the use of buffer storage registers in the I/O equipment. Buffer storage is treated later in this chapter.

READING AND WRITING

As the input medium physically moves through the input device, the data are read and converted to a form compatible with the computer system. The information is then transferred to main storage.

Writing is the product of converting information from main storage to a form or language compatible with an output medium, using an output device.

Most devices used for input-output are automatic; once started they continue to operate under the direction of the stored program. Reading, writing, storage location specifications, and the selection of required devices are accomplished by the instructions in the program.
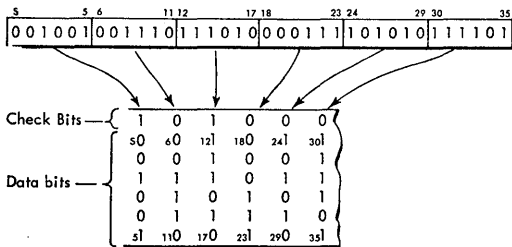
R78.26X

Figure 10-4.—Binary notation on seven track magnetic tape.

In some data processing systems, transfers, checking, coding, and decoding are performed through a control unit that contains the circuits required to perform these functions. In this text, descriptions of input-output operations are usually referred to as being accomplished by the individual input-output device.

Validity Checks

In the chapter on automatic punches we discussed the operation of reproducing and comparing. The comparing portion, in which the holes in the newly punched card were checked against the original to ensure that they were the same, is a form of validity check.

In an electronic data processing system all data transferred between storage and input-output devices are automatically checked for validity. Certain data checks are made internally as data are received and transferred by the central processing unit. In addition, the input device checks the data before release, and the output device checks the data when received. This does not mean that the machine detects the use of wrong data. That is, if an error is entered, this cannot be detected by the machine. However, if the machine misreads or misinterprets the indicated data, this can be detected automatically and indicated by the machine.

Indicators, Keys, and Switches

Just as EAM equipment has indicators, keys, and switches, so do the input-output devices of an electronic data processing system (fig. 10-8). The status of the devices is shown by the indicator lights: density selected, ready, and so on. The primary functions of the operating keys and switches are to start and stop operations manually. Because of the wide variety of input and output devices used in the Navy, the specific functions will not be covered here. For further information consult the manual for the machines and systems you are operating.

Control Panel

The control panel in a machine provides a means of deleting, rearranging, editing, and selecting data as they flow through the device(s). The principles of control panels are identical for EAM and EDPM. Therefore, the detailed explanation of control panels in previous chapters should be consulted.

R49.191X

Figure 10-5.—Magnetic ink and optically read character documents.

CARD READERS

Card readers introduce punched card data into the computer. To convert the data on the card into electronic form, the card must be fed past a reading station. Two methods of reading data are common: photoelectric cells and reading brushes.

In the brush type card reader, cards pass between a set of reading brushes and a contact roller. The brushes electrically sense the presence or absence of holes in each column of the card (fig. 10-9). The card reader circuitry utilizes the electrical impulses that are converted from the electrical sensing and stores them as data.

After the cards have been read, they are passed on to the card stacker and stacked in the same sequence as they were read. Some card readers have two sets of reading brushes; which enables each card to be read twice as it moves through the card feed unit; this serves as a check on the validity of the reading process.

The photoelectric type card reader performs the same function as the brush type; the only difference is in the method of sensing the holes. Photoelectric card reading is performed by 12 photoelectric cells, one for each of the 12 columns of the card. Cards are passed between the photoelectric cells and the light source. If the cards are punched, the light will penetrate the holes and activate the photoelectric cells.

Figure 10-6.—Example of display screen contents.

Another use for card readers is to provide a medium for transcribing punched card data onto magnetic tape for use in magnetic tape systems. The magnetic tape can then be used as direct input to the system.

CARD PUNCHES

Card punching devices are used to punch results obtained within the computer system. The binary coded characters within the system are automatically converted to standard punched card codes before punching occurs. The card punch automatically moves blank cards, one at a time, from the card hopper, under a punching mechanism (PUNCH DIES) that punches data as it is received from storage of the computer system (fig. 10-10). Once the card is punched, it is moved to a reading station where the data are read and checked with the information received at the punching station. The card is then moved to the stacker.

Card punches may also be used for converting information recorded on magnetic tape to punched card form. This is not a part of the actual system operation, but is performed as an auxiliary operation in those cases where output from a tape system must be converted to punched card form for further processing or handling.

Card Reader-Punch

Some punched card data processing systems require only one machine for both (punched card) input and output. In the type 1401 system for example, the type IBM 1402 card read-punch shown in figure 10-11 can feed punched card data into the system and punch results obtained within the system at the same time. There is no connection in this machine, either electrical or mechanical, between the read and punch units. Therefore, any information which is to be reproduced or gangpunched from the cards in the read unit into the cards in the punch unit must first pass through storage in the processing unit.
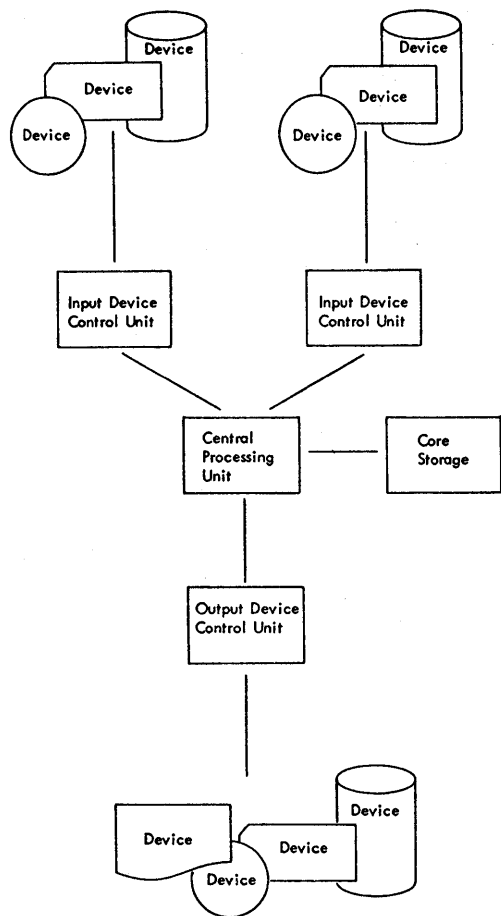
R49.361X

Figure 10-7.—Input/Output units in the data processing system.

Card Reader-Punch-Interpreter (CRPI)

The card reader-punch-interpreter shown in figure 10-12 is one of the components of the AN/UYK-5 (V) Data Processing set (UNIVAC 1500 series of computing equipments). This unit provides the required card reading, and punching. It also has the capability in an on or off-line capacity, to print data on cards. The interpreting format may consist of two lines of up to 60 characters each.

Cards are transported lengthwise through five stations: read, punch, post punch read, interpreter, and stacker stations. Each operation or combination of operations to be performed by each station and card movement is controlled by commands from the computer.

PAPER TAPE READER

Paper tape readers serve the same function as card readers. That is, they read data recorded in the form of punched holes. When used as an input device to a computer, the paper tape reader transmits the data to main storage. The tape reader feeds or moves the tape past a reading station. The presence or absence of holes in the tape is sensed and converted to electronic impulses that are used as data by the computer system. Reading of paper tape may be from 150 to 1000 characters per second, the speed depending on the type of reader used.

For faster paper tape input to the computer system, the data to be converted may be written on magnetic tape in an offline operation. The recorded tape may then be placed on a magnetic tape unit and read into the computer system at the much higher tape input rates.

PAPER TAPE PUNCH

Information from the computer system can be recorded as punched holes in paper tape by an automatic tape punch. Information to be punched is converted from computer language to paper tape code before being punched. Paper tape is usually punched with ten characters to the inch. The speed of punching varies depending upon the type of punch, but generally ranges from 60 to 200 characters per second.

MAGNETIC CHARACTER READER

A magnetic character reader (fig. 10-13) provides a time-saving method of reading and processing large volumes of daily transactions. These machines read inscribed card and paper documents and have the ability to sort the magnetically inscribed documents in an offline operation.

As the shape of each magnetic ink character passing under the read head is examined, 10 data channels send signals to an electronic storage device called the character matrix (fig. 10-14). For each of 70 character segments, there is a storage location in the matrix, and as documents
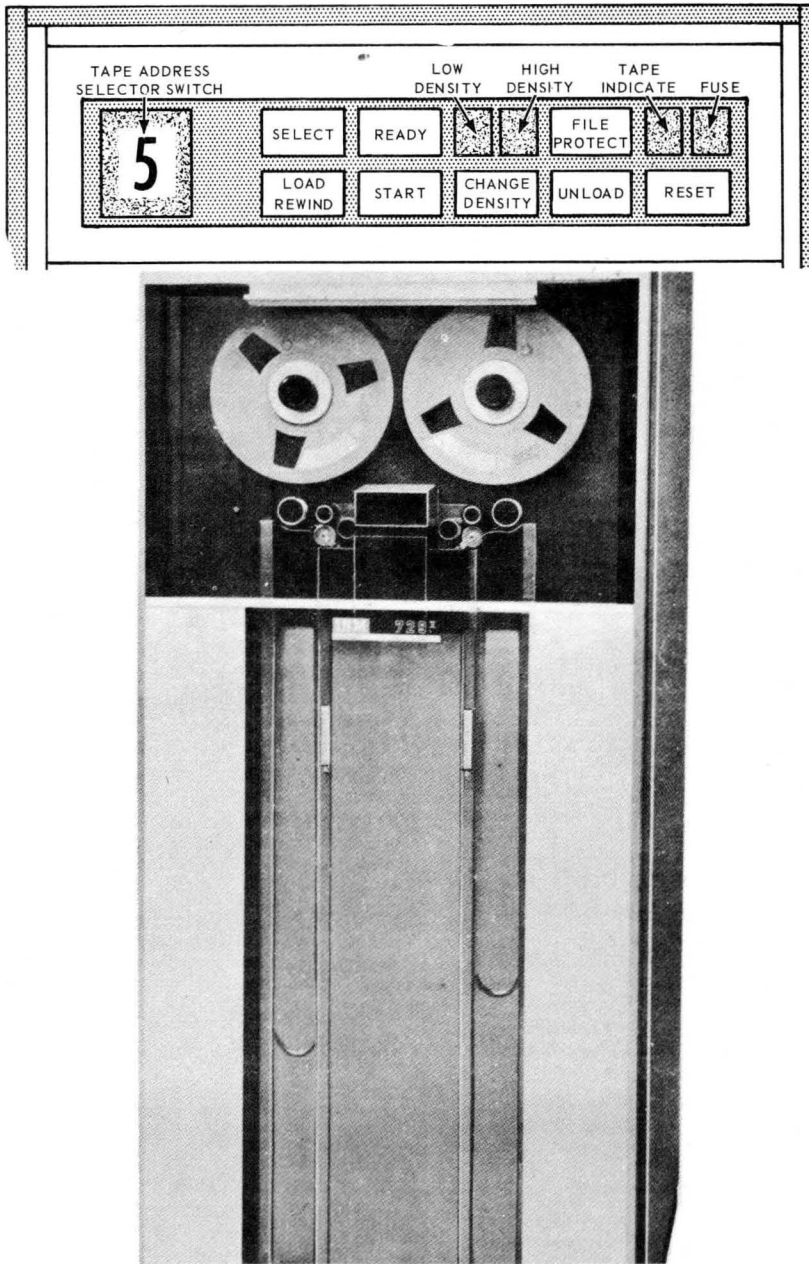
Figure 10-8.—Magnetic tape unit and indicators.

R49.161X
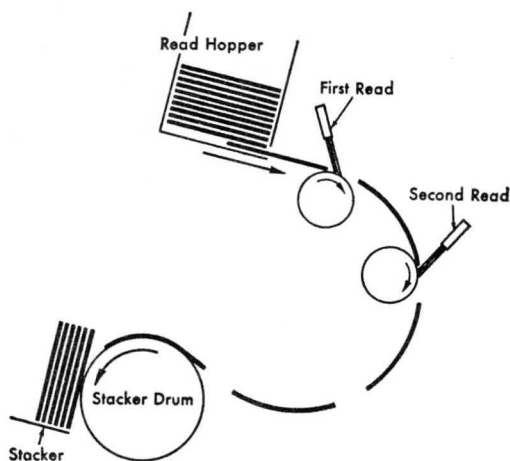
R49.290X
Figure 10-9.—Brush reading.
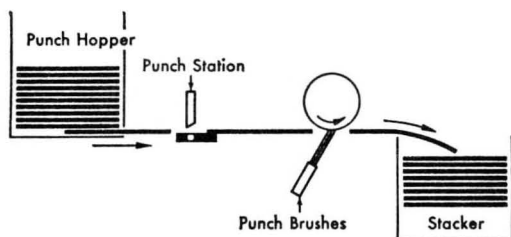
Figure 10-10.—Card punch station.

R49.291X

R49.160X
Figure 10-11.—IBM Type 1402 card read-punch.

pass under the read head, lack of any appreciable signal from a character area segment causes the machine to store a 0 bit in that storage location (unshaded portion of fig. 10-14). Likewise if there is an indication that magnetic ink is under the reading head, the machine will store a 1 bit in the specified storage location (shaded portion of fig. 10-4). The bit structure entering the matrix is also displayed on the indicator panel by the character matrix lights.

Once the entire character area has passed the read head and all segments have been read, a configuration of bits, and no bits, represents a pattern of character shape in the character matrix (fig. 10-14). To verify accuracy of processed data, the reader automatically checks

120.100.3-.4
Figure 10-12.—UNIVAC 1549 card reader-punch-interpreter (CRPI).

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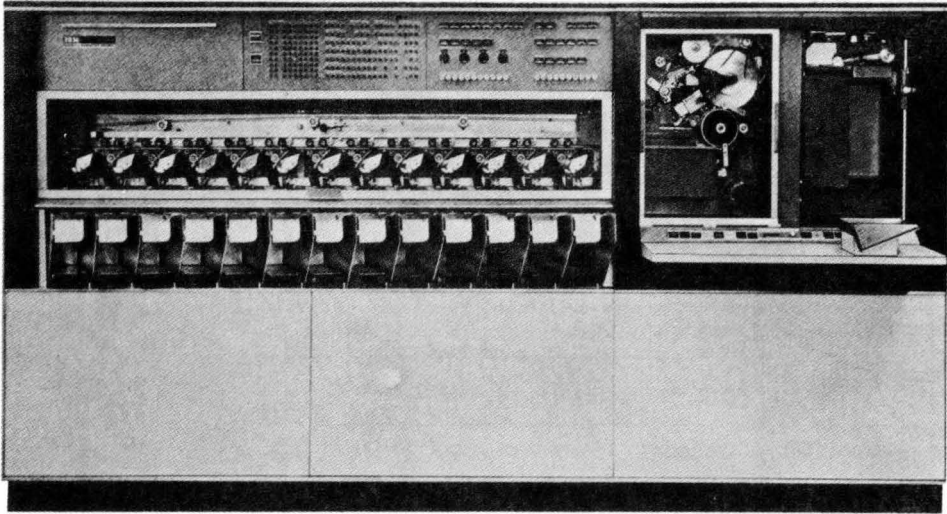
Figure 10-13.—Magnetic character reader.

each character as it is being read. When it has been determined that the characters from the reader are valid, the character register stores the characters. The characters remain in this register until they are no longer needed. Once it has been determined that a pattern is invalid, the recognition circuits provide the machine with an error signal.
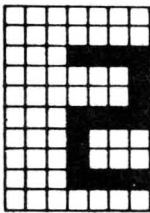
Figure 10-14.—Character matrix.

OPTICAL CHARACTER READER

The optical character reader (fig. 10-15) introduces data into the computer system as uppercase letters, numbers, and certain special characters from the printed paper document. The time between receipt and entry into a data processing system is greatly reduced due to the elimination of transcribing the source data to cards or tape.

Documents are moved from a hopper past an optical scanning station by a rotating drum.

A powerful light source and a lens system (not shown) distinguishes between black and white patterns of reflected light. A character pattern is developed when light patterns are read as small dots and converted into electrical impulses to develop a character pattern. The characters are recorded and transferred into the computer system for processing when the pattern of the optically read character matches a character pattern in the reader's character recognition circuits. The read and recognition operation is automatic and takes place at split-second speeds.

Mark-reading is another operation that can be performed by optical readers. Ordinary pen or pencil markings, when placed in a specified location on the source document, represents specific information.

PRINTERS

Printing devices provide another means of outputing data from a computer. Data from the
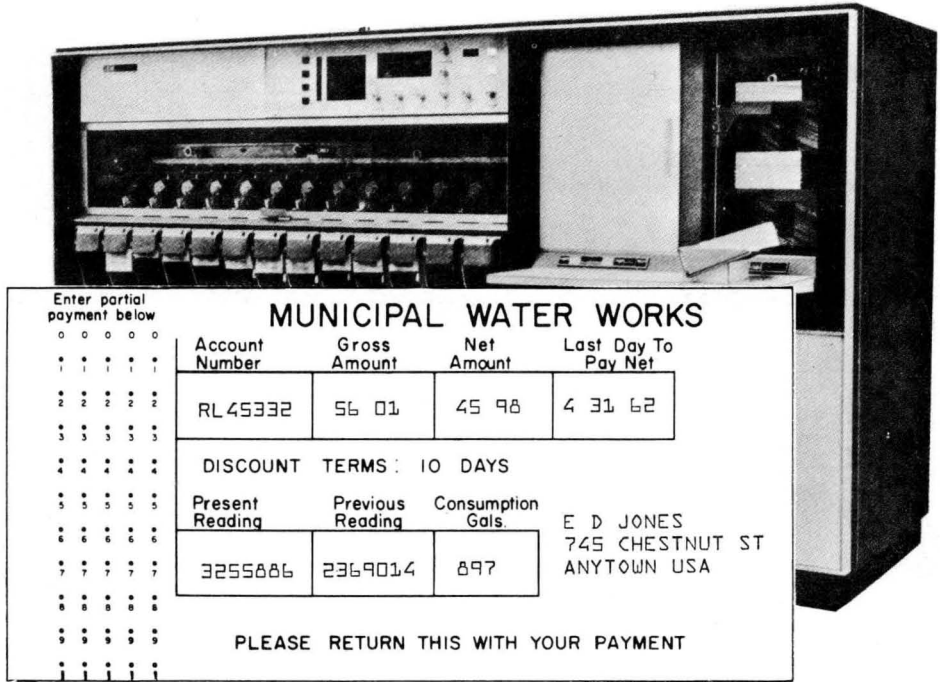
R49.297X

Figure 10-15.—Alphameric optical reader and mark-sensing document.

computer system are provided in permanent visual records, at rates ranging from a few characters to several hundred characters per second, depending on the particular device used. The discussion that follows covers some of the characteristics of the print wheel printer, print drum, wire matrix printer, chain printer, and the typewriter.

As output units, these devices receive data from the computer system in symbolized electronic form. Once these electronic signals have entered the appropriate circuits and actuate the printing elements, printing takes place. All paper or forms used with these printing devices is moved over the paper transport automatically as printing progresses.

Print Wheel

The print wheel printer prints all numbers, alphabetic characters, and special characters, utilizing 120 rotary print wheels as shown in figure 10-16. Each print wheel can print a variety of 48 different characters. Each print wheel is correctly positioned to represent the data to be printed, at which time printing may occur as one complete line of 120 characters. Speed of printing varies, depending upon the type of printer. Automatic printing and carriage spacing are under the control of the stored program.

Print Drum

Print drums are used with several printers manufactured by UNIVAC. Figure 10-17 is a photograph of the UNIVAC 1569 high speed printer. Located around the print drum (not shown) are 64 characters (including space) for each printing position, and the characters to be printed are positioned as the drum rotates at high speed.

The print drum can print a maximum of 132 print positions per line. Printing speed is determined by the type of data being printed.
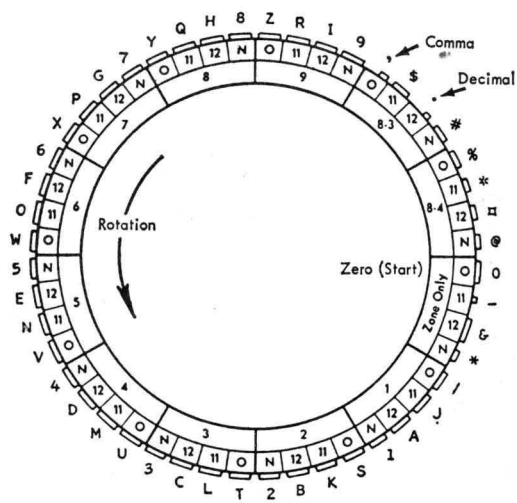
R49.108X

Figure 10-16.—Print wheel.

120.100.5-.6

Figure 10-17.—UNIVAC 1569 high speed printer.

Chain Printer

The chain printer is an electromechanical line printer using engraved type. The information is printed from characters assembled in a chain (fig. 10-18). As the chain rotates in a horizontal path, each character to be printed is positioned opposite a magnetically actuated ham-mer that presses the paper against the piece of type in the moving chain. The number of lines that can be printed per minute and the number of characters that can be printed on each line depend upon the type of printer. For example the IBM type 1403 printer shown in figure 10-19, can print a maximum of 132 characters per line at a speed up to 1285 lines per minute. All print-ing and carriage spacing is determined and controlled by the stored program.

Wire Matrix

In the wire matrix printer, the 47 printable characters include the letters of the alphabet, digits 0 through 9, and 11 special characters. Here, a 5 X 7 matrix is formed by the ends of small wires, which print each character in the form of dots (fig. 10-20). Printing is ac-complished by selecting the appropriate wires to form the character, and extending these wires until they are pressed against an inked ribbon, which in turn prints the character on paper. Printing speeds depend upon the printer. Speeds of 500 or 1000 lines (of 120 characters per line) per minute may be attained.

Typewriter

A typewriter used as an output device (fig. 10-21) has a close resemblance to those used manually. Unlike the manual typewriter, this unit accepts its instructions from the stored program in the computer. The printing speeds of keyboard-printer units are up to 600 characters per minute. Spacing and carriage returns are automatic. Keyboard-printers may be operated off-line to print information.

CONSOLES

A console normally consists of a keyboard, typewriter, and a line or a cluster of indicator lights on a pedestal base. The console provides external monitoring and supervisory control of a data processing system. Data may be entered directly by manually depressing keys or switches. Light clusters are provided so that data in the system may be examined by visual dis-plays. A typewriter provides limited input and output, such as keying in new instructions, modifying instructions, printing out messages signaling the end of processing or an error con-dition. It may also print out information that will enable the operator to monitor and supervise the operation more efficiently.

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ONE SECTION OF 48 CHARACTER

RIBBON

132 PRINTING POSITIONS

PAPER

COMPLETE CHAIN COMPOSED OF FIVE 48-CHARACTER SECTIONS
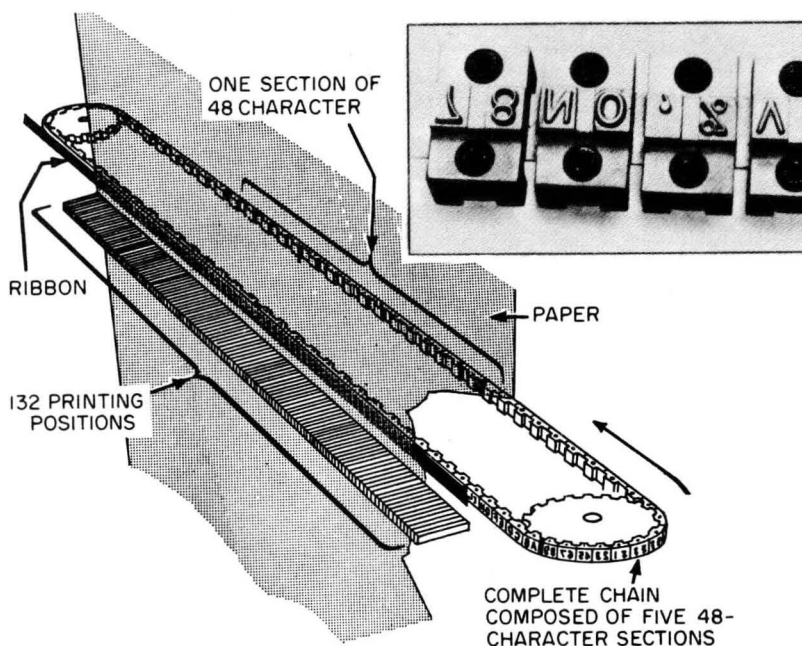
R49.305X

Figure 10-18.—Print chain.

A remote console may be used at a remote location to provide duplicate operator controls for increased flexibility and efficiency.

MAGNETIC TAPE UNITS

Just as there are many types of electronic data processing systems, there are many types of magnetic tape transport units. Each unit is equipped with various dials, switches, lights, and assorted devices for controlling and operating the unit. While the devices and features differ from one unit to another, the operation of any tape unit during a data processing routine is basically the same; each is controlled almost entirely by instructions in the stored program. These instructions consist essentially of such instructions as "read," "write," "backspace," "skip," and "rewind." Other instructions, and variations of the instructions just mentioned are used for effecting various other operations, depending upon the operations performed and the type of system used.

Feeding of magnetic tape by a tape transport unit is performed in a series of starts and stops, rather than in a steady, even flow. This is done to allow the computer time to perform the necessary operations upon an input record or record block as called for in the stored program and to perform other operations as required before the next record or group of records is read in.

Several tape transport units may be used with an EDPS for a given application, using some for input and others for output. The number of units that can operate at the same time depends upon the type of system used and the job being performed. In some systems simultaneous input from several units can be effected while other units are recording simultaneous output. In other systems, input and output may be performed simultaneously by two separate units, but only one unit at a time can be used for input or output.

Each tape unit is assigned an address so that the instructions in the stored program can reference the proper unit when needed. Each
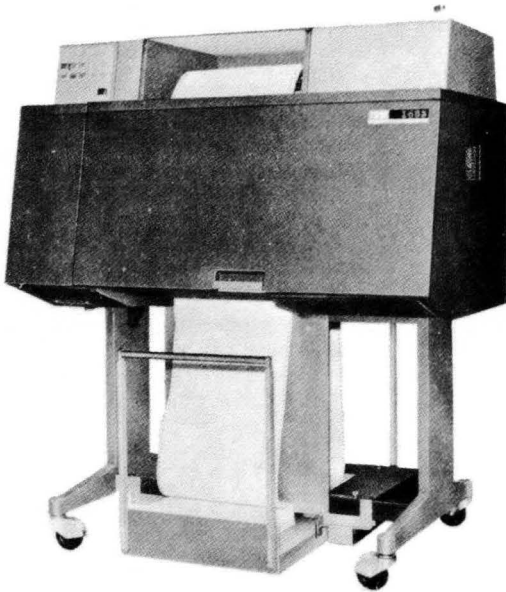
Figure 10-19.—IBM type 1403 printer.

R49.307X
Figure 10-20.—Character matrix and 5 X 7 dot pattern of the numeral 4.

unit may have a dial containing as many numbers as the maximum number of tape units which can be used with the system. For example, if ten units can be used, the dial for each unit may contain the numerals 0 through 9. When a particular unit number is referenced in the stored program, the unit set up for the

120.100.4
Figure 10-21.—Input-Output keyboard-printer.

particular operation called for by the instruction must have the dial set to the number specified in the instruction.

Loading Tape Units

Before the tape unit can read or write, it must be prepared for operation. Each type of magnetic tape transport unit has its own set of routines for loading and unloading that are performed in accordance with the rule tailored for each specific type. This situation precludes the establishment of any set rules for loading and unloading tape.

Any type operation requires two tape reels on the tape unit. In a setup operation, a file reel containing tape to be read or written is mounted on one hub, and the lead end of the tape is threaded through the tape transport mechanism onto the take-up (machine) reel. Then during read or write operation, the tape unwinds from the file reel and winds onto the take-up reel.

Information is recorded on and read from magnetic tape by a read/write head. The head assembly is built in two sections and is located between the file and take-up reels. For ease of threading, the head assembly seperates to accept tape; some tape units open and close the head assembly automatically while some are manually opened and closed. When the head

assembly is closed, the tape is in close contact for reading and writing.

Notice that the file reel in figure 10-22 is mounted on the left, and the tape is fed down through a vacuum column, up past the read/ write head, down through another vacuum column and up to the machine reel on the right. The loop of tape in each vacuum column is necessary to prevent the tape from breaking during high speed start and stop operations.

The independent action of the file and machine reels are made possible through the use of vacuum actuated switches located in the vacuum columns. When the tape in the vacuum columns reach their maximum or minimum length, either the file reel feeds tape, or the machine reel takes up tape, depending on which vacuum column has reached its maximum or minimum length. Tape may be backspread over a record or rewound to the beginning of the reel. No writing may take place while the tape is moving in reverse.

It should be noted that not all magnetic tape transports are equipped with vacuum columns. The UNIVAC 1240 Magnetic Tape Unit shown in

FILE REEL

MACHINE REEL

STOP CAPSTAN

IDLER

DRIVE CAPSTAN

SPLIT IDLERS

STOP CAPSTAN

IDLER

DRIVE CAPSTAN

R/W HEAD

MOVING PULLEYS

VACUUM COLUMNS

R49.162X
Figure 10-22.–Tape feed unit.

figure 10-23 has the file reel in the upper position and the bottom reel is the take-up reel. The tape is threaded through tension arms located above and below the read/write head that maintains the proper tension on the tape.

Reading from and Writing on
Magnetic Tape

The magnetic tape unit reads or writes data in parallel channels or tracks along the length of the tape. Each channel or track can be read by a read/write head, one for each channel, as the tape moves across the magnetic gap of the head. Read/write heads may be either one-gap or two-gap as shown in figure 10-24. The one-gap head has only one magnetic gap at which both reading and writing occurs. The two-gap head has one gap for reading and another for writing.

There is one write coil in the write head for each recording track. Electrical current flowing through these coils magnetizes the iron oxide coating of the tape, thus, erasing previously recorded information.

Checking Tape Recorded Data

The continuity of accuracy in data recorded on magnetic tape is paramount. Therefore, there must exist a means of checking the coded tape. Magnetic tape data are checked to ensure that the recorded data are of effective magnetic strength, and to verify that the recorded data are composed of valid characters. One method is the non-return-to-zero-IBM (NRZI).

The NRZI method of data recording is very reliable. Two types of errors are possible on NRZI tapes: reading a 0 bit for a 1 bit or reading a 1 bit for a 0 bit. The error detection system, using this principle of simple parity checking, has the possibility of detecting and indicating virtually all errors, although the type of error is not indicated.

Tape validity may be checked by tape units using either a one-gap or two-gap read-write head. When using the one-gap head the tape must be backspaced over the record, or the tape must be read as it is used in another operation before validity checking can occur. Although the one-gap method is satisfactory, the two-gap head gives increased speed by checking while writing. For example, a tape being written passes over the write gap (where data is recorded) and then over the read gap where errors in writing are detected almost instantly.

TAPE LOAD POSITION
TAPE RUN POSITION
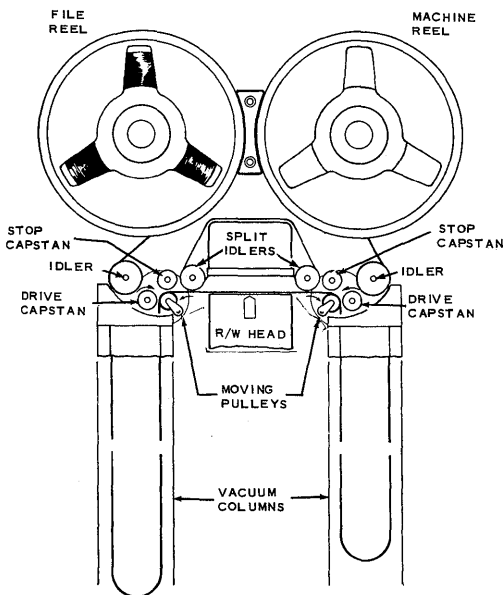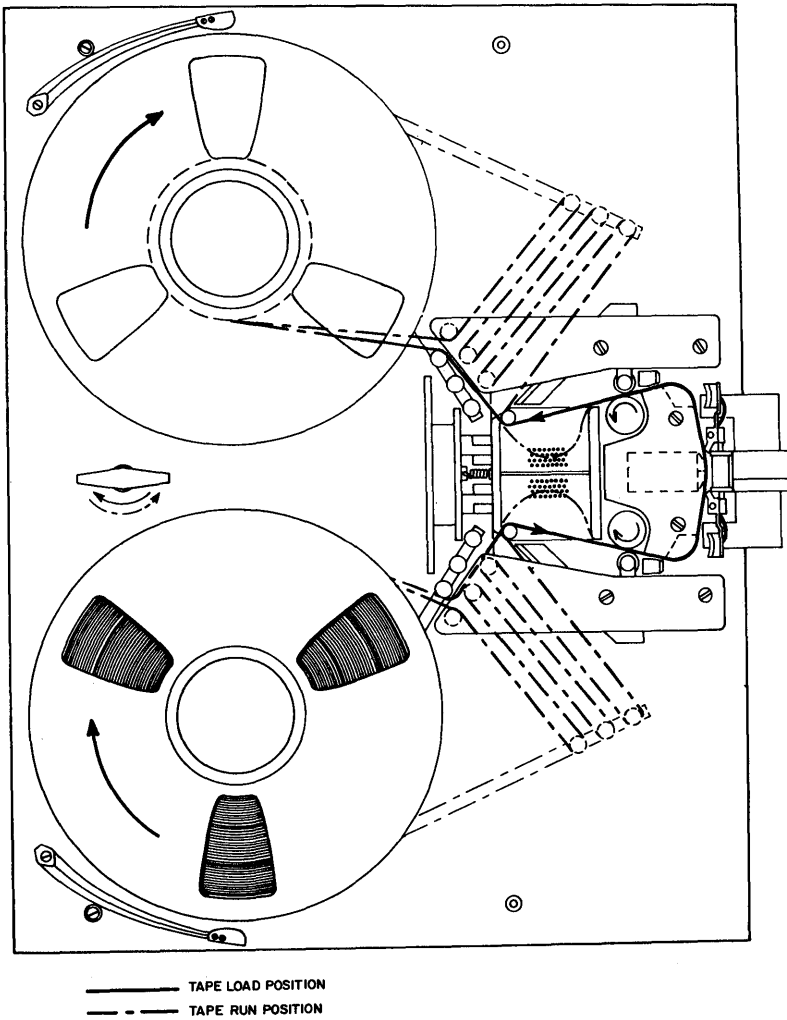
49.362

Figure 10-23.—Magnetic tape unit using tension arms.

In checking BCD tape, each binary coded character is checked for validity as it is written on magnetic tape. An automatic odd or even count is made of all bits (1 bits) in each vertical tape column. If even parity checking is used, a bit is placed in the C track during tape writing for each vertical column in which the count is odd, making the total number of bits even (fig 10-25). For each subsequent reading operation, the total count of bits in each character must be even in order to pass the parity check. If odd parity checking is used, the C bit is written when the bit count is even, making the total number of bits odd. During subsequent reading operations, each character must have an odd total bit count to be considered valid.

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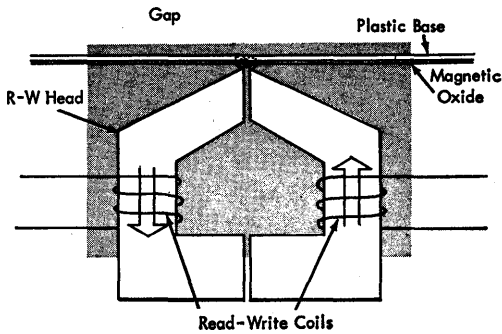
ONE—GAP READ—WRITE HEAD
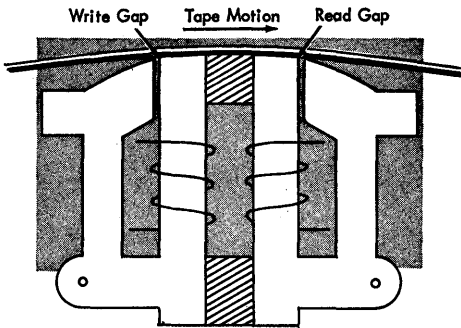
TWO—GAP READ—WRITE HEAD

R7.53.2AX
Figure 10-24.—Read/write heads.

In addition to vertical parity check, a horizontal parity check is made on each record. A record is a unit of information, such as the information recorded in a punched card. The bits in each horizontal row are counted as each record is written, and a check bit is recorded at the end of the record for each track in which the bit count is odd, if even parity is used, or for each track in which the bit count is even, if odd parity is used. Thus, each time a record is read, it is checked for parity not only by characters, but by track as well (fig. 10-25).

Checking Binary Code

In electronic data processing systems using the binary code for data representation, the basic
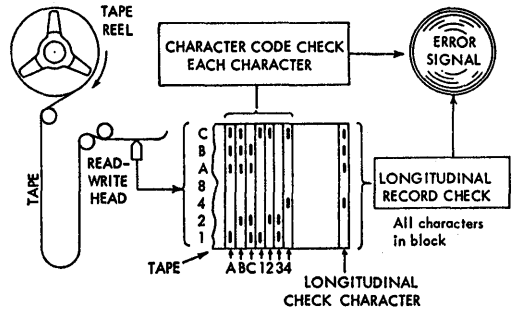
Information read from tape is checked two ways. A character code check (vertical check) is made on each column of information to insure that an even number of bits exists for each character read. If an odd number of bits is detected for any character or column of bits, an error is indicated, unless the computer operates in odd parity. A longitudinal record check is made by developing an odd or even indication of the number of bits read in each of the seven bit tracks of the record, including the bits of the check character. If any bit track of the record block indicates an odd number of bits after it is read, an error is indicated, unless odd parity is required by system design.

R49.301X
Figure 10-25.—Seven-track tape validity checks, BCD mode, even parity.

unit of information is the word, consisting of a fixed number of consecutive bit positions. These words usually are recorded on magnetic tape in six vertical columns, with six bits recorded in each horizontal track. The seventh track, or C position, is used for parity checking only. Parity checking is performed in a manner similar to that used for checking BCD tapes. That is, a parity check is vertically by column and horizontally by track.

The difference in checking binary tape and BCD tape is that the vertical parity check including the check character must have an odd parity for binary coded data; whereas the horizontal parity check, including check character, for binary tape must be even. If these conditions are not met, an error condition is indicated.

Tape Records, Density,
and Interrecord Gap

Records on magnetic tape can be of any practicable size, being restricted only by the length of the tape or the capacity of internal storage devices. For example, a record can be 80 characters long, corresponding to the 80 columns in a punched card; it can be shorter,

or it can be longer. Records can be placed on tape ungrouped, or they can be grouped. Ungrouped records consist of individual records separated on tape by an interrecord gap. The length of the gap varies, depending upon the particular system and method of recording, but is in the neighborhood of from 2/5 to 3/4 inches. Grouped records consist of a number of records, called a RECORD BLOCK. Records within a block are separated by a control symbol or record mark, and blocks are separated by an interrecord gap. During writing, the interrecord or interblock gap is produced automatically at the end of each ungrouped record or at the end of each record block. During reading, the record begins with the first character sensed following an interrecord or interblock gap, and continues until the next gap is reached. All input records are internally stored in accordance with the storage positions assigned by the stored program. Output records are written from the storage positions designated by the stored program. Examples of various ways in which records are placed on magnetic tape are shown in figure 10-26, and are discussed in the following paragraphs.

Ungrouped records fall into two general classes: fixed length and variable length. All fixed length records have the same number of set positions for each record, and each item of data is recorded in the same positions for each record. Thus, if any item is missing from any record, its position or positions must be filled in with zeros or blanks. Variable length records may vary in length from one record to another, depending upon the number of positions required to record the necessary data. All items of data which are common to all records must be recorded in the same positions of each record. If any of these items are missing, their positions must be filled with zeros or blanks. Items common to all records usually are placed at the beginning of each record, and extended for the required length. Additional items required in some records but not in others normally are placed at the end of the record. This provides for maximum speed in reading records, since less tape space is required for the shorter records.

As a general rule, fixed length records are easier to program than variable length records. When there are few differences in the length of records, the additional tape space and machine time required by fixed length records may be justified by the shortened programming time required. In applications where there are many record length differences, the saving in tape space and machine time may very well justify the use of variable length records.

In grouped records an individual tape record rarely exceeds 3/4 inches in length. In fact the average approximates 1/4 inch. Since an interrecord gap may be 3/4 inches long, you can readily see that in reading ungrouped records, more time is spent spacing between records than is spent actually reading records. This wasted time is further increased by the fact that the speed of a tape transport unit in transporting tape is greatly reduced when a record gap is encountered, and is increased before the next record is read. To cut down on this wasted time, records are often grouped in blocks, with the inter-record gap placed between each block, and only a record MARK separating the records within a block can be either fixed or variable in length. The number of records placed in a record block is called the BLOCKING FACTOR.

When record blocks contain a fixed number of records, with each record containing a fixed

UNGROUPED RECORDS

GROUPED RECORDS, FIXED-FIXED

GROUPED RECORDS, FIXED-VARIABLE

GROUPED RECORDS, VARIABLE-FIXED

GROUPED RECORDS, VARIABLE-VARIABLE
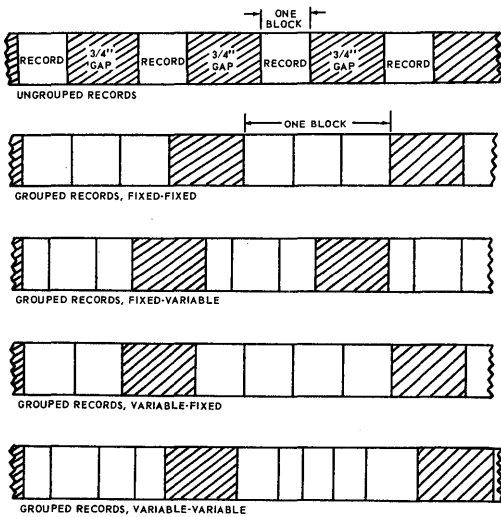
78.27

Figure 10-26.—Placing data records on magnetic tape.

number of positions, they are called FIXED-FIXED. This form of grouping records is best suited to files having little variation in record size.

The term fixed-variable applies to grouped records that have a fixed number of records of variable length in each record block. The maximum length of the records must be known in order to assign sufficient internal storage space for the incoming record blocks. The length of each record usually is indicated by a special character or control field which is part of — and is found at the beginning of — each record. Programming is more difficult for this type than for fixed-fixed.

The variable-fixed form of record grouping has a variable number of fixed length records in each record block. Records may be grouped this way when a relatively small number of records in a file exceeds the fixed length. Records exceeding the fixed length are made up into two or more grouped records, thus increasing the number of records that can be placed in a block. Programming is more difficult than for fixed-fixed.

Variable-variable is the case where each record block has a variable number of variable length records. This arrangement may be worthy of consideration when a file has many variations in the length of its records. However, this arrangement is more difficult to program than any other arrangement and should be used only if the end justifies the means.

The major differences in magnetic tape units are the speed at which the tape is moved past the read/write head and the density of the recorded information. Density describes the rate at which characters are recorded on tape. Among the most common are 200 and 556 columns per inch. Tape speed varies to a great extent, from less than 50 inches per second to more than 100 inches per second. Character rate is determined by multiplying speed and density. A representative example is illustrated in figure 10-27.

Tape Markers

A certain amount of blank space must be left at the beginning and ending of each reel of magnetic tape to allow threading the tape through the feed mechanism of the transport unit. The beginning and ending of the usable portion of tape must be indicated in some manner to provide the transport unit with a means for determining the starting and ending points for reading and

TAPE SPEED (INCHES/SEC)	DENSITY (CHAR/INCH)	CHARACTER TIME (MICROSECONDS)	CHARACTER RATE (CHAR/SECOND)
36	200	139	7,200
	556	50	20,016
75	200	67	15,000
	556	24	41,667
112.5	200	44	22,500
	556	16	62,500

R49.302X

Figure 10-27.—Character rate.

writing. These indications may be set up in a number of ways, depending upon the particular type of tape transport units used with the system. For illustration purposes, let us examine two methods for effecting these indications.

One method utilizes reflective strips for markers. These are small pieces of transparent plastic with a thin, vapor-deposited film of aluminum on one side. They are placed on new reels of tape by the tape manufacturer prior to release to the customer. The sensing of these markers is performed by photoelectric cells in the tape transport unit, as illustrated in figure 10-28. The marker at the beginning of the tape, called the LOAD POINT MARKER, indicates the point where reading or writing is to begin. The marker at the end of the tape, called the END-OF-REEL MARKER, indicates the point where writing is to stop. The end-of-reel marker is not recognized by the transport unit when reading tape; a special character written on the tape, called a TAPE MARK, signals an end-of-reel condition.

File Protection

A magnetic tape which has previously been used for recording data need not be erased from beginning to end prior to using it for another writing operation, since erasure of old data takes place just prior to the recording of new data. This feature of magnetic tape creates a necessity for providing a method whereby data files cannot be destroyed accidentally in the event tape reels containing valid data are mistakenly loaded for writing. Tape reels have a circular groove molded in the back of the reel (fig. 10-29), which permits the insertion of a

End of Reel
Photo Cell

Photo Lights

Load Point
and Tape
Break Photo
Cell

Load Point

End of Reel Mark

Tape Break Light

Tape Cleaner

R78.30X

Figure 10-28.—Sensing of tape markers.

FILE PROTECTION
RING

FILE PROTECTION
RING INSERTED

The file protection device is a plastic ring that fits into a round groove molded in the tape reel. When the ring is in place, either reading or writing can occur. When the ring is removed, writing is suppressed and only reading can take place; thus, the file is protected from accidental erasure.

R49.303X

Figure 10-29.—File protection device.

plastic file protection ring, or adapter rim. When the reel is loaded, this protection device depresses a switch protruding from the tape reel panel, setting up the condition necessary to allow data to be written. The absence of the file protection ring from a file reel causes an indicator light on the transport unit to turn on, signaling that no writing can take place.

Either reading or writing can be performed when the file protection ring is inserted in the file reel. When the device is removed, writing is suppressed and reading only can be accomplished. An easy way to remember if a file reel should or should not have the protection device inserted is "no ring, no write."

DATA BUFFERING

The usefulness of an electronic data processing system often is directly related to the speed at which it can complete a given procedure. All data processing procedures involve input, processing, and output, with each phase requiring a specific period of time. In most data processing systems, the computer can process data faster than the data can be supplied by input devices or recorded by output devices. Therefore, assuming that any given phase of the procedure is performed at a time different from the other two, as illustrated in figure 10-30, the result will be minimum usage of the processing unit.

The time during which the processing unit is idle can be reduced significantly by using buffer storage units, placed between the input-output devices and the processing unit. Data are read into buffer storage, and later transferred to main storage when summoned by the program. The time required for transfer is only a fraction of that required to read the data directly from an input device. The computer can process information previously received at the same time that additional data are being entered into the buffer from the input device. By the same token, processed data can be transferred from the processing unit to another buffer storage unit at high speed. An output device can then be directed to record the contents of the buffer while the processing unit continues with the next computation or data manipulation. The effect of simultaneous, or overlapping, operations through the use of buffer storage is illustrated in figure 10-31.

An improved method of data buffering, found in some data processing systems, is the use of main storage as the primary buffer. Data are received from input devices and transferred to output devices in words or in fixed groups of characters. The exchange of words is interspersed automatically with computation, but the time required for transmission of single words is relatively insignificant. The size and length of the data handled are restricted only by the practical limits of main storage. When external buffers are used, the amount of data handled at any time is limited by the capacity of the buffers.

R78.8X

Figure 10-30.—Example of processing without data buffering.

R78.9X

Figure 10-31.—Example of processing using data buffering.

Overlapping operations described above are based on the principle that the action of input and output devices is made to occur at fixed positions or points in the program and in a sequence established by the programmer. Some computers however, are designed for automatic interruption of processing to allow an input or output device to function. The input or output device sends a signal to the processing unit when it is ready to read or write. The processing unit then accepts the data as input if the signal is received from an input device, or transmits the required information as output if received from an output device. The input and output devices are connected to the processing unit through a data channel, which is a completely separate and independent information path. The data channel and associated circuitry provide for data exchange independently of computing. The data channel essentially controls the quantity and destination of all data exchange between input-output devices and storage. One or more data channels can be occupied with writing on magnetic tapes while others are reading from other tapes. Similarly, the operations of card reading, punching, and printing can be performed simultaneously. All operations of reading or writing magnetic tape, reading or punching cards, or printing may occur simultaneously with computing.

CHAPTER 11

PROCEDURES AND DATA FLOW

Many different jobs are performed by Data Processing Technicians. In a broad sense, the jobs in a data processing installation can be grouped in three general categories: clerical, operational, and administrative. Clerical functions include recording, coding, arranging, and filing source documents. Machine operation usually begins with keypunching and key verifying cards from source documents, and continues through the machine processing steps required to complete a given job. Administrative functions include planning and establishing written procedures for performing a job, assigning work, seeing that the work is done properly, and ensuring that jobs are completed on time.

This chapter discusses some of the work that goes on in a data processing installation other than the actual operation of machines or control panel wiring. It shows you how a procedure is developed, beginning with the original requirements for a report and continuing through all the considerations and steps required for producing the report. It introduces you to flowcharts; the meaning of different symbols and how they are used.

PROCEDURES

Before any data processing job is performed, a procedure for doing the job should be established. A procedure is a series of step-by-step clerical and machine processing functions required to accomplish an end result for each job requirement placed upon a data processing installation. We have certain procedures we follow in our daily lives. Almost everything we do is done according to procedure, although we do not have it written down, and may not always follow the same course of action each time. Different people accomplish things in

different ways. Usually this is not important so long as the desired end result is obtained. In accounting operations, however, standard procedures must be planned and developed for each operation. Any number of procedures can be prepared to accomplish a given job, however, only one procedure will be the best, and it can be found only by logical and methodical means.

Facts left unrecorded often cease to be facts, therefore, the importance of good sound procedures must be stressed.

PROCEDURE OBJECTIVES

Before a procedure can be developed, the ultimate objective must be established. This is clearly defined if the report requirements are prescribed by higher authority, such as a bureau or office of the Navy Department. But what about job requests from local offices or commands? Usually, if the personnel who request a job are not familiar with the work performed in the data processing installation, their request for data processing services may be vague, incomplete, or unnecessary because of other reports already being prepared which would serve their purpose just as well. You may have to confer with the person requesting the job to determine the exact type of report he desires. This is necessary to accomplish the following objectives:

- What information is needed in the report.
- In what sequence should items of information appear.
- What headings, types of totals, and controls are required.
- Who will receive and use the report.
- How often is the report desired.
- What priority is to be assigned to the report compared to other reports.

A sample report can be prepared and submitted for approval to the respective parties. Further meetings will then take place to determine the adequacy of source data required for the application. Reference to the schedule of reports presently in use will normally indicate the best time for scheduling a new report.

Source Documents

Once the objectives have been established, the next step is to examine the source data relative to the application, and resolve the following questions:

- Is the required information already contained in existing punched cards?
- Is it possible to add fields to present cards for punching the additional information required?
- Do present source documents contain the desired information?
- What clerical work is necessary in preparing the documents for keypunching?
- Are the documents in good form for transcribing into punched cards?

If the present source documents can be used, some of the information to be keypunched may have to be coded, circled, or underlined. Modification of card design and/or source documents may be required to facilitate coding and keypunching. These are clerical functions which are necessary to prepare source documents for the easiest and most effective use in keypunching and other processing.

Punched Card Requirements

New card layouts must be prepared if existing cards cannot be used in the new procedure. Various approaches to be taken in determining the design and types of cards to be used in the procedure were discussed in chapter 2.

Standard layout forms, such as the one shown in figure 11-1, are available from the local office of the card manufacturer to assist you in preparing the card design.

When the information for a document originates within your own installation, a study should be made to determine the feasibility of using the punched card as a source document. The advantage is that the cards will eliminate duplication of effort and the machine processing can be accomplished directly from them.

CONSTRUCTING THE PROCEDURE

A procedure should contain all detailed steps required for completing a project from the time source documents are received until the report is finished. It often is desirable to write the procedure in parts, according to the particular data processing section that is to perform a specific part of the operation. For example, the first part should include all steps required for receiving, logging, auditing, coding, and arranging source documents. The second part should contain all instructions for keypunching and key verifying the source documents. The third part should consist of all steps, both mechanical and manual, which are required to produce the finished report. In effect then, you have three separate procedures for performing one operation.

How do we go about developing the procedure? We have already determined what source documents are required, the form the punched cards are to take, and what the final report is to look like. Now we must plan the steps required to bridge the gap between the source information and the finished product. Let us now look at each part of the operation, keeping in mind that all three parts must tie in.

Processing Source Documents

There is a certain amount of work that must be accomplished before source documents can be keypunched. Some of the things you should keep in mind when developing this part of the procedure are listed in the following paragraphs.

Due-in Dates.—Controls must be established to ensure timely receipt of source documents. If documents are due in on specific dates, these dates should be maintained in a register and checked off as documents are received.

Batching.—After receipt of documents has been noted in the register, they should be batched. Each batch then becomes a unit of work for keypunching and balancing. Once cards have been punched and verified, and contents of documents proven, all cards can be combined and the documents released for filing.

MULTIPLE LAYOUT FORM

FOR ELECTRIC ACCOUNTING MACHINE CARDS

INTERPRETER SPACING

PRINTED IN U.S.A.

BRANCH OFFICE NO. _____

FORM X74-4823-3-END.

DATE _____

CUSTOMER'S NAME & NO. _____

ADDRESS _____

R49. 148X

Figure 11-1.—Multiple card layout form.

Control Totals.—Some documents, such as receipt invoices, contain an individual total for each item on the document and a recap total for all items. The recap on each document in a batch can be accumulated on an adding machine and printed on a control tape. This tape then accompanies the batch of source documents until balancing of totals for each batch is completed.

Auditing.—Each document should be checked to make sure it is acceptable for further processing. This check should not be so detailed as to create an undue slowdown in the overall processing of the documents. Many small or hidden discrepancies will be caught during keypunching or balancing and screening operations.

Arranging.—If documents are to be forwarded to the keypunch section in a particular order, they must be manually arranged in that order.

Coding.—Establish procedures for the coding, circling, underlining, or transcribing of data in preparation for punching. Another audit should be performed after documents are coded, to prevent invalid or erroneous codes from being processed.

Punching Source Documents

Procedures for punching source documents should include detailed layouts of the cards to be punched, including instructions for fields to be manually punched, duplicated, and skipped. Program cards for the keypunch and verifier should be prepared for each type of card to be punched. Instructions for handling discrepancies discovered in the documents must be established. If certain information is common to all cards, keypunching time can be saved by setting up steps for using automatic punches to gangpunch this information. Any additional instructions which will aid in keypunching and verifying should be included in the procedure.

Processing the Cards

The third part of the procedure should include all steps required for processing the cards from the time they are received from the keypunching section until the finished report is produced. This procedure must contain all steps that require machine processing. If clerical steps or special processing steps are required, they should be included at the proper points. The procedure should contain specific instructions as to the type of cards used, control panels that must be wired, or the program to be used, type of paper to be used for preparing the report, and the number of copies to prepare.

Once the procedure is developed it is important to put it on paper so that it can be reviewed, revised, and explained to the people involved. The best way to record the procedure is with the use of a flowchart which will show the flow of data, the operations performed, and the sequence in which they are performed.

Flowcharts will be discussed later in this chapter.

MANUALS OF PROCEDURE

Three basic manuals are discussed in this chapter; the Operator's Manual, the Supervisor's Manual, and a General Manual. These manuals are essential because they meet the following objectives:

● Enable machine operators to set up machines without assistance.
● Provide a source of information about job steps to be accomplished, so as to accomplish these jobs in the best possible manner and in the appropriate order.
● Provide a permanent record of the procedure in the event of personnel being on leave or being transferred.
● Provide assembled facts for simplifying corrections and improvements of the procedure.
● Enable the supervisor to regulate and coordinate the operations within his section or division.
● Provide management with a tool for regulating and coordinating operations of the entire installation.

The contents differ from one manual to the next, depending upon the purpose for which each is intended.

As a machine operator, you should be thoroughly familiar with the operator's manual, for it contains detailed procedures you follow in performing all operations. As a petty officer, you should know how to go about setting up an

operator's manual, including the preparation of operating procedures, wiring diagrams, and other information required in the manual. As a general rule, you will not be responsible for preparing the supervisor's manual until you reach the higher pay grades and are placed in a supervisory position. You should however, have a good idea as to the contents of these manuals for you may be required to prepare some information for inclusion in them.

Operator's Manual

The purpose of the operator's manual is to provide machine operators with all the information necessary for performing a job. This manual should contain the standard operating procedures for each job. If the job is a production run on a computer, the operator must have instructions on how to set up the job, what program to use, switch settings, and what to do in case of an abnormal termination of the job.

If control panels are to be wired, the operator will need a complete and legible wiring diagram. Other considerations for inclusion in the operator's manual are:

- Test decks.
- Header and trailer cards, if required.
- Sample reports, type of paper, and number of copies to prepare.
- Carriage tapes.

Supervisor's Manual

Supervisors in data processing installations are charged with such responsibilities as ensuring that procedures are developed, workloads and schedules are established, and sufficient controls are set up to control the flow of work through the installation. They are responsible also for evaluating the utilization of equipment and the performance of operators, and for making improvements to systems and procedures. As a general rule, the senior DP is responsible for coordinating and directing all operations of the installation. He maintains a supervisor's manual, which serves as the basis for all plans, controls, and evaluations.

General Manual

The General Manual outlines the broad objectives of the data processing installation and summarizes the operations performed. This manual is used primarily for the following purposes:

- To present the general picture of the purpose and operation of the installation to new personnel assigned.
- To provide other personnel in authority with information about the operation of the installation, so that personnel in other offices and activities can have a better understanding of the role played by the data processing installation.
- To show visitors the nature and scope of the work performed in the data processing installation.

Contents of the general manual should be of a general nature, and should not include unnecessary detail.

DATA FLOW

The use of data processing equipment necessitates for an orderly representation of information flow. The sequence in which operations are to be executed must be precisely stated. The data and the sequence of operations to be performed upon it together constitute the information flow.

Flowcharts provide a graphic means of presenting information and operations so that they are easy to visualize and follow. They show the flow of data through an information processing system, the operations performed in the system, and the sequence in which they are performed.

A SYSTEM FLOWCHART depicts the flow of data through all parts of a system.

A PROGRAM FLOWCHART describes what takes place in a stored program. It displays specific operations and decisions, and their sequence within the program.

Flowcharting Template

While flowcharts are widely used in the field of information processing, they are occasionally misinterpreted because of a lack of uniformity in the meaning and use of specific symbols. The Department of Defense has adopted the American Standards Association template shown in figure 11-2 as a standard for flowchart symbols. The reader is warned that this
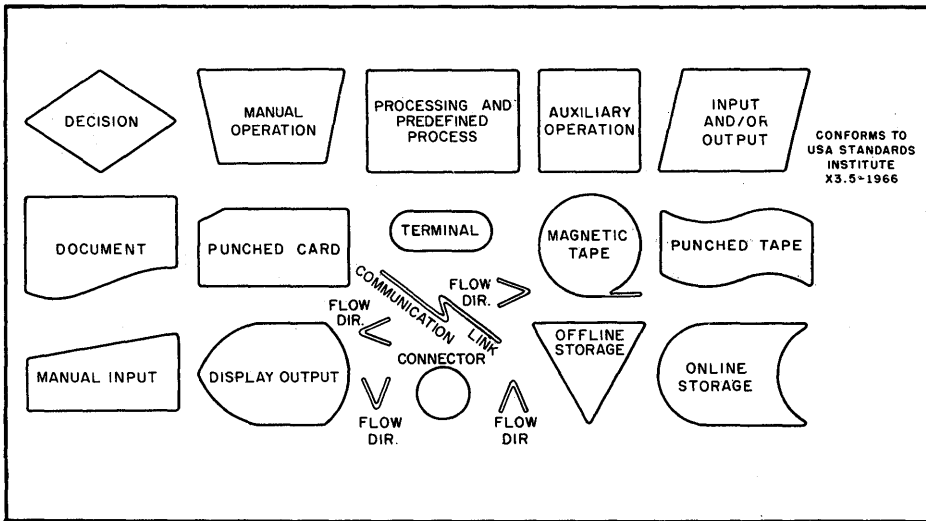
49.149(49B)

Figure 11-2.—Flowchart template.

standardization is not, at the present, industry-wide. Familiarity with these symbols will, however, facilitate the use of flowcharts employing different symbols.

FLOWCHART SYMBOLS

The language of flowcharting is composed of many symbols. These symbols represent devices and functions, and their arrangement shows the direction of the data flow. A given symbol should always portray the same general meaning wherever it appears. For example, it would not be logical to represent a COMPARE operation one time by a square and the next by another figure. Indiscriminate use of symbols serves only to confuse anyone who tries to interpret a flowchart, and increases the possibility of error during the preparation of machine programs.

Basic Symbols

Symbols represent functions. Symbols are used on a flowchart to represent the functions of an information processing system. These functions are input/output, processing, flow direction, and annotation. All flowcharts may be constructed using only the basic symbols.
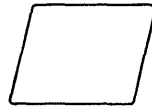
INPUT / OUTPUT SYMBOL represents any type of medium or data available for processing (input), or the processed information (output).

PROCESS SYMBOL. A major data processing function, the process of operations resulting in a change of value, form, or location of information.
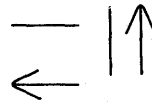
FLOWLINE SYMBOL. Normal direction of flow is from left to right and top to bottom. If the direction of flow is other than normal, arrowheads are required at the point of entry.
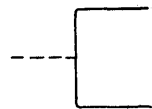
ANNOTATION SYMBOL is used for the addition of descriptive comments or clarification notes. The broken line may be extended in whatever fashion to any symbol where applicable.

Specialized Input/Output Symbols

Specialized I/O symbols may be used to make a flowchart more meaningful, and denote the medium on which the information is recorded or the manner of handling the information. If no specialized symbol exists, the basic I/O symbol is used.

PUNCHED CARD SYMBOL represents all varieties of punched cards — including gangpunched, mark sense, etc.
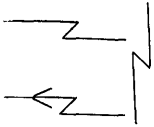
MAGNETIC TAPE SYMBOL represents an I/O function in which the medium is magnetic tape.
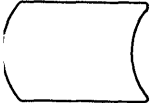
PUNCHED TAPE SYMBOL represents metallic, plastic, or paper tape.

DOCUMENT SYMBOL represents source documents and all varieties of reports and documents.

MANUAL INPUT SYMBOL is used when information is entered manually at the time of processing, by means of online keyboards, switch settings, pushbuttons, card readers, etc.

DISPLAY SYMBOL is used when information is displayed by plotters or video devices.

COMMUNICATION LINK SYMBOL denotes automatic transmission from one location to another. The direction of flow is left to right and top to bottom. Arrowheads are used when increased clarity is desired.

ONLINE STORAGE SYMBOL indicates the use of a mass storage unit such as magnetic disks and drums.
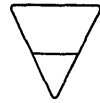
OFFLINE STORAGE SYMBOL represents any offline storage of cards, paper, and all other media.

Specialized Process Symbols

Specialized process symbols may represent more meaningful processing functions, and identify the specific type of operation to be performed on the information. If no specialized process symbol exists, the basic process symbol is used.
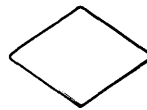
DECISION SYMBOL is used to depict a point at which a branch or switching type operation to one of two or more alternate paths is possible.
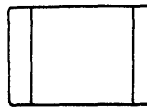
PREDEFINED PROCESS SYMBOL shows a group of operations, such as a subroutine, not detailed in the particular set of flowcharts.

MANUAL OPERATION represents all manual offline operations which do not require mechanical aid. These are clerical processes geared to the speed of a human being.

AUXILIARY OPERATION SYMBOL represents an offline operation performed on equipments not under direct control of the central processing unit.

Additional Symbols

CONNECTOR SYMBOL represents a junction in a line of flow to another part of the flowchart. The entries and exits are represented by a set of two connector symbols. When flowcharts are broken due to page limitations, this symbol is used to indicate the break, and identifications should be placed within the symbol.

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TERMINAL SYMBOL represents a terminal point in a system at which data can enter or leave; (start, stop, halt, delay, or interrupt).

Graphic Symbols

The following graphic symbols are used when appropriate on flowcharts and other documentation.

+	plus, add
−	minus, subtract
±	plus or minus
=	equal to
>	greater than
<	less than
≥	greater than or equal to
≤	less than or equal to
≠	not equal to
≯	not greater than
≮	not less than
YES or Y	Yes
NO or N	No
TRUE or T	True
FALSE or F	False

Representation of Multiple Media

As an alternative to a single symbol with appropriate text, input/output symbols may be shown in an overlay pattern, as shown in figure 11-3, to illustrate the use or creation of multiple media or files; for example, number of copies, types of printed reports, types of punched card formats, and multiple magnetic tape reels.

The overlay pattern is drawn from front to back with the first symbol as the entire I/O symbol. The order of the symbols is from front to back when establishing sequences or priorities.
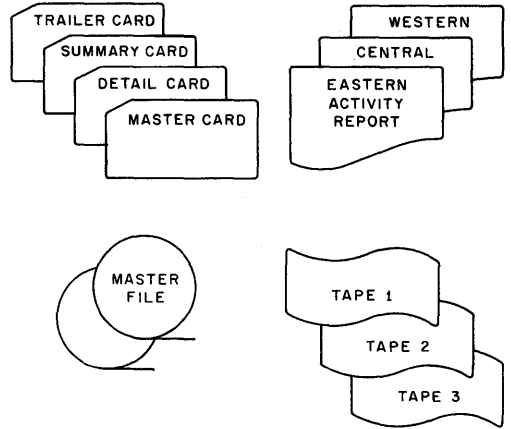
49.363

Figure 11-3.—Symbol for multiple media.

UNIT RECORD FLOWCHART

The four basic symbols used for showing unit record machine operations are illustrated in figure 11-4.

Both card punching and card verifying operations are indicated by the key driven machines symbol. This symbol can also be used for indicating transceiver operations.

Sorting and collating operations are indicated by the large circle. This symbol may have one or more card files leading into or leaving it, depending upon the type of operation being performed.

The auxiliary machine symbol is used to show operations performed on reproducing punches, summary punches, and interpreters.

The accounting machine symbol is used to show operations performed on the accounting machine. This symbol usually is associated with the document symbol, illustrating the result of an operation. Summary punching
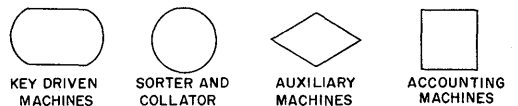
49.154

Figure 11-4.—Unit record machine symbols.

operations are usually shown by placing the accounting machine and auxiliary symbols side by side and connecting them with a straight line.

Figure 11-5 shows a flowchart for indicating some typical machine operations required to produce a Cumulative Transaction Report (ficticious). The primary direction of work flow is in a vertical line from the top of the page to the bottom. Secondary functions, such as forwarding the transaction report, are shown

to one side. The circled numbers at each job step symbol provide a simple means for referring to the job steps in the operating procedure.

SYSTEM FLOWCHART

As stated earlier, a system flowchart depicts the flow of data through all parts of a data processing system and includes the operations performed in the system and the sequence

49.364
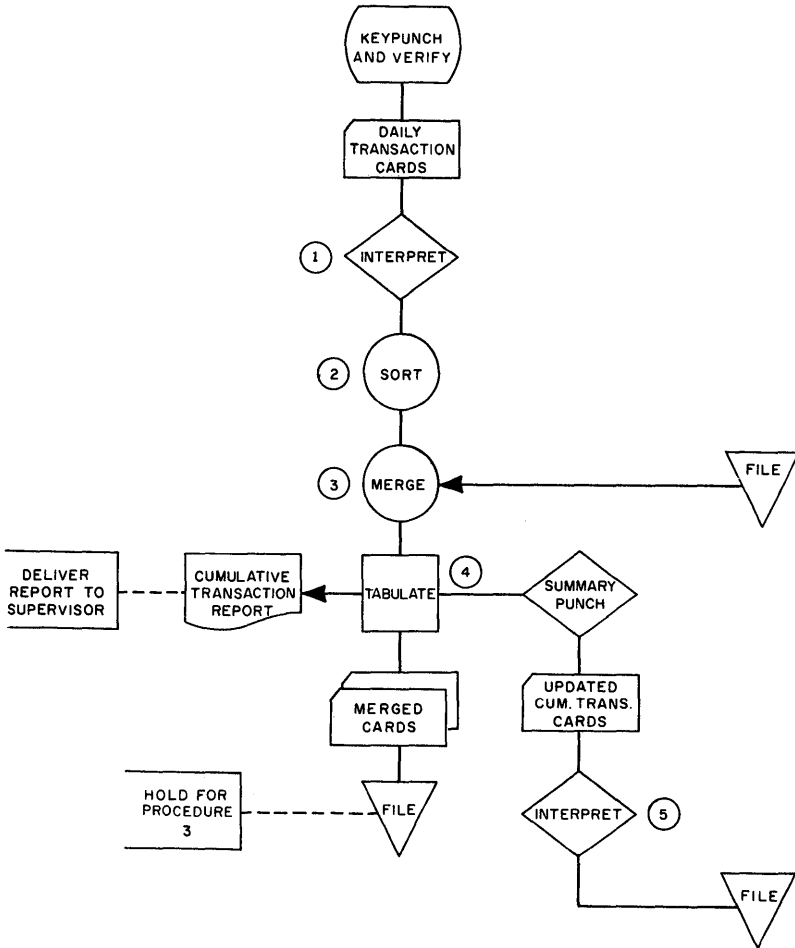
Figure 11-5.—EAM flowchart.

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in which they are performed. Often such a chart is composed of symbols that represent only the form in which data appear at the various stages of processing as shown in figure 11-6.

Overall, system flowcharts show what is to be accomplished. Here the main emphasis is on the media involved and the work stations through which they pass.

PROGRAM FLOWCHART

In a program flowchart the emphasis is on the operations and decisions necessary to complete the specified process. The program flowchart has many important uses, one of which is to provide the programmer with a kind of all-purpose tool. It is a "blueprint" of a program. In program development, the programmer uses
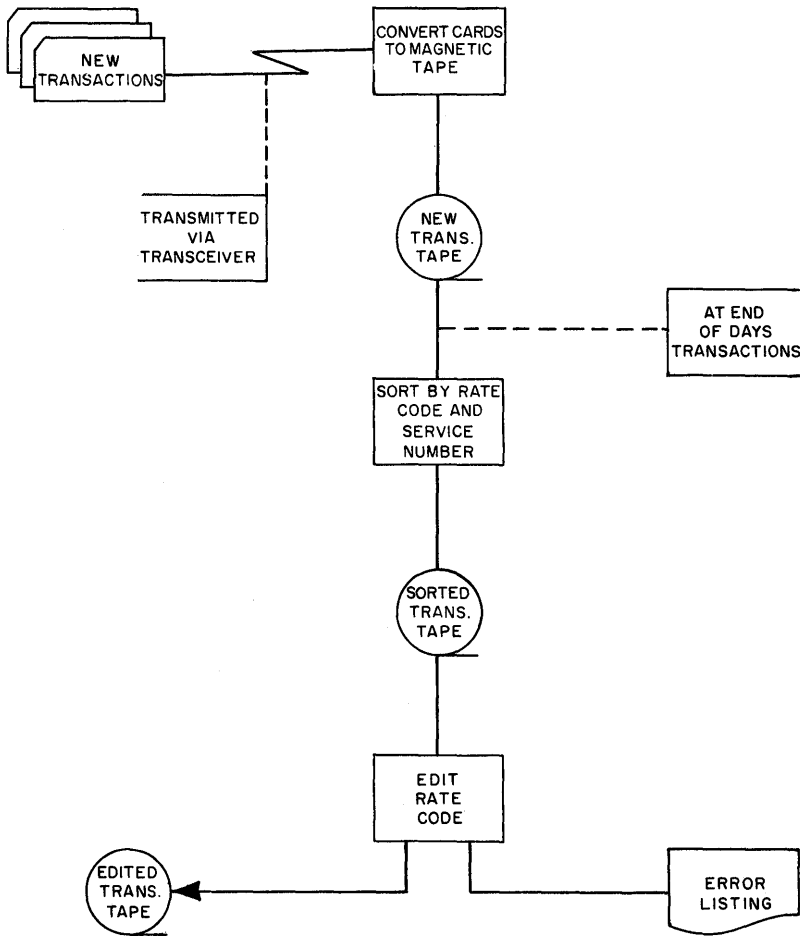
49.323(49B)

Figure 11-6.—Representative system flowchart.

49.329(49B)
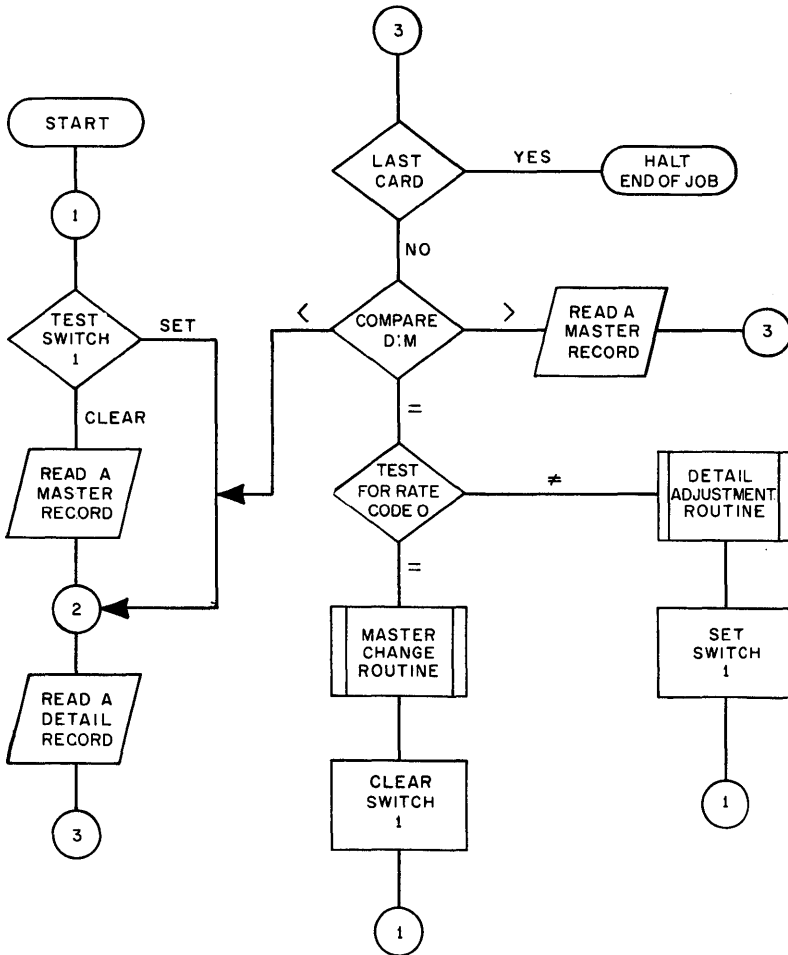
Figure 11-7.—Representative program flowchart.

flowcharting in and through every part of his task to visualize the sequence in which arithmetic and logical operations should be performed, and the relationship of one part of a program to another.

The use of a program flowchart determines the amount of detail to be included in it. The primary purpose of the chart, during early stages of program development, is to experi-

ment with and verify the accuracy of different approaches to coding the application; in this instance large segments of the program are represented by a single symbol.

Once the programmer has temporarily established mainline logic, he usually extracts large segments and describes them in more detail on subsidiary charts. This is like drawing a set of increasingly detailed maps, starting

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with a general all-inclusive map, then expanding sections of it on succeeding maps, each map showing greater detail.

Of all the important uses of program flowchart, the most important are:

- An aid to program development.
- A guide to coding the problem.
- Documentation of a program.

An example of a program flowchart illustrating the application of some of the flowchart symbols and rules is shown in figure 11-7.

DEVELOPING THE FLOWCHART

The manner in which flowcharts are developed is very similar to the way procedures are developed. In fact, flowcharts often are developed first and used as a basis for establishing the procedure. All steps required for completing a job can be sketched in flowchart form without bothering with the details as to how each step is to be performed. Then, the flowchart can be used as a guide for developing the procedure.

Your first attempt at drawing a flowchart for a given operation may not be too successful since certain steps actually required in the processing may not be discovered until the procedure is written. As a general rule, it may be best to construct a rough flowchart first, and draw the smooth flowchart after the procedure has been developed and tested.

CHAPTER 12

PROGRAMMING AND DOCUMENTATION

Before any new data processing application is started, there must be a need for information. Once the need has been established, minds go to work, planning, organizing, and making constructive decisions. Most data processing applications involve huge quantities of information and may require millions of operations before the job can be completed. The electronic computer has tremendous speed and the ability to take in huge quantities of data-deleting, sorting, merging, adding, transferring, comparing, subtracting, and providing a useful output almost without effort.

But better information is not provided by bigger and faster machines. It takes people, and only trained people can organize all the information into a pattern acceptable to the computer. The data flow must be established and the program written and documented.

The people who perform these functions in the Navy are called systems analysts and programmers. In actual practice a Data Processing Technician usually is called upon to perform both functions. Programming is the major subject of this chapter, but let us begin by defining both functions briefly.

A SYSTEMS ANALYST studies and describes an entire data processing system. He may either analyze an existing system for purposes of improvement or he may design an entirely new system. In either case he must do the following:

- Determine what information the system should produce and in what form it is needed.
- Analyze the types and format of input data.
- Determine the machines required for processing, and the most effective flow of the data through the system.
- Describe this flow by constructing a system flowchart.

If determing that a computer/data processor is required, perform the following additional functions:

- Determine how many "programs" are required.
- Determine what processing steps will be performed in each program (ie. sort, update, edit, etc).
- Prepare a list of all decision criteria (specifications) for each program in the system.

The PROGRAMMER is directly concerned with the detailed steps of processing information in the computerized segment of the system. To develop a program, the programmer must know:

- The number of different operations (and their functions) available in the system with which he has to work.
- The procedure itself, which must be translated, step by step, into computer instructions.
- The requirements to be met by the result of processing.

The programmer (figure 12-1) takes the general directions described by the analyst in the system flowchart and from them he developes a program flowchart which enables him to write the operating instructions in a language acceptible to the computer. This step, the preparation of computer acceptible instructions, is sometimes called CODING and if a separate person does it he is called a CODER.

FUNDAMENTALS OF PROGRAMMING

Programming is the manual function of converting an operational objective, as set forth in flow charts and other specifications, into a written machine program. It is not the intent of this manual to teach anyone how to write a program, for each EDPS has its own particular set of instructions which it is capable of recognizing and

executing, and individual system characteristics make possible programming techniques which are more or less peculiar to each system. The programming ideas presented here, insofar as practicable, essentially are basic to any system.

PROGRAM DEVELOPMENT

To develop a program requires more than just developing the flowcharts. It requires preparing the input media and output media, as well as the processing phase. After all, the purpose of a machine program is to translate the ideas and language of human beings, formulated during the problem definition and specification processes, into the language of the equipment, thereby providing the equipment with the means for executing and controlling all job operation steps required in the processing routine. In order to write the program along well-defined lines and in the proper sequence, aids must be used. These aids are developed during the specification phase.

The specifications for a machine run should include all the information necessary for a programmer to complete the translation of planned requirements into machine language. It must be stressed that completeness of detail is of utmost

importance because incorrect or incomplete specifications can result in useless programs.

For convenience, specifications may be broken down into three categories; input, processing, and output. Additional specifications may be included as required, depending upon the particular program.

Input Specifications

Specifications for input to an EDPS may differ, depending upon the type of input equipment and the requirements for the particular job. General guidelines for preparing the principle media, punched cards and magnetic tape, for use within a system are contained in the following paragraphs. If required, specifications for other means of input can be developed along these guidelines.

Specifications for punched cards used as input should be indicated as follows:

1. An illustration or sample layout of each card type used, and the source of each.
2. The information contained in each card field and the number of characters in each field.
3. The type of data in each field; alphabetic, numeric, or a combination of both.
4. Type and location of control punches.
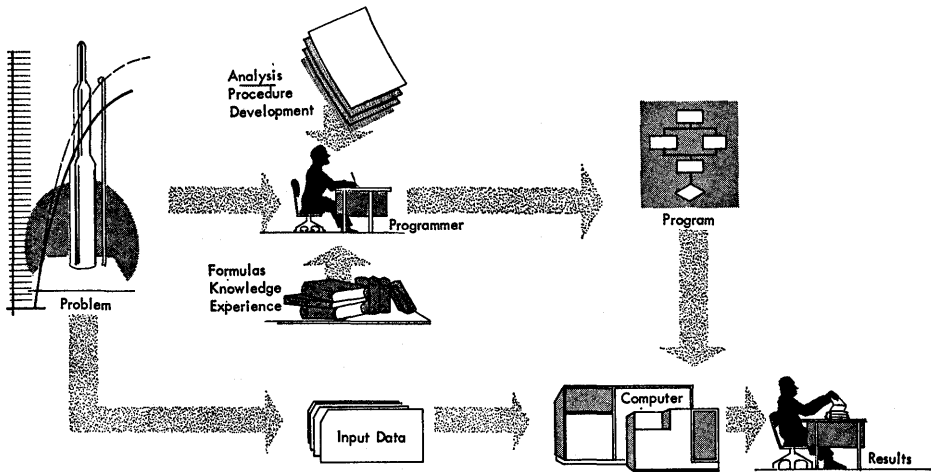
R49.365X

Figure 12-1.—Direct conversion of problem to machine program.

5. If master and detail cards are involved, the method of receipt (merged or separate-matched or unmatched - duplicates of either).

6. Whether or not editing is necessary.

7. The sequence of cards within data sets.

8. Any other information required in the processing or to be checked during processing.

Specifications for magnetic tapes used as input should be indicated along the same general lines as those for punched cards as follows:

1. The blocking factor for each tape record (the number of data records in each record block) and the size of each data record, including an indication of whether data records are fixed or variable in length.

2. An illustration or sample layout of data records, showing the arrangement of data fields.

3. The information contained in each data field and the number of characters in each field.

4. The type of data contained in each field; alphabetic, numeric, or a combination of both.

5. Explanations of control characters, codes, and valid limits for multiple codes.

6. Editing and screening operations as required.

7. The sequence of data records within tape files.

8. Tape input label, or tape number.

9. Relative size or volume of tape files.

10. Trailer information, such as identifying the end of a tape reel and identifying the end of a job.

11. Any other information required in the processing or to be checked during processing.

Processing Specifications

Processing specifications vary widely, depending upon what is to be accomplished and the type of equipment required; therefore no specific guidelines for processing specifications can be given here. But the general precept of all specification writing must be observed, which is that every possible action and contingency must be accounted for.

In general, specifications for processing and performing computations on data do not involve the specifics of data and instruction storage locations. These are the responsibility of the programmer. In practice, the determination of a machine run involves some consideration of the amount of storage space necessary to store data and that required for instructions; usually some estimate of the number of instructions must be made. Frequently there is some latitude in this determination, for a proposed machine run may ultimately require more storage space than is available, necessitating a realignment of the sequence of machine runs. Likewise, availability of additional storage space may permit a consolidation of separate runs into fewer than contemplated originally.

Output Specifications

Output specifications for a data processing system, like those for input, may differ, depending upon the type of output equipment and the requirement for the particular job. General guidelines for producing punched cards, magnetic tape, and printed output, are contained in the following paragraphs. If required, specifications for other types of output can be developed along these guidelines.

Specifications for punched card output should be indicated as follows:

1. An illustration or sample card layout, showing the sequence and size of data fields.

2. Whether nonsignificant zeros are to be punched or suppressed.

3. Any constant data to be punched, such as dates or control punches.

4. The disposition of punched output.

Specifications for magnetic tape output should be essentially the same as those listed under magnetic tape input.

Printed output specifications will vary, since printers are available with or without control panels, but in general the following should be indicated:

1. The exact layout of the printed output prepared, if possible, or standard spacing charts for the particular printer showing the following:

● Heading and identifying information to be printed.

● Horizontal placement of data, and vertical line spacing (single, double, or other).

● First and last printing lines and overflow data to be printed.

● Classes and identification of totals to be printed.

2. Whether nonsignificant zeros are to be printed or suppressed.

3. Any constant data, such as dates, which are to be printed or suppressed.
4. Carriage tape layouts for tape controlled carriages.
5. Type of form paper and number of copies of printed output required, and finally the disposition of the printed output.

INSTRUCTIONS

As you already know, a computer must be commanded to carry out a data processing function. The commands are in the form of instructions, which are units of specific information located in main storage, and a series of instructions pertaining to an entire procedure is called a program. The functions could be selection of input/output devices, decision or branching routine, reading or writing on magnetic tape, transfers, or any number of things that make up a data processing application. Instructions are normally grouped according to the type of operations they perform.

Types

The basic types of instructions are input/output, data movement, arithmetic, decision-making, and magnetic tape. A group of instructions which do not fit into any of the aforementioned groups are classified as miscellaneous instructions. Each type of instruction is discussed individually in the paragraphs that follow:

Input-output instructions control card reading and punching, reading and writing of magnetic tapes, and printing. Unlike EAM equipment, which normally feeds cards mechanically and at a continuous rate, electronic data processing readers and punches feed cards only upon the execution of specific read and punch instructions in the stored program. Magnetic tape read or write instructions, when executed, perform magnetic tape feeding. Likewise, a print cycle is initiated on the printer only when instructed to do so by the print instruction contained in the stored program. Upon the completion of a function the program must be transferred back to its beginning. This transfer is accomplished by what is known as branching instructions. As an example, suppose the first instruction was to read a card. After the execution of this instruction the computer performs a series of operations specified by the program, such as add, compare, and print. A branch instruction is then executed that directs the computer back to the

beginning or "read a card instruction." After the next card has been read, the computer repeats the series of operations until instructed to read another card. This is known as a LOOP. In this case, an instruction in the program calling for a test for last card to be made after each card is processed can be used for stopping operations after the last card has been processed.

Data movement instructions are instructions used for moving data from one storage location to another internally. Every data processing system, operating from a stored program, must have assigned specific storage areas for reading in, printing, and punching, if all these functions are performed by the system. If there were no assigned or predetermined storage locations, the system would have no way of knowing where to store the contents of a card it has read, nor where to find the information it is to punch or print. These areas of storage are specified in one of two ways; by stored instructions or wired circuitry. Figure 12-2 illustrates a typical storage assignment specified by wired circuitry; all unassigned storage is termed working storage.

To illustrate the purpose of data movement instructions, let us examine the chart illustrated in figure 12-2 a little more closely. When a card is read, the 80 columns of card data are automatically placed in storage position 001 through 080, column for column. It is possible to perform some operations with this information while it is in the read-in area, such as add, subtract, or compare. But if it is to be punched or printed, it must be moved to the punch or print area. Move instructions cause the specified data in the read-in area to go to another storage area as specified by the OPERAND of the instruction. By the proper data movement instruction, data may be moved within the working storage area, within the assigned storage areas, from assigned to working storage area, from working to assigned storage areas.

Arithmetic operations are performed by what is known as arithmetic instructions. These instructions are add, subtract, multiply, and divide. Some systems may utilize counters on accumulators for developing results; storage may be used in other systems. In the latter case, arithmetic functions are not restricted to a predetermined number of positions for any given factor. Normally, the execution of any one arithmetic operation only requires one instruction. However, this statement must be qualified. Add and subtract operations can be performed by the standard features of a system. In
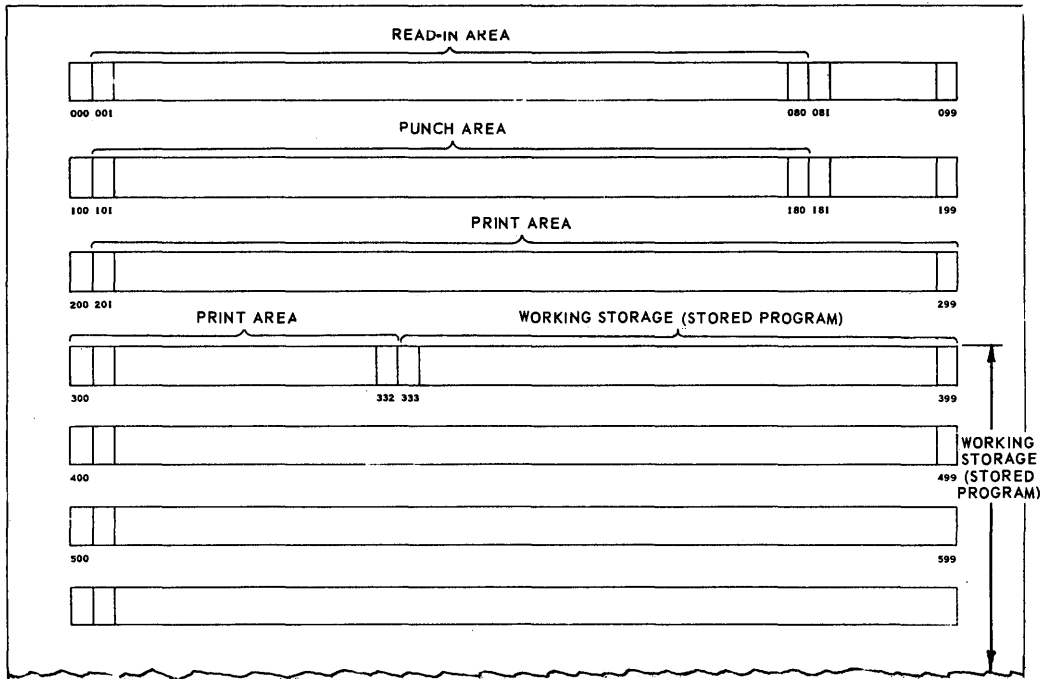
R78.22X

Figure 12-2.—Example of internal storage areas for IBM 1401.

contrast are the multiply and divide operations which may be performed in one of two ways: by a special multiply-divide feature, or through the use of a subroutine. Only one instruction is required for either multiply or divide operation when the special multiply-divide feature is installed. Without this feature, an arithmetic subroutine must be used—one for multiplication and another for division. A subroutine for an arithmetic operation consists of a set of instructions required to carry out the arithmetic function. A subroutine is normally prepared separately from any program and kept in a program library. The programmer draws the applicable subroutine from the library when needed, and inserts it at the desired point in his program. A detailed discussion of subroutines will be forthcoming.

A decision-making instruction is an instruction that allows the computer to deviate from the normal sequence of events. Instructions are normally executed by a computer in a sequential fashion. That is, it advances from one instruction storage location to the next, interpreting and executing instructions in succession. However, the programmer may insert into the program various TEST and TRANSFER instructions. These decision-making instructions cause the computer to take its next instruction from some other location, depending upon the test condition. Operations performed by the execution of decision-making instructions can be thought of as LOGICAL OPERATIONS, since decision-making is a form of logic.

The comparison of one factor with another constitutes the decision-making ability of the computer. There are three possible conditions when one factor is compared to another. These are: less than, equal to, or greater than. The particular condition obtained during comparison is the controlling factor which allows the computer to determine the next instruction or series of instructions to be executed. A few of the many

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kinds of conditions that can be tested are cited in the following examples:

1. One factor can be compared to another to determine its condition less than, equal to, or greater than.

2. A factor can be examined to determine if it is positive, negative, or zero.

3. A factor can be tested for validity by comparing it with a known and valid factor.

Magnetic tape unit functions are controlled by what is termed magnetic tape instructions. Some of the functions that may be controlled by these instructions are read, write, backspace, and rewind. Since a data processing system may use more than one tape unit, each unit must have a specific number of address as explained in an earlier chapter. Most tape operations require that the tape unit address be included in each instruction.

Various functions, not previously mentioned, are controlled by miscellaneous instructions. These functions include such operations as controlling the carriage on printers, clearing storage areas, setting word marks, and halting. Several miscellaneous instructions are used in housekeeping operations. The term HOUSE-KEEPING denotes those operations that must be performed before any data can be processed. Normally they are executed only once during a program run. For example, instructions for the housekeeping routine may include clearing storage working areas, setting word marks in the data read-in area, and establishing constant factors for use during execution of the program. These instructions are not limited to housekeeping operations, but may be used at any required point in the program.

Composition

All stored program instructions must have an operation code, which tells the machine what function or operation to perform. An instruction may also have an operand, containing a fixed number of ADDRESS PARTS which, in most cases, specify the storage location of the data to be processed. An instruction may contain additional parts having special meanings in a particular system.

For illustration purposes, let us examine the characteristics of instruction parts used with the IBM 1401 data processing system. Each instruction has an op code, and may have an A address. B address, and digit modifier (fig. 12-3).

OP CODE	A/I ADDRESS			B ADDRESS			DIGIT MODIFIER
X	X	X	X	X	X	X	X

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Figure 12-3.—Instruction format.

The op code consists of a single symbol, which may be a number, letter, or special character. These codes usually are written in MNEMONIC form during program preparation and are machine converted to the appropriate OP code during program assembly. A mnemonic code is a character or group of characters indicative of the operation to be performed. Their use simplifies the task of identifying the operation.

The A address is generally used to identify the LOCATION of a data field in storage which is to be used or affected, normally the field from which information is to be extracted. The I address is the same as the A address except it pertains to instructions instead of data.

The B address, in most instructions, identifies the location of a data field or area in storage to be used or affected when the computer performs the function specified by the OP code, normally the field to which information is sent for storage.

The digit modifier always consists of a single character. It is used with certain OP codes only, and lends power and flexibility to the OP code.

Length

The length of an instruction and the parts used depend upon the operation to be performed. For example, an instruction to READ A CARD contains an OP code only; the 80 columns of the card are automatically read into storage positions 001 through 080. An instruction to ADD may contain an OP code, an A address, and a B address; in this case, the instruction could mean "add the contents of the location specified in the A address to the contents of the location specified in the B address and store the results in the B address location." A conditional BRANCH instruction may have an OP code, A address, B address, and a digit modifier. Such an instruction could mean "branch (or transfer)

to the location specified in the A address for your next instruction if a single character located at the B address is the same as the digit modifier character."

STORAGE OF INSTRUCTIONS

Computers operating from a stored program must have their program stored internally before they can execute the instructions. Instructions are placed in a separate word location for those systems using magnetic drum as the storage medium. Instruction addresses may be assigned by the programmer, or they may be machine assigned during a program assembly routine. In systems utilizing magnetic core as the storage medium, instructions normally are placed in consecutive core positions. The programmer may designate the beginning position, or let it be designated by the machine during a program assembly routine.

Location of Instructions.—As a general rule, no special storage area is reserved for storage of instructions. In most instances, they are grouped together and placed in ascending sequential locations in the normal order in which they are to be executed by the computer.

Loading the Program.—Loading the program is the process of placing instructions in storage prior to the start of an operation. This is equivalent to insertion of a panel in a wired control panel machine.

STORAGE ADDRESSING

You will recall from reading an earlier chapter that the number of storage positions used for storing a word may be fixed or variable, depending upon the type of storage device used within the system.

In fixed word length storage devices, the address of both the instruction word and the data word always refers to word location. In fixed word length, addressing a word in storage pertains to only those storage positions assigned that particular word location. An example of a fixed word length storage device is magnetic drum storage.

In some data processing systems utilizing magnetic core as the storage medium, the variable word length may be established. Each word, whether it be instruction or data, occupies only the number of core positions actually needed for an instruction or data field. Words are not limited to a specific number of storage positions, and each position of core storage is addressable. The word length is controlled by a control character placed in the word storage area. The data processing system will specify the type and use of the control character.

The IBM 1401 is used here to illustrate how variable word length is established in core storage. In this system, a WORD MARK determines the length of a word. The word mark is placed in core in the high order position of the word (fig. 12-4). This is actually the low order storage position in the word, since storage positions are numbered in ascending sequence from left to right. A word going from left to right, extends from the storage position containing the word mark up to, but not including the next word mark. Data word marks are set and removed in accordance with the instructions in the stored program; instruction word marks are set automatically during the program load routine.

Addressing Instructions

Instructions are addressed in the position containing the word mark (or high-order position). This position and all positions to the right, up to, but not including, the next position containing a word mark, are treated by the machine as being part of the instruction field. For example, if the digits in position 376–380 of (fig. 12-5) represent an instruction, the address of the field is 376. Included as part of the instruction are the remaining positions through 380.
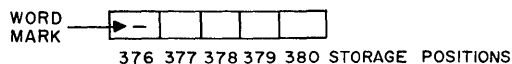
Figure 12-4.—Word mark identification.

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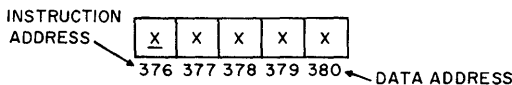
Figure 12-5.—Identifying the first instruction and data address.

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Addressing Data

Data fields are addressed in low order, or units, position. This position, and all successive positions to the left, up to and including the one containing the next word mark, are considered the data field. For example, in (fig. 12-5) if the digits in position 376-380 represent data, the address of the data would be the low order position, or position 380. The machine uses position 380 and all positions through 376 as the data field.

CONTROL REGISTERS

The task of interpreting instructions and processing data is accomplished by the computer through the use of registers. Some registers are used in transmitting data between internal storage and other parts of the data processing system. Other registers are used to hold parts of an instruction while the instruction is being executed. Still others hold data or results obtained from arithmetical operations. At this time we

are concerned with registers whose functions are storing and interpreting instructions for operating on data in internal storage. A simplified system of such registers, with an explanation of their use, is illustrated in figure 12-6. Two types of registers are shown in this illustration: an instruction address register, and an instruction register.

Instruction Address Registers

Instruction address registers are used to store the address of the next sequential instruction character in storage. As instructions are read from storage from left to right one character at a time, the instruction address register is automatically incremented by one for each instruction character read. Thus, upon completion of reading an instruction for storage, the instruction address register is standing at the address of the next sequential instruction.
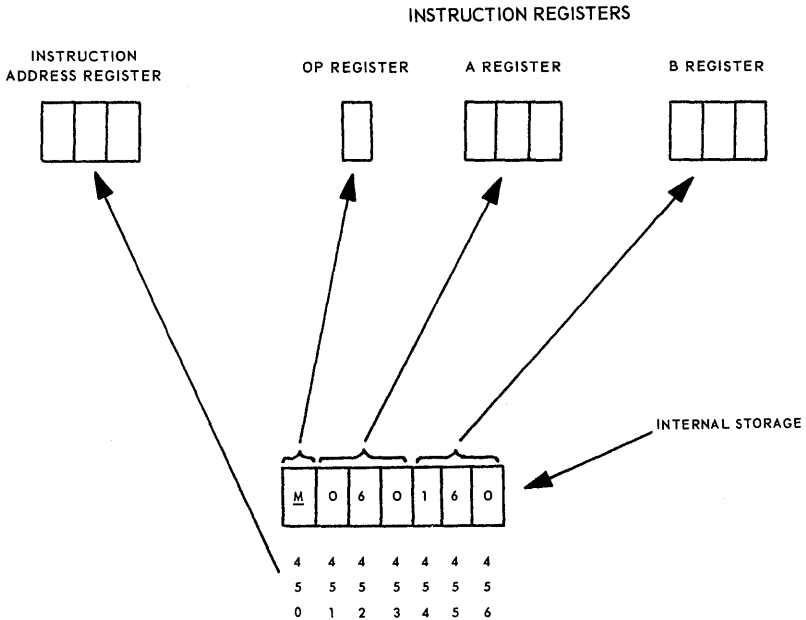
Figure 12-6.—Storing an instruction in registers.

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Instruction Registers

Instruction registers consist of an OP register, an A address register, and a B address register. The actual operation code of the instruction being executed is stored in the OP register for the duration of the operation. The A address register is normally filled with the storage address of the data in the A address part of an instruction. As the instruction is executed, the number in this register is normally decremented by one after each storage cycle that involves the A address. The B address register is normally filled with the storage address of the data in the B address of an instruction. Like the A register, this register is normally decremented by one after each storage cycle during the execution of an instruction, involving the B address.

Function of Control Registers

To delve a little further into control registers, let's see how these registers function when an instruction is read. Suppose the instruction requires that an item of data be moved from one storage location to another. The instruction could be set up as a seven-position word as follows: "M̲ 060 160." In this case, the OP code is M, meaning move, the A address is 060 and the B address is 160. The line under the OP code represents a word mark, and indicates the beginning of the instruction. The length of the data field specified in the A and B address parts generally is controlled by word marks set in data storage locations. Assuming this instruction is located in storage positions 450 through 456, and the previously executed instruction ended in storage position 449, the instruction address register would be standing at 450 before the move instruction is analyzed. This is because the instruction address register always contains the address of the next sequential instruction character to be obtained from storage.

As pointed out in an earlier chapter, a computer operates in two phases: an instruction phase and an execute phase. The instruction is obtained from storage and interpreted during the instruction phase and is carried out during the execute phase. During the instruction phase the instruction M̲ 060 160 is read; M̲ is moved into the OP register, 060 into the A address register, and 160 into the B address register. The instruction address register advances seven

times, once for each instruction character. It now stands at 457, which is the storage location of the next sequential instruction character. During the execute phase, the A and B address registers are automatically decremented by one after each storage cycle. Thus, assuming the fields specified in the A and B address parts of the instruction each consist of ten storage positions, the A address register stands at 050 and the B address register at 150 upon completion of the execute phase.

CHAINING INSTRUCTIONS

Some programs may call for performing a series of operations on several fields that are in consecutive storage locations. Instructions for such operations as ADD, SUBTRACT, MOVE, and LOAD have the ability to be CHAINED, thus saving space in storing instructions. Chaining involves the use of address register contents after execution of one instruction to execute the following instruction. For example, consider the MOVE instruction discussed in the preceding section. If this operation were followed by four similar MOVE operations, each involving a 10-position field, the instruction COULD be written as follows: M̲060160M̲050150M̲040140M̲030-130M̲020120. This would take a total of 35 storage positions for storing the five instructions. After the first instruction is executed, however, the A address register stands at 050 and the B address register stands at 150, corresponding to the same number in the A and B address parts of the following instruction. Thus, the second instruction need not contain A and B addresses since the correct addresses are in the A and B registers. The same holds true for the remaining three instructions. Therefore, using the principle of chaining, these five instructions can be written as M̲060160M̲M̲M̲M̲, and 24 positions of storage can be saved.

SOFTWARE

Software is a term that applies to the totality of programs and routines used to extend the capabilities of automatic computers, such as compilers, assemblers, narrators, routines, and subroutines, and the term is in direct contrast to hardware. Included in these titles are specific programming languages and systems.

PROGRAMMING LANGUAGES

A programmer can state a data processing procedure in a way that is convenient to him and

provide for transferring much of the clerical effort of program writing to the computer through the use of a programming language used with any programming system. A programming language, like any other, follows established rules for grammar, punctuation, and expression. To allow the programmer to state a procedure in a language closely resembling his own is the main purpose of the programming language. However, the terms of expression must be precise when describing any procedure to the computer. These statements must convey to the computer exactly what is to be done.

Symbolic Language

Programming, for an EDP application, can sometimes be a laborious and time consuming task. Providing for every aspect and contingency of an application may require hundreds of individual instructions, code tables, formulas, and other reference material. Programming could be even more burdensome if the programmer were required to use actual machine OP codes, assign storage addresses for all instructions and data, and write instructions for standard or fixed routines common to several applications.

It is hard to remember actual machine OP codes, because they are not always indicative of the operation to be performed. It is easier to write them in MNEMONIC language; meaning a language "aiding the memory." For example, clear core in actual machine code may be "1," but it would be easier to remember if it was written in a mnemonic equivalent, such as, CC.

The programmer has a difficult job if he must designate the storage address for each instruction and item of data. For example, variable length instructions would require the programmer to count the number of characters in each instruction prior to the assignment of the address of the next instruction. If, through error, he should leave out an instruction, he must insert the instruction in the proper sequence, and in doing so, he must reassign all subsequent instruction addresses. Assigning data addresses to each item of data and each working space would require the programmer to keep track of all assigned storage positions. Also, he must specify the exact address each time these items or areas are used during execution of the program.

In storage devices of the fixed word length variety, such as magnetic drum, the as-

signment of addresses for instructions and data is less difficult. This is because each storage position has a preassigned address.

Symbolic programming allows the programmer to denote areas in storage symbolically; the computer, during a program assembly routine, assigns the actual addresses automatically. To illustrate, assume that during the assembly routine the computer assigns all instruction addresses. When writing the program, you wish to branch, or transfer to an instruction other than the next one in sequence. At this time you do not know where the computer will place the instruction to which you wish to branch. So you write, in the operand field of your branch instruction, a symbolic label and assign this same label to the label field of the instruction to which you wish to branch. Your labels will be automatically converted to a machine address, during the assembly routine, thus providing the mechanics for branching from one instruction to the location of another instruction.

When a programming system is used, many of the problems and difficulties encountered when writing programs in actual machine language can be eliminated or simplified. A programming system allows the programmer to write his programs in symbolic form, and have it converted by machine to a computer-processable program. Programming in this manner consists of two parts: a language and a processor. The language refers to the symbols and terms used by the programmer in writing the program, and the processor relates to the program used to convert the programmer's language to machine language.

The program written by the programmer is called the SOURCE program. The translated program prepared by the processor is called the OBJECT program. When a programming system is utilized, the computer can be used for two distinct and separate purposes: as a translator (or program assembly device) and as a data processing system. As a translator, instructions in the source program are translated into machine coded instructions. Storage areas are assigned automatically, factors used as constants and other reference factors are included, and library routines for such functions as input-output, restart, and housekeeping are assembled. As a data processing system, the assembled program can be used over and over to control the operations during program execution.

Processor Instructions

A program that translates the codes, symbols, and statements of the source program into machine coded instructions, makes assignments in storage, and assembles the instructions into an object program, is known as the PROCESSOR. In addition to the written instructions, the programmer may introduce from a program library other information for use by the processor in assembling the object program. The contents of a program library may be pretested routines for input-output, error checking, housekeeping, printing, and other operations which may be inserted into any given program, thus relieving the programmer of the task of preparing instructions each time these routines are required. A processor program consists essentially of the following parts:

1. An assembly program that controls the computer in converting the source program data into an object program.

2. Tables that contain all acceptable mnemonic operation codes and the equivalent machine codes.

3. Instructions for interpreting each operation that is directed to the processor.

4. Counters to locate instructions and data in the source program.

5. Instructions for setting up a table of instructions and data locations as tags with their equivalent calculated storage locations.

6. Provision for editing the program for accuracy during assembly and to identify errors.

7. Provisions for assembling the object program in accordance with the method prescribed by the data processing system with which the program is to be used.

EXECUTIVE ROUTINES

An executive routine (EXEC) is a software (program) package designed to control other routines. That is, the EXEC is a program which "directs" the operation of other routines or programs and provides the major medium of communication between the programs and the operator.

.The executive routine provides for the processing of a series of jobs and handling the I/O functions for the operational program.

The EXEC is normally a residual program, meaning that the EXEC, or at least a portion of the EXEC, is found in the computer at all times.

Included as a part of the EXEC are several individual subprograms or components as well as several service programs, such as utility programs and sort-merge routines.

The EXEC provides for interface between the operational programs and the operator. The executive routine is directed to perform a specific function by means of control statements provided by the operator normally via the keyboard.

SUBROUTINES

A group of instructions that performs a specific segment of a data processing routine is generally classed as a subroutine. There are many types of subroutines in existence, and their number and uses vary according to a particular situation. Subroutines for the more common recurring applications encountered in many processing programs may be standardized and placed in a program library for use by any programmer when the need arises. Other subroutines may have to be written by the programmer when he encounters a situation unique to his program only. The reason for this is that some subroutines are used for performing standard, routine tasks that are required in practically all programs, such as end-of-file, end-of-job-(EOJ), and error routines. Others are used for performing standard tasks applicable to certain programs only, such as multiply and divide routines. Still others are inserted in a program and called upon only when exceptions to the normal processing routine are encountered.

Use

Possible subroutines are so numerous and so varied that their use is best illustrated here by example. For instance, let's examine one procedure for checking data records, for accuracy, as they are read from magnetic tape units. As the processing unit reads each tape record, a read error indicator is examined to see if the record was correctly read. If the record was read correctly, the normal program routine is executed. If not, the computer is directed to transfer to a subroutine of instructions that will attempt to correct the error.

A program flowchart for the subroutine just mentioned is illustrated in figure 12-7. In the majority of cases, perhaps even in all cases, each record will be read correctly throughout an entire data processing application. Thus, the

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Figure 12-7.—Representative subroutines.

to continue backspacing and re-reading the record until a correct reading has been obtained or until the counter has reached zero. If the counter is zero, the computer may be instructed to terminate the program and initiate the EOJ or to perform some other function that will clearly indicate to the operator that a record has been read incorrectly.

Types

All subroutines have one common objective; to carry out a well defined mathematical or logical operation. Subroutines have many names, such as dynamic subroutine, in-line subroutine, standard subroutine, static subroutine, open and closed subroutine. Our discussion of subroutines will be limited to the open and closed subroutines.

The manner in which subroutines are used depends upon the number of times they are needed during execution of the program. If a subroutine is needed only once or twice, for example, it may be inserted in sequential order within the main program and executed in this manner. The need for a branch or transfer instruction in conjunction with the subroutine would depend upon the type of subroutine used. If the subroutine calls for a standard operation to be performed for each record processed, no branch instruction would be required since the program would continue normally after the last instruction in the subroutine had been executed. If the subroutine is required only when a certain condition is encountered, then a branch instruction would be needed to bypass the subroutine when the specified condition did not exist. A subroutine located in sequential order with the main program is called an OPEN subroutine; that is, it is inserted in the main program where it is needed, and appears in the program as many times as needed.

Now suppose that the subroutine is needed at a dozen different places in the program. Inserting the subroutine in twelve different places obviously requires a considerable amount of storage space. Instead it can be placed in one storage place, apart from the main program, and instructions can be written to BRANCH to the subroutine when needed. This type of subroutine is called a CLOSED subroutine. The main program branches to it when necessary, and the subroutine branches back to the main program when it is finished.

normal program routine is: read a record, check reading accuracy, perform the necessary computations, write a record, and loop back to read the next record. Incorrect reading of a data record is a rare exception rather than the rule. However, this contingency must be taken into consideration to ensure that the data are processed correctly. In this illustration, the computer is afforded three attempts to read a record correctly after it has failed to pass the record check. When a read error occurs, the computer branches to a subroutine. The first instruction in the subroutine causes a counter to reset to 3, indicating the maximum number of attempts permitted for reading the record correctly. The record is backspaced and read again. If it is correctly read at this attempt, the computer is directed back to the normal processing routine. If not, a 1 is subtracted from the counter, and the counter is tested for a zero indication to determine if 3 attempts at reading have been made. If the counter is not zero the computer is directed

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UTILITY PROGRAMS

Utility programs encompass certain functions that are common to all data processing applications. These programs are written to perform recurring operations to free the programmer from the repetitive task of writing these common instructions over and over again.

There are many types of, and uses for, utility programs. They will perform the operations of clearing storage, loading instructions into storage, and printing out specific areas of storage for analysis, over and over as long as the requirement remains the same. The clear storage program, for example, causes the entire main storage area to be cleared. Normally this program is placed in front of each object program to be loaded into storage to ensure that each program run begins with a clean slate. Thus, interference from data which may have been left in storage from a previous operation is avoided.

A program for loading instructions into storage causes all instructions and constants in the object program to be loaded into the specified storage locations. The address of the first instruction to be executed is usually specified by the last instruction in an object program. When this last instruction is encountered, signalling the end of the load routine, the loader program causes the computer to branch to the address of the first instruction.

Specific areas of storage can be printed out at any time utilizing a storage print-out utility program. Its primary use is debugging a new program after an attempt at running the program has been made. If a programming error is detected during the check-out process, analysis of the printed contents of storage may be useful in determining the cause of the error.

The types of utility programs required and their structural content depend upon the needs of, and type of equipment used by, a given installation.

TEST DATA AND DEBUGGING

After the program has been written and the desk checking routine performed, you should prepare test data in the form used by the program to force the program to execute every instruction. The test data should contain every possible condition, whether or not the condition represents a legitimate occurrence. Real data may be modified to meet these requirements. It is often helpful to mark each data record with the condition that it represents and list all these conditions on a separate sheet of paper.

A completely tested program should include all the following tests:

1. All possible combination of input data.
2. Possible input data errors.
3. All possible codes in the input data which the program checks for validity.
4. Both conditions of each branch or switch in the program.
5. Each loop or table search for a beyond-the-limit situation.
6. Error routines, including the necessary console operations to correct or by-pass a record.
7. End-of-reel and end-of-file tests, as appropriate.
8. Restart routine.
9. End of job routine.

Test data should not be destroyed after use, but should be retained by the section maintaining the program. This allows you or other programmers to use the test data when subsequent programs are developed.

Debugging is the actual process of testing a new or revised machine program. The purpose of this test is to detect and correct any errors which may have been committed during programming. Debugging is usually performed in two phases: first using test data assembled specifically for the test, and again using real data.

When difficulty arises during the first phase of debugging, you should analyze the machine status at the instant of failure, determine what has occurred, the reason, and the corrective action to be taken to allow the machine to fully execute the complete program. Generally, the complete analysis is not apparent while you are at the console of the machine. Therefore, you should obtain all readily available information (console indication, storage dumps, tape print-outs, etc.) and get off the machine. Further checking of this information can be accomplished as a desk check.

When you are satisfied that the test data have been correctly processed by the program, the second phase of testing should be conducted, using representations of real data. The same corrective procedures used during the first phase should be followed.

The results of the test using real data should be completely varified using manual computations or EAM results as a comparator. Outputs

should be printed out and used to ensure accuracy. For operations involving magnetic tape, no program can be considered completely checked out until multi-reel tape handling has been tested.

PROGRAMMING SYSTEMS

If all electronic data processing systems were constructed in the same way, it would be conceivable that a program prepared for one would work equally well with any other. Such, unfortunately, is not the case. Each system has its own particular physical configurations, its own machine codes, and its own way of doing things. This tends to specialize the job of programming, so that each system requires a program tailored to its own individual specifications. One or more programming systems have been developed for each machine system to relieve the programmer of many clerical details and to make his task easier in preparing a program for a given system. Some programming systems lend a certain degree of compatibility to several data processing systems, and some may possibly be used with any system, provided a few alterations are made to fit the needs of a given system.

SYMBOLIC PROGRAMMING SYSTEM (SPS)

The symbloic programming system (SPS), developed by International Business Machines Corporation, is designed to allow the programmer to write a program expressed in symbolic statements rather than in actual machine language. These statements include mnemonic operation codes and symbolic names which the programmer uses to identify operations, items of data, instructions, and work areas. A program written in this form must provide for three types of operations: declarative, imperative, and control.

Declarative operations consist essentially of statements, or area definition entries, written by the programmer that instruct the processor to set up spaces in storage for working areas and constant factors required in the execution of the program, and to associate symbolic names assigned to data in the source program with actual storage addresses. The processor examines these statements during assembly of the object program, and assigns storage areas and addresses as necessary. Declarative operations do not produce any instructions for execution in the object program.

Imperative operations are the instructions written by the programmer in symbolic form for executing a program routine. These statements are translated to machine language by the processor during program assembly.

Control operations are special instructions which the programmer gives to the processor program. They consist of commands for controlling the assembly process, but are never executed in the object program. They are used for such purposes as advising the processor program how much storage is available in the machine that is to execute the object program, where to begin assigning storage for the object program, and where the program ends.

The symbolic programming system utilizes two decks of cards in developing the machine, or OBJECT, program. One deck consists of cards punched from line entries on the SPS coding sheet, and is called the SOURCE program. The second deck, called the PROCESSOR program, contains pre-punched cards that provide the machine with information necessary to translate the programmer language into machine language.

AUTOCODER

AUTOCODER is another programming system developed by International Business Machines Corporation which supplements and extends, but does not replace, the SPS. It provides for greater programming flexibility than SPS, and allows the use of magnetic tape for the program assembly routine.

AUTOCODER enables the programmer to insert program library routines for operations that are common to many source programs. These routines are tailored automatically by the processor to meet the particular needs for the program as specified by the programmer in the source program.

Like SPS, a program written in AUTOCODER language must provide for declarative, imperative, and control operations. The instructions for these operations, and the method of execution, are similar to those required for SPS. In addition, a fourth type of instruction can be used, called a MACRO instruction. A MACRO instruction is a single symbolic instruction written by the programmer that causes a SERIES of machine language instructions to be created automatically in the object program. The use of a MACRO instruction relieves the programmer of much repetitive coding by enabling him to call a sequence of instructions from a library routine,

and have these instructions tailored automatically by the processor to fit his particular program.

UNICODE

UNICODE is a programming system developed by Sperry Rand Corporation for use with certain Remington Rand UNIVAC data processing systems. It is designed for scientific routines and enables the mathematician, physicist, or engineer to express his problem concisely in a simple form that can be machine-translated into an OBJECT program. The best application for UNICODE is for problems which require a quick solution, and which will be run on the computer a limited number of times. For operations which must be run on the computer many times, the assistance of a programmer may be required so that the program can be developed in a form which requires minimum computer time for execution. UNICODE, like so many other programming systems, allows the programmer to draw subroutines from a program library for insertion in his program, thus saving considerable programming effort and time.

FORTRAN

Another programming system for scientific applications, developed by International Business Machines Corporation, is called FORTRAN, meaning FORMULA TRANSLATION. The FORTRAN closely resembles other systems in content, for it embraces a SOURCE program and a PROCESSOR program for producing the OBJECT program. FORTRAN may be used with a number of electronic data processing systems. However, a different PROCESSOR program must be used for preparing a program for each different processing system. This is necessary because the FORTRAN processor must translate a source program into the particular machine language of the processing system which is to execute the program.

COBOL

The programming system that comes closest. to providing a language common to many electronic data processing systems is called COBOL. This system, derived from the words "Common Business Oriented Language," was developed through the joint efforts of computer manufacturers and users, in cooperation with the United States Department of Defense.

COBOL is problem-oriented; that is, the language and techniques for using it are expressed in terms of the problems to be solved and the results to be obtained rather than in terms of the technical features of a data processing system. Even so, a PROCESSOR program, or COMPILER, unique to the data processing system used for executing the OBJECT program must be used with the SOURCE program expressed in COBOL to produce the desired OBJECT program.

The basic elements required in a source program written in COBOL are contained within four divisions as follows:

1. Identification division.—The identification division provides information that will identify and label the particular program, such as program and run number, name of programmer, and date written.

2. Environment division.—The environment division describes the equipment to be used in the application. Among the many descriptions included in this division are such factors as storage requirements, number of tape units, hardware switches, and printers.

3. Data division.—The data division contains descriptions pertaining to the files and associated data records which are to be processed. Also, working areas and constants required in the program are defined by the programmer in this division.

4. Procedure division.—The procedure division specifies the processing steps which the programmer wishes the computer to follow. These steps are written by the programmer in meaningful English words, sentences, statements, and paragraphs. This division often is referred to as the PROGRAM. In reality, it is only one part of the problem specification, with the remainder of the problem specification provided in the other divisions. Since the procedure division is essentially problem oriented, any COBOL user can understand the information appearing in this division regardless of the data processing system involved. Further, every COBOL compiler or PROCESSOR program interprets procedural information in the same way.

PROGRAM DOCUMENTATION

Many details must be considered and many decisions made during the development of an

application for a data processing system. Most of this effort is performed considerably in advance of actually putting the application into operation. All details concerning each and every application can hardly be remembered by one or several individuals. Moreover, the loss of one or more of these individuals that had a hand in establishing the application could create a void in the total and accessible information needed to ensure accurate execution and control of the application. For these reasons, it is important to get down on paper or document all aspects of each application as quickly as possible.

Advantages

All information pertaining to a particular program should be documented and combined to form a program package. The exact form of the package is not as important as ensuring the inclusion of all necessary items. Among the principal benefits to be derived from an adequately recorded program package are that it:

1. Avoids misunderstanding between personnel· in data processing and other personnel within an organizational structure—particularly after the program has reached the operational stage.

2. Aids in understanding and maintaining a program by programmers and other personnel concerned after the program is in an operational status.

3. Provides for each program a text for indoctrination of new personnel and for enlightening other personnel as to the purpose and content of the program.

Contents and Format

The program package should be prepared as the parts of an application are performed. The package format should be established as soon as possible after the study of a problem is initiated. The items which should be included in the format are included in the following checklist:

● Program name, number, and purpose.
● Correspondence relating to agreements and decisions made, such as source data avail-

ability, output requirements, approximate volumes of records and transactions and exceptions.

● A narrative run description, including general and detailed program flow charts.

● Listings required for reference and cross reference. These include listings of the program as written, program listing by instruction location, listing by operation code, et cetera.

● A list of both on-line and off-line equipment required, and the correct program addresses for equipment on-line.

● The estimated running time required for the execution of the program.

● Completeness of operating instructions. The following minimum items should be included:

a. List of all programmed halts and the prescribed action for each.

b. Specifications for setting the console switches.

c. Identification of the tape units and FILE and MACHINE reels to be used.

d. Description of abnormal routines, such as tape labeling, error correction et cetera.

e. Applicable restart procedure for other than a standard restart routine.

● A description of equipment setups and input material required.

● Output material required, such as tape reels, cards, and forms.

● Instructions for labeling, storing, and distribution of all input-output material upon completion of the program run.

● Detailed layouts of all printed forms and input-output records.

● Main storage allocations layout, assigned input-output areas, main program, constants and variables, subroutines, and working spaces.

● Auxiliary storage allocations layout.

● Description of appropriate registers contents and usages.

● Designation of the location and the setting and purpose of all switches used with the program.

● A history of the program, a record showing such items as the date the program was written, date assembled, programming progress, date place in production, date and description of all changes made.

CHAPTER 13

OPERATION AND CONTROL

This chapter on automatic data processing deals with the operations and controls involved in almost all data processing systems. These operations and controls are frequently referred to as operations and procedure checks. Operations refer not only to the machine operations but also to the manual operations involved in handling data, operating equipment, and maintaining a magnetic tape library and tape rehabilitation equipment.

Procedure checks encompass control checks on data, system checks, and machine checks. These checks are designed to test the accuracy of the procedure from input preparations to the final output.

OPERATION OF ADP EQUIPMENT

There are several areas of concern for an operator or data handler in an ADP installation. In addition to being familiar with the various methods employed in controlling data and procedures, he must be thoroughly familiar with the operating procedures of a given system as dictated by the activity.

Operation of a data processing system is an important business in the Navy. Skill in operating any machine requires practical experience, but experience alone is not enough. A machine operator can become skilled only through a combination of personal instruction, practice, and study of written manuals. The basic operating steps of all machines are very much alike, although the results obtained from each type of machine may vary considerably.

Regardless of the type of machine you operate, or the accounting procedures you follow, there are certain rules you should observe in order to maintain the highest degrees of efficiency. These tasks are basic and easily learned. Once you have performed them once or twice, you will be able to carry them out without difficulty.

RULES FOR MACHINES

Under normal conditions a machine will give long and trouble-free service. There are a few things you can do to assist in the safe and efficient operation of machines.

1. Keep personal belongings off the machines.
2. Keep paper clips, rubber bands, and related items off the machines unless it is absolutely necessary to have them there. If you must have items on the machines, provide receptacles for proper stowage to prevent them from falling into the machines or getting between cards.
3. Keep all beverages, such as coffee and soft drinks, off the machines. Liquids, if spilled, are detrimental to the proper operation of internal machine parts.
4. Brush feed hoppers daily to remove lint.
5. Do not allow unused wires to hang loose from control panels, for they may cause a short circuit.
6. Use hands to push down on the control panel bail lever, which is attached to the machine, and secure the control panel in the machine. Do not attempt to push the bail lever down with your foot, as such a practice may damage the jacks or wires in the control panel, or the prongs in the machine.
7. Do not turn the power off at any time during a machine operation except in case of an emergency.
8. Do not alter the settings of switches or make any changes in machine setup while the machine is in operation.
9. Before operating any punching machine, check its punching registration with a card gage as shown in figure 13-1.
10. Make use of test decks that are provided for ensuring that machines are functioning properly to perform specific jobs.
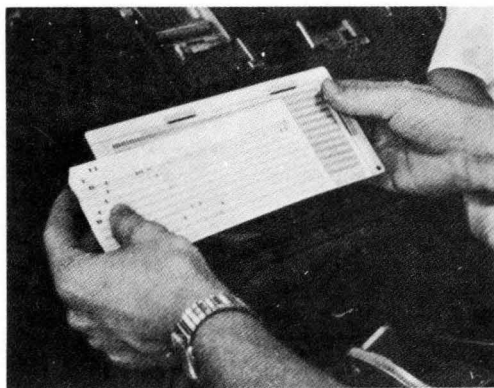
49.237

Figure 13-1.—Checking the punching registration.

11. Do not feed other than standard cards into machines (e.g., tab index cards). Keep card weights on cards in feed hoppers of machines at all times while machines are running (except when not required by certain type card feeds); do not rest your hands on the cards in the hopper.

12. When removing card jams, match pieces of torn cards to be certain none remain in the machine to cause further jams. Should jams necessitate the removal of brush assemblies, consult with your supervisor.

13. Do not change or switch the electrical cords between machines unless duly authorized to do so.

RULES FOR CARDS

When properly handled, punched cards can be used over and over again in a variety of applications for a long period of time. These cards must be handled with care in order for them to feed properly through the various machines in which they will be processed. To maintain cards in the best possible condition, observe the following rules:

1. Use rubber bands on cards only if necessary. If a rubber band must be used, cross it over the back of the cards and around the corners. Never place a rubber band around the center of the cards, as this can damage the edge of the card that passes under the throat of the machine.

2. Keep all cards under pressure and properly stored when not in use to prevent the cards from warping.

3. To ensure proper feeding, fan cards to remove static electricity and foreign particles, and joggle and align them (fig. 13-2) before placing them in machine feed hoppers.

4. File cards promptly when you are through with them, being careful not to misfile them. When small groups of cards are to be used later within the same procedure, they should be plainly marked.
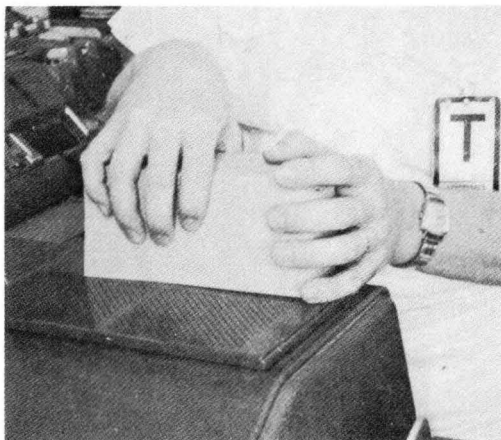
49.236

Figure 13-2.—Joggling and aligning cards.

5. Replace nicked or damaged cards immediately. Do not try to force them through the machine. All replacement cards must contain exactly the same information as the original cards. Tear the top margin or mark the damaged cards in some manner so that other machine operators will not use them by mistake. Damaged cards should be saved for checking purposes in case an error is discovered later.

OPERATING THE CONSOLE

You recall that the entire computer system can be controlled via the console. To perform efficiently as a console operator there are two associated areas that must be familiar to you. These are knowledge of the console and the ability to manipulate the required controls.

Knowledge

Because there are many types of operating systems in the Navy, each with its own particular operating procedures, it would be impossible for any individual to be familiar with them all. However, the operator must have a good working knowledge of the system employed at his particular activity. System knowledge includes:

- Knowing the switches and breakers used in bringing up power for the system.
- Knowing the systems emergency power, keys, and switches.
- Knowing the bit configuration of the particular system.
- Knowing the system's console keys, switches, and lights.

Ability

It is possible to have the knowledge of a given system without having the ability to operate it. Knowledge can be obtained through various sources, but ability comes only from experience. An EDP operator must have the ability to:

- Display the contents of accumulators, registers, or any particular position of storage.
- Trace the path of data, or instructions, within the CPU.
- Restart the system in case of unscheduled interrupts or halts.
- Give the status of the system at any given moment.

In addition to complete familiarity with the system, console operators should be completely familiar with the various utility and assembly programs used in the installation.

Operating logs should be kept on the console to indicate which programs are run, time started, time finished, which peripheral equipments are used, etc. On certain systems these logs may be kept by the use of the console typewriter.

Operating logs or records are invaluable and are used for various time utilization reports and a history of the operation.

HANDLING MAGNETIC TAPE

Magnetic tape is a precision engineered product, manufactured and tested under conditions that are carefully controlled to ensure the greatest quality and reliability. An actual performance test is conducted by the manufacturer on each reel of tape before it is released to a customer. Rigid reliability and life tests are made to ensure that the high quality of magnetic tape is maintained with usage.

Dust, dirt, and damage are the common enemies of magnetic tape. Maximum accuracy of tape reading and writing operations can be greatly reduced or prevented by their presence. Proper cleaning of tape units, careful tape handling, clean operating spaces, and proper tape stowage can prolong the usable life of magnetic tape.

Loading and Unloading Tape Units

Each type of magnetic tape transport unit has its own routine for loading and unloading that are performed in accordance with the rules tailored for each specific type. This situation precludes the establishment of any set rules for loading and unloading magnetic tape. However, there are some general guidelines which should be observed during any loading or unloading routine. These guidelines are listed as follows:

1. Prior to loading a file reel, determine if the reel should have the file protection device inserted or removed (fig. 13-3). A tape reel MUST have the file protection device INSERTED to permit writing on the tape.

2. Exercise due caution to ensure that the tape reel is properly mounted. Reels which are not mounted correctly may cause the edge of the tape to receive undue wear and become burred.

REMEMBER THE SIMPLE RULE: *NO RING, NO WRITE.* THIS MEANS THAT A REEL OF TAPE CANNOT BE WRITTEN ON UNLESS THE RING IS INSERTED IN THE REEL.
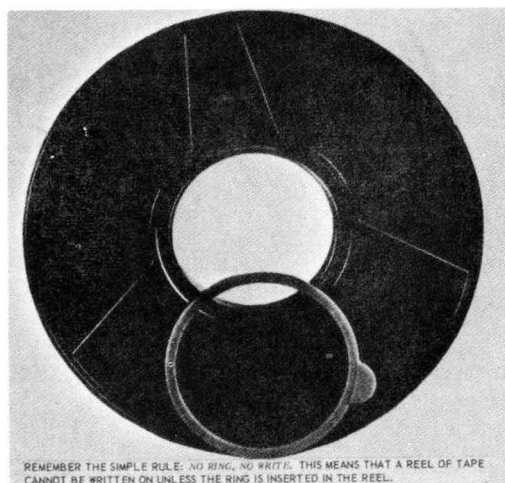
49.366
Figure 13-3.—Tape reel showing file protection method.

Burring causes one edge of the tape to be slightly thicker than the other, and in time the edge of the tape will be permanently stretched and will present a wavy appearance. Continued use of such tapes proves unpredictable and generally unsatisfactory; errors during reading, usually random and nonrepetitive, are encountered.

3. Follow the procedures prescribed for the particular unit when loading reels, when threading the tape from the file reel to the machine reel, and when unloading reels. The exact procedures will be demonstrated by your supervisor, or, if necessary, can be obtained from the appropriate reference manuals of the tape transport manufacturer.

4. When a tape reel is removed, determine if it is to receive a file protection device and if it is labeled correctly. Place the reel in a container and stow in accordance with established procedures for the installation.

Handling Tape Reels

Information is recorded on magnetic tape to within .024 inch of the lateral edges of the tape. Nicks and kinks, along the edges of the tape, caused by careless handling, can and do impair proper reading and writing. Damage of tape

should be avoided whenever possible. Protection of magnetic tape can be increased by observing and enforcing the following rules:

1. Tape reels should be handled near the center, or hub, of the reel.

2. Avoid contact with, and pinching of, tape edges that are exposed through the reel openings.

3. Tighten the mounting hub securely to prevent the reel from wobbling during reading and writing operations.

4. Do NOT fold or wrinkle the tape ends. This could result in uneven tape winding and resultant tape damage.

5. When storing tape reels, use the manufacturer-prescribed devices to prevent the tape from unwinding in the container.

6. Smoking should not be allowed in working spaces where magnetic tape units are installed. Smoking is NEVER permitted while handling magnetic tape, attending tape units, or working in the tape storage area. Ashes may contaminate tapes, and live ashes may cause permanent damage if they come in contact with the tape.

7. Avoid dropping tape reels.

8. Never use the top of a tape unit as a working area. Materials placed on top of the units are exposed to heat and dust from the blowers in the unit. Interference with tape unit cooling will also result.

9. Always follow the rules and procedures as established by your activity or installation.

CAUTION

The glass access door to the tape unit must be closed for the unit to operate. If the door is opened during processing, the tape unit will stop.

DO NOT open the access door during a high-speed wind or rewind. This sudden stop could break or damage the magnetic tape.

Irregular Winding.—As tape is wound on reels it is normal for some of its edges to protrude slightly. These irregularities usually result from high-speed rewinding. The speed at which tape moves, during high-speed rewinding, produces the slightly irregular wind due to air being trapped between adjacent layers of tape. This in itself will not cause improper operation of the tape, but it requires that proper care in the handling be exercised by all operators.

Reel Warpage.—When not being used, tape reels must be properly supported. The plastic container is designed to fully support the reel. A tape reel that is supported in any other manner may lead to a warped reel.

If a reel is not seated properly on the tape drive hub during use, it will wobble or appear to be warped. If the file protection ring is not completely inserted, it produces the same effect. In either case, the reel behaves as though it were warped, and the edges of the tape can be damaged.

Tape Markers

If, during the mounting of a tape you discover that there is no load-point marker, one must be put on the tape. There also must be an end-of-tape marker at the other end of the tape. The markers are small pieces of transparent plastic with a thin film of aluminum on one side. Pressure-sensitive adhesive covers the aluminum film so that the markers can be pressed onto the tape.

The load-point marker (fig. 13-4) is placed at least 10 feet or more from the beginning of the tape to provide a leader for threading the tape on the tape unit. This marker is placed on the uncoated (shiny) side of the tape, parallel to, and not more than 1/32 of an inch from, the edge of the tape which is nearest the operator when the reel is loaded.
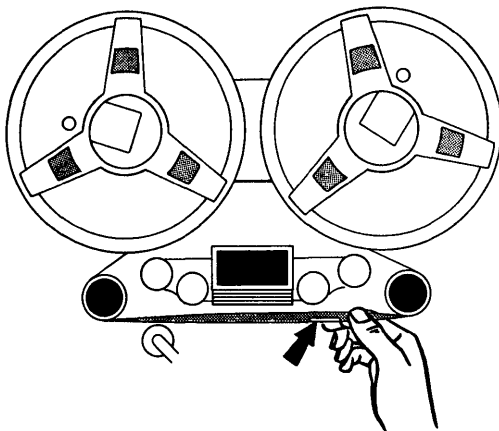
49.367

Figure 13-4.—Load point marker.

The end-of-tape marker (fig. 13-5) is placed at least 14 feet from the end of the tape to provide 10 feet of leader and 4 feet for the recording of data after the end-of-tape marker is sensed. This marker is placed on the uncoated side of the tape, parallel to, and not more than 1/32 of an inch from, the edge of the tape which is nearest the tape unit when the reel is loaded.
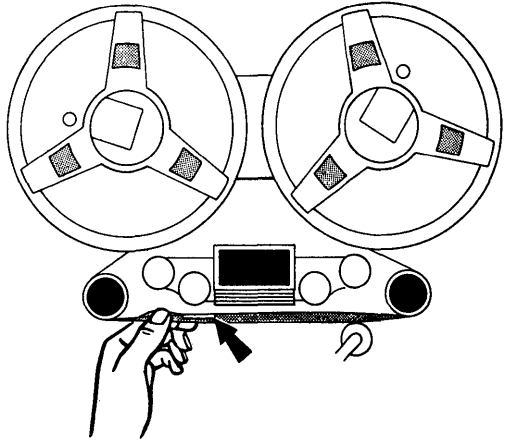
49.368

Figure 13-5.—End-of-tape marker.

MAGNETIC TAPE LIBRARY

Each computer center that utilizes magnetic tape records should have a tape library for proper control and storage of magnetic tapes. A tape library may contain relatively few reels of magnetic tapes or it may contain several thousand. In any case, these reels contain vital records, and an adequate system of control is essential in the filing and maintenance of tape records. A tape librarian, as designated, is the custodian of all tape reels in the library.

As the tape librarian you should be familiar with the procedures in maintaining a tape library. Before the types of records and controls are discussed, let's get an idea of some of the duties a tape librarian may be required to accomplish:

● Retrieve and file magnetic tapes in accordance with schedule.

● Maintain and physically inventory tape files.

● Control tape reels on a rotational basis.

● Prepare tape usage reports.
● Maintain tape reel use logs, tape labels, and associated files.
● Maintain control of certain required data and program files.
● Test tapes for quality, clean tapes, and degausse tapes according to schedule or upon release by programmers.
● Make recommendations concerning the disposition of faulty or damaged tapes.
● File all library material in a neat organized, uniform manner.

LIBRARY CONTROLS

Procedures and controls for adequately operating a tape library must be established and maintained if maximum and efficient usage is to be realized from magnetic tapes. The following should be provided for through efficient tape library controls:

● A quick means for physically locating any reel of tape in the library. Each reel should be identified with the file number and reel number, since there may be more than one reel per tape file.
● If a file or reel is absent from the library, the name of the person to whom it was issued should be recorded.
● Identifying scratch date expirations so that tape reels may be released for reuse. A scratch date is the date that the data recorded on a particular tape is no longer required.
● Maintenance of records written in concise, easily understood terms, and requiring a minimum number of entries.

Library controls for magnetic tapes may be set up in various ways as long as they provide the proper control of all tape reels in the computer center. It must be remembered, however, that each time the tape status changes, all records pertaining to that tape must be changed accordingly. Following is one system which may be used to meet these requirements, and is intended only to provide basic ideas and guidelines for maintaining a magnetic tape library.

EXTERNAL TAPE LABELS

Every reel of magnetic tape must be correctly labeled. This is accomplished by the use of two external labels which every reel must have. These are called permanent reel and temporary file labels.

Permanent Reel Label

The permanent reel label, in this case, is a paper label with adhesive backing that is physically attached to the side of new reels. An example of this type of label is shown in figure 13-6. Information included on this label is:

● Serial number of the reel.
● Current length of the tape.
● Date received from the manufacturer.

49.319
Figure 13-6.—Permanent reel label.

This label is never removed from the reel. Each tape is assigned a sequential cabinet slot number which shows the permanent storage position for that tape.

Temporary File Label

The temporary file label (fig. 13-7) may be a three-part form consisting of one buff copy, one colored copy, and a white tape label with adhesive backing.

49.320
Figure 13-7.—Temporary file label.

The form is hand prepared on all newly generated tapes, showing the reel number, classification, cabinet slot number, programmer's name, identification, the date the tape was created, and the retention period, which is the number of days the tape must be saved before it can go back into the scratch pool. (A scratch tape is a reel of tape on which new information may be written.)

The white tape label is affixed to the reel of magnetic tape, the programmer receives the buff copy for his records, and the tape librarian gets the colored copy.

The tape librarian uses his copy as a source document to be keypunched and interpreted. Once keypunched, the card is filed in the master card file and the document may be kept for historical records, or destroyed. In order to keep the file up to date, this procedure should be followed every day, in order to provide easy and prompt access to any tape by the tape librarian.

A reel which has a temporary file label on it must have the file protect ring removed immediately.

AVAILABILITY OF TAPES

In a data processing application involving punched cards, the method employed in obtaining blank card stock is quite simple; the operator merely draws the required quantity from the blank card storage area. Little control over blank cards is required except to ensure that demand never exceeds the supply. In applications involving magnetic tape the operator cannot draw from a file of new tape reels each time he is to perform a writing operation. This may be the case in newly established systems, but once a system has reached an operational status, procurement of new tapes is limited to those needed for expanded or new operations, or to meet requirements unforseen in the original planning. The principal source of magnetic tapes, for writing operations in an operational system, is provided through scratch (nonrecord) tapes containing data no longer needed.

One method of controlling available tapes for writing operations involves setting up the tape records on punched cards and maintaining all cards representing record tapes in one file and all cards for scratch tapes in a separate file. Periodic listings for audit and control purposes can be obtained when library records are in the form of punched cards.

Save Tapes

When the librarian gets a request to use a save tape, the master card is extracted from the save tape card file and is filed in the tapes out of library file using reel number for the sequence. The tape reel is taken from its cabinet slot and sent to the computer floor for use. When the job is completed, the tape reel is returned to the library and filed in the appropriate cabinet slot if it is to be saved. The master card is removed from the tapes out of the library file and returned to the master file.

Deletion of Saved Tapes

It is essential that each tape reel or file be made available when its contents are outdated or no longer required if an adequate supply of scratch tape is to be assured.

Whenever a programmer wants to release a tape saved by him he can sign the buff colored form that he received as his record when the tape was created and give it to the tape librarian to delete.

Another method that can be employed is to produce listings from the master save tape file on a regular basis (weekly, biweekly, etc.), by programmer sequence, with each programmer on a new page, indicating reel number and identification. All tapes saved by each user would be grouped together, and upon delivery, he may review the listing to determine which tapes have reached the end of their usefulness and may be scratched.

In all cases, the tape librarian upon receipt of the properly signed buff form or listing removes the card from the master file and stamps it as being deleted. The master card is sent to keypunch and the deletion date is punched. The master card is then filed in the deleted file. The save tape is removed from its cabinet slot, the temporary tape labels are removed, the file protect ring is inserted, and the tape is now available to the scratch pool.

SHIPPING MAGNETIC TAPE

When magnetic tapes are to be shipped to another activity, place them in containers and seal each in a plastic bag. Additional protection should be provided by packing each tape in individual stiff cardboard shipping cartons.

Ordinary plastic bags that can be sealed with a hot iron and shipping cartons can be obtained from the local magnetic tape vendor.

TAPE CLEANING

Tape failures on your activity's computer can be extremely costly. Careful maintenance of magnetic tape will minimize or even possibly eliminate lost computer time.

The first step in every magnetic tape maintenance program is obviously careful cleaning. The majority of all tape errors result from contaminants which collect on all magnetic tape in normal computer use. This debris is composed mainly of fragments of oxide or backing material dislodged from the tape itself. These particles of "self dirt" cause loss of contact (DROPOUT) between the computer read/write heads and the surface of the tape. The largest source of such surface dirt is the tape edge.

An effective method of cleaning tape is by using a Magnetic Tape Cleaner similar to the tabletop model shown in figure 13-8, which will clean a 2400-foot tape in approximately six minutes.

A rotating cleaning blade skims off imbedded oxide lumps, dirt, and other foreign particles.

Loosened dirt is removed from the tape by wiping assemblies on each side of the blade, which are mounted on turrets. When the end-of-tape marker is sensed by the photoelectric switch, the tape automatically reverses and the wiper turrets adjust to the new tape travel direction and clean the entire length of tape in the opposite direction. The wiping tissue is made of a special texture fabric and mounted on spools.

It is important that wiping material be changed frequently at the point of contact with the tape in order to avoid entrapment and retention of abrasive dirt particles at the tape surface being wiped.

OPERATING AND PROCEDURE CHECKS

Two main areas of activity are included in a data processing procedure; control of the procedure and accomplishment of the desired
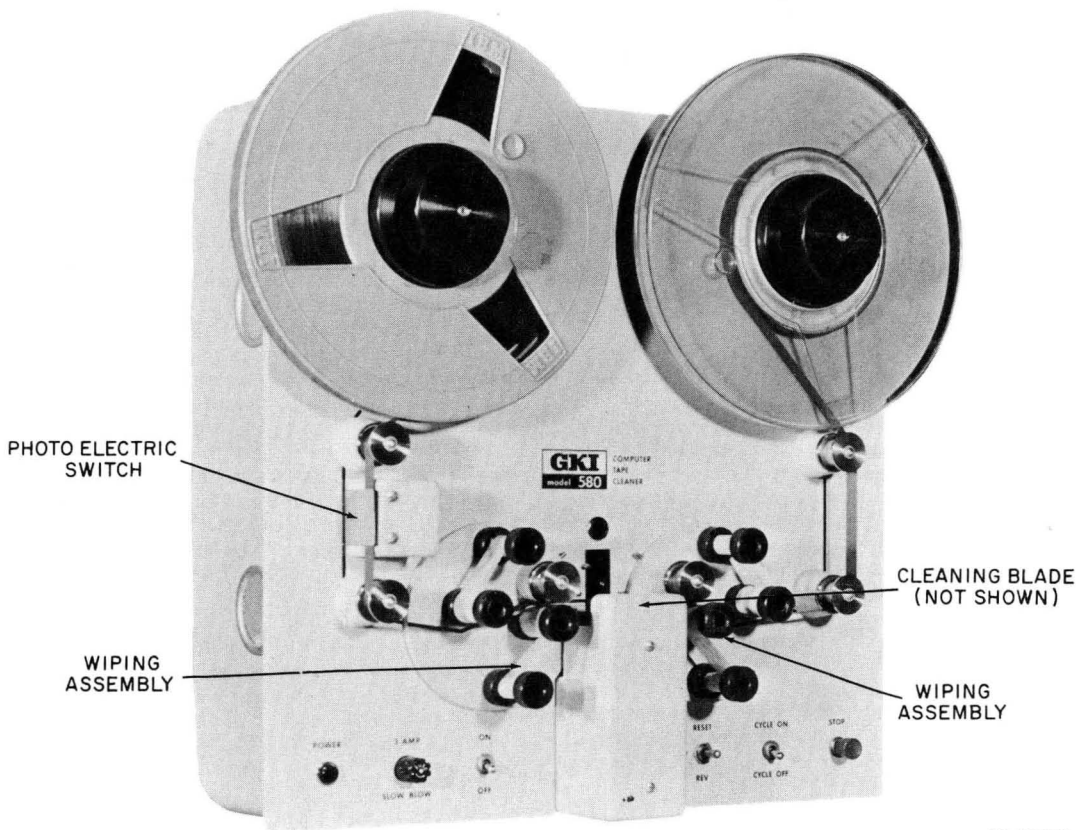
Figure 13-8.—GKI magnetic tape cleaner.

49.369X

results. Checks designed to supervise the quality of work that the computer produces will not suffice for complete controls. Complete controls must take into consideration the entire data processing application. Included in operating and procedure checks are areas of data control checks, system checks, and machine checks.

DATA CONTROL CHECKS

Data control checks consist of methods developed to control the information flow into and out of a data processing system. These checks also give assurance that all information received was correctly included in the required output. These controls also include methods devised to establish an audit trail should an omission or duplication occur. Without an established audit trail, retracing an entire procedure may be necessary to locate an error.

Every data processing application must have some form of data control checks. Because individual activities may require different control checks, we will not go into a detailed discussion of them. The control and method used will be determined by the requirement of each activity, however in all instances the following areas should be covered:

- Assurance that all input data are accurate.
- Arrangement of data in a form best suited for use by the computer.
- Assurance that all data are complete and not duplicated.
- Provide a means of auditing the steps of the procedure so that in the event of error or inconsistency the trouble may be located with minimum lost time.

SYSTEMS CHECKS

Systems checks are controls, within the computer system, designed to control the overall operation of a data processing procedure. Systems checks ensure that all data required for processing are received and that all output data are complete and accurate.

Controls may be included to ensure that all input records are for a current processing period and unrelated or incorrect records are excluded. Distribution of detail transactions to update master records, when distribution is made by coding, may also be verified by these checks.

With each computer application, systems checks vary, as do the types of systems checks

with each particular type of computing equipment. Particular attention should be paid to incorporating systems checks during the early stages of planning the application, because such controls can be fitted into the program more effectively at this time. In some cases the procedure must be modified to incorporate the most efficient controls; usually this is less costly than designing a procedure without the required controls.

Procedure requiring strict accounting controls with provision for audit trails requires that the program for the application be designed to take full advantage of the data processing system's built-in reliability.

In some systems, built-in checking features make detailed systems checks unnecessary, while data manipulation in the CPU of others is less stringently checked. This is particularly true where the required checking circuitry would increase the cost of the system without a significant proportionate increase in accuracy.

In computer applications checking is a form of quality control. It follows that, when errors can be tolerated to a degree, systems checks may be used more sparingly. Some specific systems checks are discussed in the following paragraphs.

Record Counts and Control Totals

Record counts and control totals are established when the file is assembled or first calculated as the case may be.

A record count is a total of the number of records contained in a file. A record count is established when the file is assembled, or in the case of magnetic tape, the count is established when the file is written. At the end of the file or reel the number of records is carried as a control total. Adjustments are made to the control total as records are added or deleted. A recount of the records is performed each time the file is processed and this count is compared or balanced against the original or adjusted total as the case may be. If the counts are in agreement it is accepted as proof that all records have been run.

Utilizing the record count as a control, it is very difficult to determine the cause of an error if the counts are not in agreement. This is because the record count does not identify the missing record nor does it indicate which record has been processed more than once. Therefore,

the records must be checked against the source records, a duplicate file, or a listing containing all of the original records.

On magnetic tape the record count that does not agree usually indicates a read error because once written on tape, a record cannot be misplaced or lost.

Control totals are usually composed of accumulated amounts or quantity fields in a group of records. When the file is originated or first calculated, either manually or by machine, the control totals are established or accumulated. The control can be on the level of a grand total, but would be more convenient on a major, intermediate, or minor total.

During processing the fields are again accumulated and the results are compared against the control total. If in agreement, it serves as proof that all records have been processed.

An efficient checking system can be developed using control totals when they are used to predetermine a calculation or update procedure. For example, in a payroll application, employees total hours worked can be preestablished from clock or job-card records. This figure then becomes the control total for all subsequent reports. Totals may be broken down into different control groups, such as work centers and clock stations, but the sum of all totals must balance back to the complete original total.

Normally control totals are established by batches, in convenient size, such as department, work center, and activity. By this method, each group may be balanced and/or corrective action taken as the records are processed. Errors are normally limited to small, easily checked groups rather than to one grand total.

Proof Figures

Proof figures are valuable, in the sense that they can be used to check on computer operations as well as a systems check. The proof figure is normally carried as additional information in a record. Multiplication in a procedure may be checked by proof figures. As an example of proof figures used in multiplication, let's use the units of hours worked by hourly rate for 1 week. The relationship between actual earnings and a fixed ceiling cost (proof cost) is the basis for this check. A fixed figure (X) larger than the maximum scale is set up. If the maximum scale for an employee in 1 week is $200, X might equal $201. Proof cost is the remainder when actual earnings are subtracted from X. The formula for proof cost may be expressed as follows:

$$X = \text{proof cost} + \text{actual cost}$$

Each record carries the proof cost as an extra factor. X is placed in storage, as a constant for use in calculating the proof figure.

Whenever quantity (hours worked) is multiplied by cost (hourly rate), it is also multiplied by proof cost. The factors that are accumulated during processing are normally quantity, quantity x cost, and quantity x proof cost. Once these calculations are completed up to this point, it is possible to check the sums (Σ) of all factors accumulated as follows:

$$\Sigma(\text{qty x cost}) + \Sigma(\text{qty x proof cost}) =$$

$$\Sigma(\text{qty x X})$$

To check the left side of the equation, merely add the two progressive totals that have been accumulated during processing. Multiplication of the accumulated quantity and the constant factor X is required in the calculation of the right side of the equation. This check ensures that each particular multiplication was performed correctly.

Tape and Disk Labels

Information recorded at the beginning and/or ending of a reel of magnetic tape are called the header label and the trailer label, respectively. They are used for proper file identification. The label may specify or identify the job total and/or number, the last processing date, reel number, and so on.

While tapes may have both a header and a trailer label located physically before and after the data, disk labels can appear physically anywhere on the volume, as long as the user specifies where it is located.

As an added control, to ensure that the proper records have been processed, the labels are read into storage at the beginning and/or end of a program. The labels may also be used to ensure a true end-of-file or end-of-job and may also include a record count.

Housekeeping Checks

Every program of any value must contain a housekeeping routine. This routine is normally established at the beginning, or first instructions, of every program and is intended to perform housekeeping functions prior to

processing. These functions may include: setting program switches, moving constants, setting up print area, clearing accumulators or registers, et cetera. Also systems checks may be performed by housekeeping instructions. These include testing to determine if all required input-output devices are attached to the systems and are ready for operation. Housekeeping instructions may calculate constant factors, file labels may be updated and checked, and other information pertinent to the proper operation of the system may, through programmed instructions, be brought to the attention of the operator.

Checkpoints and Restart Procedures

A procedure for establishing checkpoints is a programmed checking routine performed at designated processing intervals or check points. The purpose of this routine is to determine if processing has been performed correctly up to a designated checkpoint. Once a checkpoint has been reached by the machine and processing up to that point has been performed correctly, the status of the machine is recorded, usually on magnetic tape. The normal processing procedure is then continued until the next checkpoint is reached.

Checkpoint procedures are used to break up a long job into a series of small jobs. In this way each portion of the work is run as an independent and separate part, and each part checked once completed. If processing to this point is correct, enough information is written out to make it possible to return automatically to the last point where a check started. If not, the system restarts from the checkpoint at which the work is known to be correct and the portion that was not performed correctly is discarded.

A restart procedure:

1. Restores the computer's storage to its status at the preceding checkpoint. This may include reloading the program itself, resetting switches and counters, restoring constants, and making adjustments to accumulated totals.

2. Backs up an entire computer system to the specified point in the procedure, normally a checkpoint. Card units and printers must be manually adjusted; tape files are rewound or backspaced automatically.

The proper use of checkpoint and restart procedures contributes to the operating efficiency of a computer system. For example, many hours of machine time may be saved during a power failure or serious machine malfunction by simply rerunning a small part of the job (between checkpoints).

Interruption of a job that requires immediate or emergency attention is provided through restart procedures. Thus, the operator may interrupt any procedure and replace it with another job if necessary. Restart provisions are also convenient at the end of a work period or shift, when the job must be terminated without loss of production time.

MACHINE CHECKS

Procedures used for machine checks have a twofold function:

1. They accomplish useful work.

2. They control quality and accuracy of work.

Useful work in a data processing procedure consists of sorting, collating, calculating, reading, and printing operations. Operations controls are necessary to establish and maintain accounting controls, calculation checks, and machine checks. These checking devices are used by the programmer at his own discretion. Basically, two types of checks may be written: first, checks on the validity of data handled by the input-output devices, and second, checks on the data handled within the computer. These include checking for arithmetic overflows, valid signs of numeric quantities, legitimate instruction codes, and other check indicators.

The programmer may insert into the program special branch or transfer instructions designed to handle certain types of errors as exceptions. These instructions prevent unnecessary interruptions of computer operations (halts) upon detection of an error. For example, he may program the machine to backspace the tape and reread the record upon an indication of an error during the reading of a record from tape. At this point if the record is read correctly, normal operations are continued. If not, operations can be interrupted, or the incorrect record can be noted and operations continued. In all systems, however, the interrogations and interruptions of a data processing system are under the control of the programmer.

All processing is halted immediately under some machine check indicators. These indicators include conditions such as: blown fuses, air or humidity conditions beyond the prescribed limits, broken magnetic tapes, or card jams. All these cases must be brought to the operator's attention immediately and, therefore, cause the system to halt.

MAINTENANCE

You, as a machine operator, should ascertain to the best of your ability that all machines operated by you are in good working order. Many production hours are lost redoing jobs performed inefficiently by operators who are unaware of machine failures that occur during a processing phase. This can be attributed to poor operating habits. Such habits can also be the direct cause of machine breakdowns, which result in the work schedule falling behind and excessive periods of remedial maintenance (DOWN TIME) by customer engineers or Data Systems Technicians.

Your compliance with the rules previously listed for machine operating can reduce many of these nonproductive hours.

MAINTENANCE OF EQUIPMENT

As a general rule, ADP equipment installed on a rental basis ashore is maintained by customer engineers of the supplying company. As the customer, the data processing installation has certain responsibilities to the company in utilizing the equipment. As the supplier, the company has certain responsibilities to the customer in maintaining the equipment. Cooperation and understanding on the part of both the customer and the supplier are necessary to obtain the maximum available machine utilization time.

Schedules are established to provide customer engineers/technicians with the necessary time for accomplishing routine machine inspections and internal preventive maintenance (sometimes referred to as "PM").

The responsibility for maintenance of equipment installed aboard ship, whether it be purchased or rented, lies with the Government. Repairs are performed by qualified shipboard Data Processing Technicians, Data Systems Technicians, and in some cases, Electronics Technicians.

EAM Operational Failures

When a machine fails to operate properly, your first step is to determine the cause of operational failure. Following a reasonable amount of operating experience, you should be able to remedy simple causes, such as a sort brush not properly timed, switches set incorrectly, or control panels improperly wired. The diagnosis of failures becomes more complex when the trouble appears to be INSIDE the machine. These inner failures usually are one of two types; those you can remedy and those requiring the attention of a customer engineer. Typical failures you should be able to diagnose and remedy are reading brushes not firmly in place, brushes worn or frayed, loose punching dies, blown fuses, and card jams. Failures requiring the attention of a customer engineer include those attributed to worn parts and gears, malfunctioning relays, broken belts, and improper machine timing. If you cannot determine the cause of operational failure, or if you cannot remedy the situation after the cause is determined, you should immediately inform your supervisor.

Diagnostic Maintenance Programs

Even with the built-in accuracy inherent in electronic data processing systems, they cannot go on forever without attention. Certain parts or devices must be inspected and serviced at regular intervals to ensure that the equipment continues functioning properly.

The manufacturer may have a diagnostic routine specifically designed for testing all major features and devices, although it is almost impossible to test every individual component. Such routines run anywhere from five minutes to a half an hour, depending upon the system, and the diagnostics program.

Testing of equipment should be done daily with maintenance engineers readily available to find and correct equipment malfunctions during the operation.

INSTALLATION MAINTENANCE

The efficiency of a data processing installation is often judged by its appearance. Although every installation has certain maintenance procedures, some procedures are common to all.

You can help maintain a neat appearance by observing a few simple rules of good housekeeping.

- Keep cards, magnetic tapes, wires, and paper forms in their proper stowage when not in use.
- Place discarded paper and cards in receptacles provided for them.
- Place control panels in their proper racks when not in use.

- If you have desk, deep it neat. Do not clutter it up with a lot of unnecessary material.

- In general, abide by the well-known adage, "a place for everything, and everything in its place."

CHAPTER 14

MAINTENANCE AND MATERIAL MANAGEMENT SYSTEM (3M)

You should already be acquainted with the Maintenance and Material Management (3-M) System since it was discussed in the Military Requirements For Petty Officer 3 & 2, NAVPERS 10056-B.

In order to refresh your memory on the 3-M System, a brief review is included in the following pages.

The 3-M System, now implemented in the fleet, is the Navy's answer to the increased complexity of naval systems, increased tempo of fleet operations, and constant decline in available human and material resources. Now, more than ever, the most efficient management of material and manpower is required to maintain combat readiness of the U.S. Fleet.

"Maintenance" by Department of Defense definition and by all common sense rules, includes ".. servicing, repair, modification, modernization, overhaul, conversion, rebuild, test, reclamation, inspection and condition determination, and the initial provisioning and reprovisioning of support items."

Thus it is apparent that "maintenance" covers just about every aspect of effort concerned with Navy hardware after the initial procurement stages; and it may even be involved in those earlier stages as a result of design, reliability, or maintainability studies.

"Maintenance Management" by definition not only includes supervision of actual maintenance actions or effort, but it also includes all forms of effort to plan for, and support, the maintenance efforts. In brief, a maintenance manager is anyone who makes decisions that affect maintenance or the support of maintenance.

The basic purpose of the 3-M System is to increase the operational readiness of the fleet through a planned system of scheduled (preventive) maintenance. To accomplish this objective, the 3-M System standardizes preventive maintenance requirements, procedures, and reports on a fleetwide basis. Although the 3-M System standardizes preventive maintenance, it also establishes specific maintenance requirements for the system, subsystems, and equipment on each ship. In other words, the 3-M System is individually tailored to each ship. Maintenance requirements are made specific for every system, subsystem, and component that is actually found on the ship.

The 3-M System is relatively simple, logical, and easy to follow. Like most systems, however, this one is not foolproof and it will not run by itself. As a petty officer, your responsibilities will include:

1. Understanding what the 3-M System is designed to accomplish and understanding some of the operations of the system.

2. Keeping yourself informed of changes that occur in the 3-M System.

The basic sources of information are:

• Maintenance and Material Management 3-M Manual, OPNAV 43P2. This manual prescribes policies and procedures for the management and reporting of maintenance of ships of the Operating Forces.

• Data Processing Manual for the maintenance and material management system, aviation and shipboard.

• OPNAV Instructions and Directives issued by the type commander (TYCOM).

• Equipment Identification Code Manual: The EIC manual provides a method of encoding ship equipment that is subject to maintenance practices.

In data processing applications, it is desirable to have a coding system because an assembly, system, or even a component can be identified by a seven-character code, thus avoiding vague or ambiguous descriptions or

noun names. You can see in the following example that these codes are designed to permit inclusion of extensive information in a relatively small space.

EIC	DESCRIPTION
AK07030	Motor, AC, FAN, Heater Unit
AK07031	Housing, Bearing
ZP01010	Main Steam Valve

The keypunching, sorting, or any other processing time is greatly reduced by utilization of the equipment ID codes.

Inherent in the total 3-M System will be a reduction of excessive paperwork. Most of the forms and charts used in the system require only pen or pencil entries, and are maintained by the maintenance group supervisor.

DATA SERVICES

The 3-M System is made feasible mainly by the availability of data processing equipment which makes it possible to collect and analyze data in time to effect performance of existing equipments and overall maintenance procedures.

You, as a DP, could be assigned to Data Services, which is the activity that converts documented data into data processing records and utilizes these records to produce machine reports, listings, and punched/interpreted cards.

Maintenance and material management data will be forwarded from maintenance and supply activities to data processing facilities that have the capabilities of either an IBM 407 accounting machine, or the AN/UYK-5 (V) ADP System (UNIVAC 1500 series of computing equipments, shown in figure 14-1). These installations process the 3-M data.

ANALYSIS SECTION

An analysis section is established in each activity and is charged with the responsibility to monitor and control the 3-M System in an orderly and efficient manner. The analysis section serves as the contact point for the data
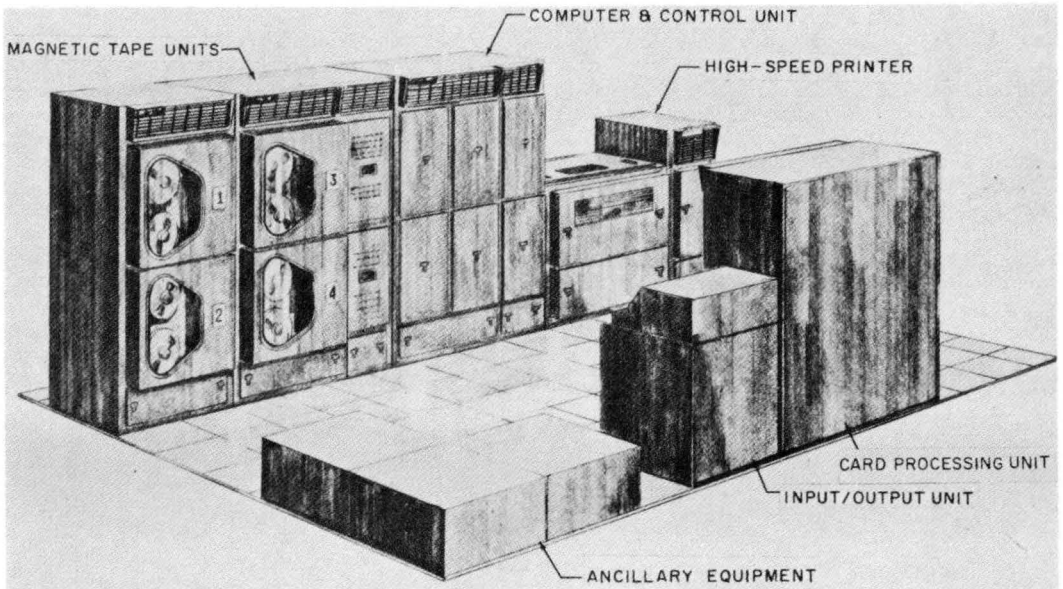
120.100(124A)

Figure 14-1.—AN/UYK-5 (V) ADP System Installation Configuration.

services, and coordinates with data services in the day-to-day system operation and data flow.

Data Accuracy

The entries on most source documents received by data services will be handwritten. Handwritten data is often difficult for a keypunch operator to interpret. If there is doubt concerning interpretation of data, the document should be rejected for correction and/or clarification and resubmitted. Daily machine reports are provided to the analysis section to check reporting and processing accuracy. To ensure that proper emphasis will be placed on careful preparation of source documents, illegible, invalid, or incomplete source documents must be rejected.

It is your responsibility as a petty officer to make the analysis section aware of the problems involved in preparing documents in a machine processable form (keypunching, etc.), and insist upon proper screening and document rejection practices in the analyst section.

MASTER INSTRUCTION TAPE (MIT)

The Fleet Work Study Group, Atlantic (FWSGLANT) has the responsibility to furnish AN/UYK-5 (V) ADP System activities afloat with a MIT (Master Instruction Tape) that contains all the programs used in the 3-M System. Revision, addition, or deletions to the MIT are accomplished only by the highly skilled programmers and analysts at FWSGLANT.

When FWSGLANT makes a revision to the 3-M System programs, an updated MIT is forwarded to each activity. Included with the MIT are operator guides, card formats, tape formats, specifications, and sample reports to provide the user with information necessary to sucessfully run the programs on the tape.

Extreme care must be used in the maintenance and handling of the MIT. At least one back-up copy of the MIT must be maintained at each activity. In the event the working MIT is damaged and cannot be used, the first step to take is to duplicate the back-up MIT. Sensible procedures dictate that an activity should never attempt to operate with only one copy of the MIT.

REPORTS

The reports that are produced are everchanging, but the overall objectives of some of them are:

● To keep track of the man-hours used in certain labor classifications for distribution of personnel and workloads.

● To keep track of material usage and cost of any one type of equipment.

● How many man-hours it takes to keep a certain type of equipment operationally ready.

● Reasons for equipments not being operationally ready.

● To obtain the repair time on individual pieces of equipment.

Example Objective

The Maintenance Data Reporting (MDR) System used in the Naval Aviation System is used to obtain the malfunctions and the repair time on any one type of equipment to be used in research for modifying this equipment. For example:

● Equipment XYZ has to be constantly repaired because valve No. 2 keeps splitting. Valve No. 2 is made of number 3 aluminum which can stand 300 lbs of pressure per square inch when new. After 36 hours of actual use time, valve No. 2 can stand only 150 lbs of pressure per square inch.

SOLUTION- Valve No. 2 is now being made of number 14 aluminum compound which will stand 300 lbs of pressure even after 100 hours of use.

INDEX

BASIC DATA PROCESSING

Prepared by the Bureau of Naval Personnel

This is a complete, A-to-Z explanation of the theory and operation of data processing systems, originally prepared as a training course for U.S. Navy data processing technicians and thoroughly updated in 1970. Because it is based on the leading commercial systems—IBM, UNIVAC, R.C.A., Honeywell and General Kinetics—and begins with the barest fundamentals, it is ideal for those who wish to learn data processing as their occupation, and for those who want a practical manual on procedures and maintenance. It is also a fascinating volume for anyone interested in how these systems, which increasingly affect our daily lives, function. The explanation is crystal-clear.

Starting with the revolution in record keeping brought about by automatic processing, and introducing the reader to such areas as "punched card language" and the workings of a computer, the text goes on to separate chapters on card sorters, interpreters, automatic punches, collators, accounting machines, electronic data processing, input and output, procedures and data flow, programming and documentation, operation and control, and finally maintenance of the systems and material management.

Throughout, the emphasis is on actual, current practice and effective use of techniques and equipment. The question that the text seeks constantly to answer is "How?" No matter how complex a given area covered, the explanation is in simple language that proceeds point by point in detail. It is profusely illustrated—on virtually every page—with photographs of the actual equipment and its named parts and easily understood diagrams.

The beginner, the technician and the interested layman can hardly find a clearer, more thorough coverage of data processing systems than this.

Unaltered, unabridged republication of 3rd (1970) revised edition of *Data Processing Tech 3 & 2*, originally prepared as NAVPERS 10264-B by the Bureau of Naval Personnel. Innumerable illustrations. Index. iv + 316pp. 6½ x 9¼. 20229-1 Paperbound

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